A Proposed National Surveying And Mapping Policy In Nepal

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Keywords: *Land policy, Surveying and mapping policy, Land management, Poverty reduction,Geoinformation*

Abstract

The political objective of Nepal is poverty reduction and sustainable development. The sustainable land administration and management is a tool to achieve the political objectives. From an institutional perspective, land administration and management includes the formulation of land policy, the legal framework, resource management, land administration arrangements, and land information management. In Nepal, The draft of National Land Policy document has been formulated and it is under discussion at ministerial level. One of the recommendations on that National Land Policy document is the formulation of National Surveying and Mapping Policy. It is realized that the time has come to formulate the "National Surveying and Mapping Policy" based on the proposed National Land Policy document in keeping abreast of development and changes in the global technological environment. In this paper, an attempt has made to prepare National Surveying and Mapping Policy in Nepal. The main issues and challenges are also raised on this paper to formulate the National Surveying and Mapping Policy in Nepal.

This paper starts with Background and describes the background for developing this policy document. It then describes about Survey Department activities. It then elaborates the policy on Surveying and Mapping in Nepal with policy on Geodetic Surveys and Space Science, Topographic Survey and Geographical Information Infrastructure, Cadastral Survey and Land Information, Research & Development, Resource, Administration. Finally, it concludes with some concluding remarks.

1. BACKGROUND

Land is one of the main resources in Nepal for economic growth as well as overall development of the country. The land administration and management is the main concern for Government of Nepal to achieve the national objective of poverty reduction. From an institutional perspective, land administration and management includes the formulation of land policy, the legal framework, resource management, land administration arrangements, and land information management.

National Land Policy is of fundamental importance to sustainable growth, good governance, and the well-being of and the economic opportunities for people. It consists of a whole complex of socio-economic and legal prescriptions that dictate how the land and the benefits from the land are to be allocated. In Nepal, comprehensive National Land Policy is yet to be formulated in the new changing contest and the draft policy document is under discussion. There is a need of political commitment to formulate the National Land Policy. National Surveying and Mapping Policy should be based on the National Land Policy. There are various instruments for land administration and management. The surveying and mapping is one of the world wide recognized tool for the land administration and management.

The Ministry of Land Reform and Management (MLRM) is mandated to formulate and implement policies for land administration and management. There are three departments and one corporation (an autonomous body) responsible in the field of mapping, land management and geo information. The land reform and management department mainly deals with the records of land holding, land taxation, land valuation, land ceiling and land tenancy. The Department of Land Information and Archiving is mandated to develop and maintain a nationwide land information system (LIS) and national land records archive. Similarly, Guthi Corporation is responsible for managing trust land and to maintain the management of the worship in temples and other cultural and religious heritage of Nepal.

Survey Department is responsible for the national surveying and mapping activities in Nepal. There is also Mapping Committee constituted by land survey act 1963 (revised 1999) for the co-ordination, monitoring and evaluation of surveying and mapping activities.

In order to formulate the plan and policies to guide the survey department, it needs detail formulation of the different activities related to geoinformation production and its distribution. Survey department attempted in the past to formulate its plan and policies and published a book on national mapping (issues and strategies) 1998. The National Land Policy document has been formulated and it is under discussion. It is realized that time has come to formulate the "National Policy on Surveying and Mapping" based on the National Land Policy document in keeping abreast of development and changes in the global technological environment.

2. Survey department activities

Geodetic Surveying, Topographical Surveying with geo-information services, and Cadastral Surveying with land information services are main activities of Survey Department. The department also assists and coordinates the surveying and mapping, geographic information and land information system activities conducted by different agencies in Nepal.

Geodetic Surveying activities of Survey Department are:

- to establish and maintain National Geodetic Control Network including horizontal control, vertical control with bench marks and gravity anomaly of the country
- to establish and archive national geodetic data base of the country with proper computation and adjustment.
- to make available the geodetic horizontal and vertical ground control data for the users of development activities.

Topographical surveying and geo-information activities of Survey Department are:

- to provide aerial photography and prepare orthophoto maps as required,
- to prepare, publish, update and make available national topographic base maps and national topographic data base with related information,
- to prepare, update and publish small-scale topographic maps, administrative maps and land resource maps of the country.
- to prepare map specification reports and co-ordinate the activities of aerial photography, surveying and mapping, geographic information system and small scale maps publication and their distribution.

Cadastral surveying and land information services of Survey Department are:

- To prepare large scale cadastral plan and records of governmental, private and public land of all the districts of Nepal and distribute land certificate to the landowners.
- To co-ordinate land information system activities.
- To update and maintain the large scale cadastral plan and records of all the district
- To delineate the parcel boundary if required.
- To co-ordinate the integrated land development programs land pooling and land acquisition for development works of different agencies.
- To provide services on land information for the land owners

3. Policy on surveying and mapping

All socio-economic developmental activities, conservation of natural resources, planning for disaster mitigation and infrastructure development require high quality spatial data. The proposed Surveying and Mapping Policy has been formulated based on the draft National Land Policy document. Survey Department is responsible for producing, maintaining and disseminating geoinformation throughout the country. The policy has been formulated based on the legislative and institutional framework for the surveying and mapping activities in Nepal.

3.1 Vision

“To produce and make available high quality geo information products and services for sustainable land administration and management as well as planning and various lands related development activities to achieve the national objective of poverty reduction and sustainable development"

3.2 Objectives

The surveying and mapping policy shall be formulated to achieve the following objectives of the survey department

- To establish and maintain the national horizontal and vertical control network of the country.
- To publish, maintain, update and make available national topographic base maps, including small-scale maps and other different types of maps and related information and their subsequent updating.
- To maintain cadastral system and develop parcel based national land information system based on large scale cadastral plan and land records.
- To study technical development activities in the field of surveying and mapping and formulate the necessary activities as required in this field.
- To provide the geo information services and co-ordination of the different agencies involved in the field of surveying and mapping.
- To formulate and recommend the concerned authority of the government about the plan and policies of surveying and mapping activities of the country.
- To promote the use of geospatial knowledge and intelligence through partnerships and other mechanisms by all sections of the society and work towards knowledge-based society.

3.3 Issues and challenges

There are some issues which are not addressed properly and need to be address on the surveying and mapping policies such as efficient & effective updating national topographic data base, pricing policy of geo information products like national digital topographical database and ortho photo, cadastral survey & its updating, cadastral survey of the un surveyed village block areas and uncultivated government lands, high accuracy cadastral maps on dense areas, the 3D cadastre with condominium ownership of housing, access & use of land information, growing demands for the use of RTK GPS data, review of the spheroid , projection system & national geodetic control network of the country, the focal institution to promote space technology in Nepal, formulation of space law, human resources development and use of modern technology etc.

The following are the main challenges on surveying and mapping sector in Nepal:

- Review on national surveying and mapping policy : Implementation of norms and standard of surveying and mapping on all the mapping agencies, research and development, wider sharing of geographic information and maps, coordination of different agencies involved, collection & maintenance of geographic/land information/geographic names and human resources for the surveying and mapping.
- Maintenance of cadastral maps and documents: Strengthening of district cadastral survey offices. Require physical facilities. Monitoring system through regional office. The existing cadastral maps are very old and the parcel boundary on the maps are unclear
- Updating national topographic data base and topographic base map series and preparation of small scale map: The topographical maps should be updated regularly in certain interval of time period.
- Maintenance of geodetic network, Geodetic survey activities and research: The extension and densification of higher order geodetic control points are required. Re-observation and subsequent computation & adjustment of the extended geodetic control network are required to define the positional accuracy of the geodetic control point.
- Unavailability of sufficient gravity points distributed all over the country: Gravity anomaly map and magnetic charting of whole country needs to be prepared.
- Coordination between the national /international survey agencies: Global control network and mapping, boundary survey, sharing of geographic information, congress – seminar,etc.
- Collaboration with the national /international educational institution/university: Human resource development on strengthening geodetic survey capacity, development of land information services and development of digital mapping system
- Development of digital mapping system: Cadastral Information System , Land Resource Information System and National topographic data base (System development, data acquisition, updating, data

generalization ,digital production system and information dissemination etc)

3.4 National policy on Surveying and mapping

On the basis of the goal, objectives and issues, the national policy on surveying and mapping is identified on the following fields:

- Geodetic Surveys and Space Science
- Topographic Survey and Geographical Information Infrastructure
- Cadastral Survey and Land Information
- Research & Development
- Resource
- Administration

3.4.1 Geodetic Survey and Space Science

Geodetic data includes horizontal and vertical ground control points distributed all over the country in their own network system. The development and maintenance of horizontal and vertical ground control networks comes in the responsibility of the national government. These data are the main bases for national and regional mapping activities. Homogeneous, accurate and well-maintained geodetic control networks are also the prerequisites for geographic information systems/ Land information system. Geodetic, astronomic, gravimetric data are required to define the shape and size of the earth corresponding to the country. This information is also useful to study the outer space events and also to detect deformation of earth structure.

Geodetic Surveys policies of Survey Department are

- Precise higher order geodetic control network (horizontal and leveling network) shall be carried out by Survey Department and maintain the records in an archive.
- The lower order control network (i. e. horizontal and vertical) for large scale map preparation shall be carried out by Survey Department and maintain the records in an archive. Permission of lower order control survey may be granted to other agencies with the condition that the control survey shall be carried out within the stipulated specification and the control survey data shall be provided to Survey Department for quality control and archiving.
- Gravity points shall be established on all over the country so that gravity anomaly map shall be available to know the gravitation field of the country.
- Magnetic observations shall be carried out at different places of Nepal for the preparation of magnetic charting of the country.
- Maintenance of geodetic ground control points (i.e. first, second and third order) and precise bench marks shall be carried out to ensure that the position of points are not disturbed in the field.
- GPS tracking stations shall be established for the real time GPS data capturing
- Survey Department shall promote the users to use geodetic data for development activities and collect the revenue by selling control points coordinates and bench marks data.

Space Science policies of the Survey Department are

- Survey Department will be the focal point for users to contact for using high resolution satellite imagery data and aerial photographs in the country
- Survey Department shall coordinate and provide technical supports for the aerial photography and space technology
- Survey Department with Ministry of Science and Technology shall coordinate for the promotion of satellite technology
- Space law shall be formulated based on the existing laws
- Satellite technology shall be introduced for large scale mapping

3.4.2 Topographical Survey and Geographic Information

Topographic survey includes the preparations of topographic base maps, derived scale topographic maps, thematic mapping, the development and maintenance of horizontal and vertical ground control networks comes in the responsibility of the national government. Land resources mapping and large scale topographic mapping. Topographic base maps are an important general source of information for any land related inventory, planning and implementation of the development projects. Derived/ administrative maps, Thematic maps/land resource maps, and large scale maps are required for nation-wide development, administration and statistical purposes.

Topographical Survey policies of Survey Department are

- Topographic base maps and digital database of terai and middle mountain region of Nepal shall be prepared at the scale of 1:25000 with 20m contours.
- Topographic base maps and digital data base of higher mountains region of Nepal shall be repaired at the scale of 1:50000 with 40m contours.
- Geographic information system (GIS) and Remote sensing (RS) tools shall be used and provide services for the study, monitoring and management of socio-economic, environmental and other development projects.
- Total updating of base maps shall be carried out on a 10 to 20 year cycle through the use of new airborne or space borne imagery.
- Small-scale maps (i. e. derived administrative maps) shall be prepared to assist general planning and decision making process of various governmental and non-governmental organizations.
- Land resource maps/land use maps and corresponding reports shall be prepared in co-ordination with other agencies concerned.
- Atlas, tourist maps and wall maps shall be prepared with the co-operation with the other agencies concerned.
- Large scale maps for development projects and urban area digital topographic data base shall be prepared upon the request of various development projects and municipalities.
- Large scale aerial photography of selected region shall be carried out and orthophoto maps shall be prepared upon request of other agencies.

Geographic Information policies of the Survey Department are

- The institutional and technical framework for NGI centre shall be defined
- The custodianship of framework data shall be with Survey Department
- Clearing house shall be developed for the access and use of actual data sets through metadata
- The standard of metadata shall be defined and make available for all the stakeholder

3.4.3 Cadastral Survey and Land Information

Cadastral survey includes the recording of location, extent, land ownership rights, area, land use and the physical characteristics of a parcel. Special care should be taken in the preparation of cadastral maps and records as this concern with the individual land property right, the social order and the public confidence.

Cadastral Survey policies of Survey Department are

- Large scale cadastral plans and land records shall be prepared for all the districts of Nepal on the basis of national geodetic control system to cover all the government, private and public land of the country and distribute the land ownership certificate.
- Each and every parcel in urban areas shall be adjudicated and individual parcel plan with dimension shall be prepared as per the boundary demarcation by survey monuments
- Cadastral plan and relevant records shall be updated and maintain on all the districts as requested by the district land revenue offices.
- Delineation of parcel boundary shall be carried out upon the request of landowners.
- Technical assistance on cadastral survey shall be provided to the various governmental organizations including municipalities.
- Complete records of government as well as public land shall be prepared
- Public-public and public-private co-operation shall be introduced for cadastral surveying
- Partnership with local authority for the creation and sharing of digital cadastral database
- Total Quality Management principal shall be developed to verify the works carried out by private sectors/licensed surveyors

Land Information policies of the Survey Department are

- The maintenance of spatial parts of land information shall be with Survey Department
- The rights and restriction for the use and access of land information will be defined
- E-conveyance method with digital signature will be introduced for the electronic transaction of land ownership to promote e-governance
- The computer technology shall be introduced for

cadastral surveying and cadastral map printing
- Partnership shall be done with local authority, private sector and academia for the development of national wide land information system

3.4.4 Research and Development

Research and development (R&D) on surveying and mapping is necessary to look into technical developments taken place, to formulate the necessary adjustments to the working procedure of various phases and to introduce new functions in surveying mapping activities.

Research and development policy of Survey Department

- Geodetic observation and analysis of the computed results shall be carried out to determine the shape and size of earth and corresponding most suitable geoid for the country.
- Research and development in the field of geodesy and astronomy shall be carried out for analyzing and monitoring precise geodetic information in collaboration with national and international agencies.
- Quality assessment of the topographic base maps and geographic information shall be carried out to make the recommendation for the improvements.
- Quality assessment of the land information product and the cadastral survey system shall be carried out for a reliable land administration.
- Research and development in the land administration sector shall be carried out to solve the various technical and socio-political issues on land management

3.4.5 Resource Policy

Resource policy includes the human resources, equipment for the production process and technology required for surveying mapping activities.

The Resource policies of survey Department are:
- Seek the co-operation with the other national and international institutions/universities to train the lower, middle and higher level of technicians in the field of Geoinformatics and land management.
- Promote the survey professional to attend national / international workshop seminar and conference.
- A system shall be developed to provide the survey license to the qualified surveyors
- Out source the laborious and tedious jobs to the private sectors
- Establish a lab for calibration of Survey equipment and publish specifications and manuals.
- Drive towards the cost recovery policy

3.4.6 Administration Policy

Different agencies use maps and geo-information data produced by Survey Department for land related applications. Some of them have their own special map production units. At present map and geo-information data producer have no obligation to take into account the consistency and compatibility of the system. Duplication of work is another problem in geographic information system and services.

In recent years changes have occurred in surveying and mapping technology with the introduction of computer techniques and space science. Therefore an integrated approach to system co-ordination and management should be developed to ensure efficient and effective application.

Administrative policies of Survey Department are

- Map specification and standard shall be set by Survey Department to follow in all surveying and mapping works.
- Private survey companies and licensed surveyors shall involve in surveying and mappings activities for reliable and quality of the geoinformation products.
- Mapping committee constituted by land survey act 1963 (revised 1999) shall be activated for the co-ordination and management of different agencies involved in the geoinformation system and services as well as monitoring and evaluation of surveying and mapping activities.
- An effective marketing and customer information program shall be lunched to promote the use of maps and geo-information data for development activities.
- Customers satisfaction shall be assessed and user council shall be formed
- Organization restructuring shall be done to cope with the technological development.

4. Concluding remarks

The proposed National Surveying and Mapping policy is formulated based on the draft National Land Policy document. The vision of policy is defined as "To produce and make available high quality geo information products and services for sustainable land administration and management as well as planning and various lands related development activities to achieve the national objective of poverty reduction and sustainable development". Based on this vision the policy on Surveying and Mapping in Nepal are formulated and policy on Geodetic Surveys and Space Science, Topographic Survey and Geographical Information Infrastructure, Cadastral Survey and Land Information, Research & Development, Resource and Administration are discussed on this paper. The main issues and challenges are also raised in this paper for the formulation of Surveying and Mapping Policy.

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Assessment of the Digital Cadastre in Nepal from the Cadastre 2014 Vision

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Keywords: *digital cadastre, cadastre 2014, data model, land administration, SDI, evaluation*

Abstract

In Nepal, the value and price of land in urban areas is very high. Due to the scale constraint, the cadastral maps prepared by graphical cadastral surveying method does not satisfy the land owners as they are asking for the accuracy of centimeter of land in the front face of their land parcel. The land owners are also asking for the recording and documentation of 3D real estate objects. Considering these facts, Cadastral Survey Branch under Survey Department has initiated digital cadastre program focusing on the urban land areas. Last year, the piloting of this program has been successfully completed to prepare digital cadastral database in ward number six of Banepa Municipality, Nepal. After the success of digital cadastral mapping, the programme has been continued and some observations are made. Some lessons have been learned from this programme for the cadastral information system (CIS) development in Nepal. There are various ways to evaluate the cadastral projects. In this paper an attempt has been done to evaluate the digital cadastre programme from Cadastre 2014 perspectives.

This paper starts with introduction and background for the initiation of digital cadastre programme in Nepal. It then describes about evaluation methods for cadastral system. It also describes about the background and context to evaluate digital cadastre from the cadastre 2014 perspectives. It compares the digital cadastre system of Nepal with six statements of the Cadastre 2014 report. Finally, it concludes with some conclusions.

1. Introduction

In Nepal, Ministry of Land Reform and Management (MLRM) is responsible for the administration and management of land through its central Departments and District Offices. Survey Department (SD) is one of the departments under MLRM responsible for the initial land registration and cadastral surveying. Cadastral Survey Branch under Survey Department is responsible to carryout adjudication of land ownership rights, identify and survey land parcels/objects and owners, prepare cadastral maps, classify land parcels, prepare and issue the land ownership certificates. In the beginning, cadastral surveying was sporadic in nature but later systematic cadastral survey was began to support the land reform programme launched by Nepalese Government. The cadastral maps were prepared using chain survey and plane tabling survey method. Those maps were mainly prepared for fiscal purposes. Due to urbanization and population growth, the value of land is increasing rapidly. The graphical cadastral maps are not adequate to reflect the real field situation in the urban areas as the value and price of land in urban areas is very high. Due to the scale constraint, the cadastral maps prepared by graphical cadastral surveying method does not satisfy the land owners as they are asking for the accuracy of centimeter of land in the front face of their land parcel. The maps are in very ruin condition due to the continuously used and improper documentation. The land owners are also asking for the recording and documentation of 3D real estate objects. SD are not able to satisfy the demand of land owners. Considering these facts, SD has prepared its Logical Framework Plan (10 years from fiscal year 2005/2006) and one of the outputs after ten year will be the replacement of traditional technology with digital cadastral system for effective service delivery in cadastral related organizations in Nepal (Survey Department, 2006). Cadastral Survey Branch under Survey Department has introduced digital technology for data acquisition in urban areas as a piloting. After the success of this technology in piloting phase the

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FIG Working Week 2007
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program has been continued and improvements are going on. The traditional plane tabling method has been replaced by modern numerical cadastral surveying method using total station instruments and the cadastral database has been developed in fully digital environment. Some lessons have been learned from this programme for the cadastral information system (CIS) development in Nepal. There are various ways to evaluate the cadastral projects. In this paper an attempt has been done to evaluate the digital cadastre programme of Nepal from Cadastre 2014 perspectives.

2. Evaluation trends

There are various methods in practice for the evaluation of cadastral systems. Currently there is no accepted framework or methodologies to compare and evaluate national cadastral system. The evaluation of cadastral system demonstrates strength and weaknesses of the current system, gives the justification for the improvement, and identifies priorities in policy, management & operations. Several development agencies use a method called "Logic Framework Analysis" (LFA) as a classic tool of aid management to investigate and evaluate projects and programs in the field of aid development (Steudler and Rajabifard, 2004). The first attempt for benchmarking of cadastral system was started by Australian Surveyor in 1997. The FIG Commission 7 working group has published a Report of Benchmarking Cadastral System in 2002 covering the scrutiny of the international renowned personalities. In the same way Cadastral Template is another document to measure the performance of cadastral organizations. Dr. Steudler has developed a framework and methodology to carry out comparisons and evaluations of Land Administration system taking economic, social and environmental issues into consideration in his PhD dissertation (Steudler, 2004). The Cadastre 2014 document is another tool to evaluate the modern cadastral project of a country. Various research results show that the vision for Cadastre 2014 is also applicable for the cadastral projects supported by ICT in developing countries (Chimhamhiwa, 2006). In this paper an attempt has been made to evaluate digital cadastre of Nepal from the Cadastre 2014 perspectives.

3. Background and context

When I was studying GIM2 course (2003-2005) in ITC, the Netherlands, I got the opportunity to study and understand Cadastre 2014 report. Most of the students including me were from developing countries. We discussed each other and concluded that none of the statements are relevant for the cadastral related organizations of developing countries. We concurred with this document knowing that the vision was developed in the case of developed countries. It was the case of only three years back. After returning from ITC, I am involving in digital cadastre programme run by Cadastral Survey Branch of Survey Department. Now, I have courage to evaluate this programme with cadastre 2014 vision. I need to salute to the then Working Group 1 of FIG-Commission 7 which have prepared this vision. Actually, the group was commissioned to: *Study cadastral reform and procedures as applied in developed countries, about taking consideration automation of the cadastre and the role of cadastre as part of a larger land information system, evaluate trends in this field and produce a vision of where cadastral systems will be in the next twenty years, show the means with which these changes will be achieved and describe the technology to be used in implementing these changes.* The working group submitted the booklet "Cadastre 2014 – A Vision for a Future Cadastral System" and basically formulated six vision statements for a future cadastral system (Kaufmann and Steudler, 1998) to the XXII FIG Congress in Brighton in 1998. Since then, a lot of discussions are going on and it is becoming an important theme for the discussions on conference/seminars and lecture rooms among professionals as well as academicians. The booklet is becoming a sacred document for cadastre/land registry related organizations all over the world. Primarily, the vision was developed focusing the future cadastral system of developed country assuming that developing and transitional countries would adopt the traditional methods. Coming on the half of the way, developing countries are also initiated cadastre project using latest Geo-ICT technology (Kaufmann, 2002). The Cadastre 2014 document is becoming much more relevant for the cadastral related organizations all over the world as the year 2014 is coming near to nearer. The cadastral related organizations are benchmarking as well as preparing strategic plan based on this document. The affordable Geo-ICT (internet, geo- database, modeling standards, open systems, GIS etc) is available every where. The developing and transitional countries are making use of latest technologies. It is becoming easy for those countries having no or less infrastructure to modernize their cadastral system from zero level using these affordable Geo-ICT tools. Hence, the Cadastre 2014 document has been taken as a base for the evaluation of digital cadastre programme of Cadastral Survey Branch.

4. Evaluation with six statements

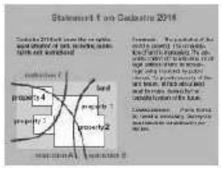
According to the definition of Cadastre 2014, Cadastre 2014 is a methodically arranged public inventory of data concerning all legal land objects in a certain country or district, based on a survey of their boundaries. Such legal land objects are systematically identified by means of some separate designation. They are defined either by private or by public law. The outlines of the property, the identifier together with descriptive data, may show for each separate land object the nature, size, value and legal rights or restrictions associated with the land object. In addition to this descriptive information defining the land objects, Cadastre 2014 contains the official records of rights on the legal land objects (Kaufmann, Steudler 1998).

In this section, the digital cadastre program of Nepal has been assessed from the six vision statements of Cadastre 2014. The evaluation is based on the author's own experience as he is involving on this program. The technological innovations are predicated based on today's perspectives. All six statements are explained and digital cadastre has been evaluated based on these statements. Finally, some observations are made.

Explanation: As land becomes a scarce resource and more and more public rights and restrictions influence the private landownership, the cadastral system of the future needs to show the complete legal situation in order to provide the required land tenure security.

Evaluation: In Digital Cadastre of Nepal, complete documentation of the legal situation of land has been addressed. The surveyor verifies and validates the information about the land objects during adjudication. The land objects are delimited and all the rights and restrictions on the land objects are recorded, registered and modeled to provide the land tenure security. The land information thus prepared could provide the legal security for financial institutions for the purpose of mortgage. Digital cadastre is based on the principal of multipurpose cadastre so all the field details are captured during cadastral surveying. For example, if there are informal settlements, the huts are also shown on the cadastral maps. Spatially, it has addressed the complete legal situation of land. It also has opened the door to recognize indigenous/non-formal land object rights and the restriction according to new laws concerning physical planning, environmental protection, land use and the exploitation of natural resources. Being based on the existing land laws the restriction according to new laws has not addressed much but has kept the room to address these issues.

Observation: In my observation, in 2014 (from digital cadastre programme perspectives) it will show the complete legal situation of land, including public rights and restrictions! If there is no cadastral map, the legal situation of land will be incomplete. The land right issue of informal settlers/indigenous people is the concern of Nepalese Government. Hence, cadastre 2014 will have the 100% of cadastral coverage of whole country and address the issue of indigenous/non-formal land object rights and restriction according to the new laws.

Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (Digital Cadastre view)
One	Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions! 	Cadastre 2014 will show the complete legal situation of land, including public rights and restrictions (including indigenous/non-formal land object rights and restriction)

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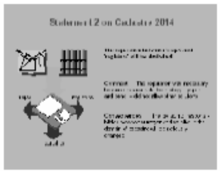
Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (From Digital Cadastre)
Two	The separation between 'maps' and 'registers' will be abolished! 	The separation between 'maps' and 'registers' will be abolished!

Explanation: The separation was historically necessary because of the available technology at the time, but this can nowadays be overcome, at least technically if not institutionally as well.

Evaluation: In Digital Cadastre of Nepal, the Digital Cadastre team performs adjudication, cadastral surveying, land registration, cadastral database preparation and land ownership certificate distribution. In the beginning, there is no separation between maps and registers as both the documents are prepared by the same organization. The documents will be separated only after handed over the documents to the respective district land registry and cadastral office. Hence, technically being the same source and standard sharing and integrating of data is possible with the modern Geo-ICT tools that will be available. Institutionally, It will force to amalgamate both organizations into a single organization. Nepalese government has given priority for the service delivery through one door policy. The ICT tools will make easy to integrate both spatial and non-spatial data related to land. The digital cadastre office will be single point of contact for cadastral information. The role of surveyors will be more and lead for land administration.

Observation: In my observation, the separation between 'maps' and 'registers' will be abolished in 2014. There are two possibilities either two cadastral and land registry organizations will be merged institutionally /technically or the land administration work (at least operational work) will be deputed to local authority (Municipality or Village Development Committee).

Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (From Digital Cadastre)
Three	The Cadastral mapping will be dead! Long live modeling! 	The Cadastral mapping will be dead! Long live modeling!

Explanation: The production of plans and maps has always been the main objective and responsibility of surveyors; modern concepts and technology provide different and much more advanced opportunities, which surveyors need to acknowledge by adopting principles from information technology.

Evaluation: The Digital cadastre is based on the principal of multipurpose cadastre. Land Owners could trust more on images and models rather than on maps. The ortho photo/high resolution satellite imagery could be very useful tool during adjudication and land registration. Land owner could be more faith on the aerial photographs or satellite imagery as they could visually interpret their parcel boundary. During numerical cadastral surveying, the land objects are described by 3D co-ordinates so the 3D real estate objects will be described by 3D model. A detailed specification for Cadastral Information Service (CIS) and National Cadastral Database (NCDB) has prepared and the core cadastral model has been developed. It will be very easy for the users to access and use the cadastral information. The NCDB will be important element for the development of NSDI.

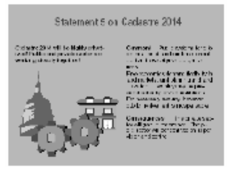
Observation: In my observation, the cadastral model will be used for adjudication, land registration and to resolve the boundary disputes. The land objects are described by 3D co-ordinates and the spatial context of parcel history has been maintained. The concept of 3D and 4D will be come under practice. Surveyor will use the low cost products like Google Earth and open source tools in cadastre 2014. Cadastral database will help for the development of NSDI throughout the country.

Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (From Digital Cadastre view)
Four	'Paper and pencil - cadastre' will have gone! 	'Paper and pencil – cadastre' will have gone!

Explanation: Digital technology will be a prerequisite for efficient and adequate service.

Evaluation: In digital cadastre programme, the traditional plane tabling method has been replaced by numerical cadastral mapping using total station instruments. The raw data captured from field are managed as a separated layer. The data captured by total stations are directly transferred to PC/Laptop. After processing, cadastral database are created. The digital database could be delivered in the digital format. There is no more use of paper and pencil on this digital cadastre program. For our traditional cadastral system also there is scarce of high quality papers and pens as we were getting them from developed countries. The companies are not producing those products any more. Both due to market pull and technology push factor the use of paper and pencil will be abolished.

Observation: In my observation, there will be no more use of paper and pencil. There will be great use of Geo-ICT tools in cadastral organization. The digital technology will be easier and faster.

Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (From Digital Cadastre)
Five	Cadastre 2014 will be highly privatized! Public and private sector are working closely together! 	Cadastre 2014 will be Public Corporations. Public –Public and Public Private coordination will be there. Cadastre 2014 will be highly decentralized

Explanation: Public systems tend to be less flexible and customer oriented than private organizations; the private sector can help to improve the efficiency, flexibility and introduce innovative solutions while the public sector can concentrate on supervision and control.

Evaluation: There is not the direct involvement of private sectors for digital cadastre in Nepal; but for data modeling and system development, there is the involvement of private sectors. There is the provision of licensed surveyor in the in the Land (Survey and Measurement) Act, 1963. Our experience shows that some of the jobs like cadastral surveying, database preparation, information system development, software development, research works, and training works could be outsourced to the private sector. A robust quality control mechanism should be introduced for the works carried out by private sectors. The public sector could involve for adjudication, land registration, land ownership distribution and boundary dispute resolution. In 2014, both public and private sectors will work together. There will be public-public or public-private co-ordination.

Observation: In my observation, the Cadastre 2014 will be public corporation rather than to be highly privatized. The private sectors will involve for various jobs like cadastral surveying, database preparation, information system development, software development, research works, and training works. There will be the direct involvement of local authority (Village Development Committee or Municipality) for operational works.

Statement	Cadastre 2014 (From Cadastre 2014 booklet)	Cadastre 2014 (From Digital Cadastre)
Six	Cadastre 2014 will be cost recovering! 	Cost sharing modality with local authority and private sectors

Explanation: Cost/benefit analysis will become an important aspect of cadastral reform projects and the considerable investments need to be justified. Cadastre 2014 will cover its running cost which is anyway to be covered by registration and transaction fees and contribute to a return of investment (ROI).

Evaluation: The financial matter is very much important for digital cadastre as the program is expensive in the beginning. It provides quality products and services and mainly focused for urban areas so the land owners will be ready to pay for the quality of products and services. The local authority and utilities company also need cadastral data hence through the cost sharing modality the program will be sustained.

Observation: In my observation, the Cadastre 2014 will be public corporation rather than to be highly privatized. Their will be involvement of local authority, private sectors and utility companies (Telecommunication, water supply, cable lines, gas supply etc.). The running costs, which are anyway to be covered by registration and transaction fees.

5. Conclusions

Due to the technological innovations and customer's need Cadastral Survey Branch under SD has initiated digital cadastre programme in urban areas where the value and price of land is very high. There are various ways for the evaluation of cadastral system or cadastral projects. In this paper the digital cadastre programme has been evaluated with the six vision statements of Cadastre 2014 report although the vision was developed focusing the future cadastral system of developed countries. Coming on the half of the way, the vision is very much relevant in the case of cadastral projects supported by ICT in developing countries too. From this, assessment it could be concluded that the digital cadastre programme run by Cadastral Survey Branch of Survey Department is one of the strategy of Survey Department for land tenure security and sustainable land management in Nepal.

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Obituary

All the officals of Survey Department pray to the Almighty for eternal peace to the departed soul of the following officals of the department and remembered them for their contribution towards the achievment of the goal of the department

1. Late Mr. Khadga Prasad Bhattarai, Surveyor
2. Late Mr. Ram Prasad Yadav, Team Leader
3. Late Mr. Ram Lakhan Chaudhari, Team Leader
4. Late Mr. Balaram Kumar Shrivastab, Kharidar
5. Late Mr.Batu Krishna Gautam, Amin
6. Late Mr. Indra Bahadur Shrestha, Amin

Papers Submitted at the
FIG Working Week 2007
Hong Kong SAR, China, 13-17 May 2007

Astronomy And Gravity Surveying In Nepal

Punya Prasad Oli
Former Director General

1. *Abstract*

Astronomical observations and gravity measurements were carried out in Nepal along the boundary since 1800. They are very important due to high deflection of verticals with irregular variation. It is also impractical to carry out precise levelling with conventional method due to large variation of relief at a short distance. Absolute gravity points are established in Siddharthanagar- Pokhara and Eastern part of Nepal in 1996 with micro gal accuracy. The gravity observations carried out on first order and some GPS stations. Gravity and astronomical observations are necessary in GNSS method of establishment of control points to compute orthometric (geoidal) heights.

Astronomical observations of points are useful to calculate deviation of verticals to determine the GPS heights, controlling the geodetic network and change in longitude, latitude and azimuth of control points and crustal and local dynamics. The fixed astronomical observatories are now used to determine the precise positioning of points.

Astronomical observations carried out in Nepal since the Prehistoric era. Chhatedhunga (stone hinges) are visible all over in hills of Nepal. The book Sumati Tantra" in 576-880 and "Sumati Shidhanta" written 1409 written and later in Sanskrit and Nepali. However, no modern survey records are available of astronomical and gravity observations for survey work before 1924.

The first survey of Nepal carried out astronomical and gravity observations in 1924-27 to produce 1=" 4 mile maps and in 1950-58 to produce 1"= 1 miles maps, were produced. Base line and astronomical observations carried out during boundary survey 1960-61. After establishment of Geodetic and Astronomical Branch on Survey Department, modern astronomical observations were carried out using astronomical theodolites like Wild T4, DKM3 /Circum Zenithal manually to determine the latitude, longitude, azimuth and deviation of verticals in 1970-90. Geodetic astronomy will be used in future to determine deviation of verticals to determine precise height, geoidal spheroidal separation and cm or better height determination. Geodetic total station, digital imaging sensor, GPS for timing and determination of geodetic coordinates, and personal computer will be used in the field.

Gravimetry will be extensively used in determination precise coordinate, geopotential datum instead of mean sea level and geoidal spheroidal separation. The absolute and relative gravimeters using digital technology are available of mgals (1 mgal= 3.25 mm of height) precision. Nepal is facing same problem of lack of dense control points point with required accuracy as in 1970s where topographical control points with accuracy of 2-18 m and at 25 Km interval and lack of surveyors and draftsmen. The 0.5 -1m accurate and at about 1 Km distance plannimetric control points was the requirement of that time for cadastral mapping. The plannimetric and height control points of cm accuracy and at about 5 Km distance for digital mapping, and environmental and infrastructural development works, and survey graduates to operate the modern automatic instruments and technologies are the requirement of present time.
It is recommended that the survey Department conduct study to strengthen the Nagarkot observatory and first and second order control networks and provide cm accuracy control points on urban areas, and level network on Himalayan Region.

2. Definition of Terms

Astronomical observation

Astronomical observation are the observations of celestial bodies to determine azimuth, deviation of verticals, figure of earth, correction of coordinates and observation for astronomical events.

Equipotential Surface

Equipotential Surface is the surface where the gravitational potential is same along the surface, which is also called levelled surface.

Deviation of verticals

Deviation of verticals at any point on ground is the angle between plumb lines and spheroidal normal.

GNSS (Global Navigation Satellite System)

GNSS (Global Navigation Satellite System) is the methods of determination of spheroidal coordinates using navigational satellites of systems like GPS, Glonass. These points may be continuously observed Receiver (COR) or accurately fixed points repeated every 5/10 years.

Gravimetry

Gravimetry is branch of geodesy where acceleration due to gravity(g) at different points on/over the earth surface is measured to study the shape/form of the earth, distribution of density within it and its external gravity field and to determine equipotential surface.

Geoidal- spheroidal separation (N)

Geoidal- spheroidal separation (N) is difference of height between geoid and reference spheroid surface at point measured along the plumb line.

3. Background

Nepal is situated on the slope of Himalayas where elevation varies 60 m to 8850m at short distance. There are few roads and deviation of vertical varies from -21" at Bhadrapur, Jhapa, to -43" at Nagarkot and -70" at Siranchok. The geoidal - spheroidal separation varies from 12 m at Sandakphu (Ilam), 0 m at Nagarkot and to - 21 m at Nepalganj. It is also difficult to carry out precise spirit levelling in northern part of Nepal. Therefore, it is required to be carried out either by trigonometrical or GPS levelling along with Astro-geodetic and gravimetric observations. The nearest sea shore of Bay of Bengal is more than 850 km in foreign countries. The elevations in Nepal are based on the 1930 mean sea level of Bay of Bengal. It is required to convert the mean sea level datum to equipotential datum surface in Nepal.

The equipotential surfaces are also not parallel/variation of gravity to each other due to isostasy, where the thicker crust and Moho (rocks) varies in thickness 20-47 km below the surface of Nepal.

The India plate is colliding with Eurasian plate 20 Km below the Himalaya at northern part of Nepal and it is approaching each other at the speed of 18 mm/year at north- east direction and rising 10mm/year. The other southern parts are changing with various degrees of movement and height is rising 2 mm and 4 mm per at tarai and hill respectively. Some places are also sinking due to geological or human activities.
The control points established and coordinated for surveying and mapping are being used for development purposes. Their accuracy and the status (rate of movement) are needed to verify and required to reobserve to achieve the required accuracy. It is very critical for large scale construction and scientific purposes. There are also lacks of awareness on accuracy requirement and importance of these points to public and surveyors.

During mapping and crystal dynamics study, gravity observations were made at first order (Trigonometrical, some spirit levelling and GPS) control points. Absolute gravity points were established Bhairahawa - Pokhara and eastward. The astronomical observations were made on control points in hill and tarai. It is also required to establish along Himalayan and north of Himalayan regions.

The control points mostly established 1970- 2000, which may have moved more than decimetres and will not be sufficient for precise mapping and development works. The educational situation is also changing. There will be lack of educated and trained staffs to handle the recent development of surveying and mapping technologies.

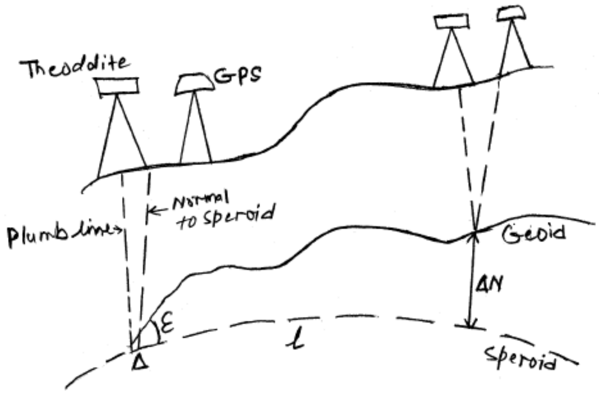
4. Introduction

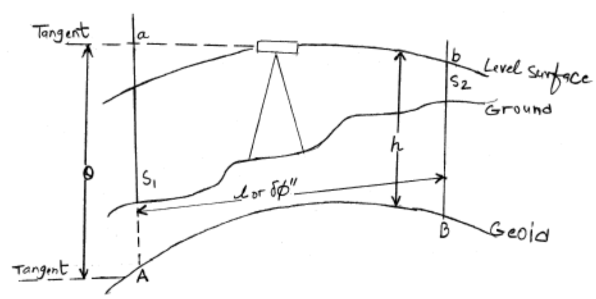
Most of geodetic control data required as control points of surveying and mapping, planning and implementation of development activities. Present and future surveying and mapping will be creation of accurate spatial data (digital maps) for development and GIS. Therefore, control points are required of cm accuracy. Earlier decimetre or 1m accurate 4^{th} order points are longer useful to surveying and mapping for development works. The trigonometrical control points are also not available on most of the urban areas and tarai areas, where development activities are taking place at greater speed. The control points/ land surfaces are also moving at different rate and points are also destroyed by development and other activities. The heights of trigonometrical control points need to be accurately measured. Therefore, it is high time the Geodetic Survey Branch should establish or re-observe all 1^{st}, 2^{nd} and 3^{rd} order trigonometrical control points using GPS with appropriate gravimetric/astronomical observations. All GPS control points data be available to development projects including established by National Geographical Information Infrastructure Project.

Geodetic control points are generally established with GNSS (Global Navigation Satellite System e.g. GPS) or conventional methods. Bench Marks established using precise spirit levelling along the roads. Combining GPS with gravimetric observations or spirit levelling will also be used for precise levelling about 5 Km intervals. The coordinates (WGS84) obtained from GNSS are spheroidal coordinates and are required to convert geoidal/ orthometric heights and national coordinates system.

Astronomical observations will be carried out to observe azimuth and deviations of verticals i.e. deflection plumb line at that place. The latitude and longitude and polar motion will be better determined by GPS continuously Operating Receiver (COR), which are generally maintained at 100- 500 Km interval.

Gravity observations are required to observe at every BM (2 Km) in mountain and 5-10 Km interval in tarai with accuracy of ±0.1 m gal. Equipotential surface or equal gravity surface may not be parallel to each other that depends inner structure of rock. The geoid /orthometric height difference be define as following.





$$\delta o = \delta h + \theta l = \delta h - \frac{hl}{g}\left(\frac{dym}{dl}\right)$$

where δh = diff. of staff readings

δo = diff. of orthometric height,

$$\theta = -\frac{h}{g}\left(\frac{dgm}{dl}\right) = \frac{Bb - Ab}{AB} = \frac{diff.equipotatialsuface}{dis\tan cebetweentwostaff}$$

$$g - 1/h - 978.032\,(1-0.0053\sin^2\phi - \frac{2h}{R})\ \text{gal} \quad \text{------------- (1)}$$

$$g - 1/h - 978.03184558(1-0.00530236\sin^2\phi+5.850*10^{-6}\sin^2 2\phi-3.2*10^{-8}\sin^2\phi.\sin^2 2\phi) \qquad (1a)$$

Where l = length is between to staffs

g − geopotential or gravity at a point,

R − mean radius of earth

h, ϕ − height and latitude of the point respectively.

The deviation of verticals also affects the vertical angle, as following,

$$\Delta N = NB - NA = \frac{1}{2}(\psi A'' + \psi B'')l \sin l'' \ldots\ldots\ldots.2$$

$$\psi = -(n\sin A + \xi\cos A)$$

Where η, ξ deviation of verticals obtained from astronomical observation.

A− Azimuth

ΔN is error in height due to deviation of verticals.

$$\varepsilon^2 = \eta^2 + \xi^2$$

$$\Delta N = l*\tan\varepsilon\,, \qquad (3)$$

Where l is distance between points.

5. Historical Background

5.1. Astronomical observation

Astronomical observations were carried out in Nepal since prehistoric era. Stone hinges (Chhatedhungas) are visible from Memeng, Sikkim border, Chhatedhunga, Dolphu, Mugu and west ward. The books "Sumati Tantra" in 576-880, "Sumati Siddhanta" and "Bhaswati" were translated in Nepali language 1496-1845 and various books were written in Sanskrit/Nepali after unification of Nepal 1793. However, records of modern astronomical surveying are not available before 1924.

Earlier astronomical works were mostly used for determination of azimuth by sun/star or Polaris observations. Availability of good Theodolites, latitude, longitude, azimuth and deviation of verticals were observed.

Latitude, longitude, azimuth and baseline were observed at Kathmandu valley and azimuths were cheeked during 1924-27, and at 25-30 stations during 1950- 58 survey to compile 1"- 1mile maps of Nepal.

Systematic astronomical observations were carried out after establishment of Geodetic Survey Branch (then, Trigonometrical Survey Branch) in 1968. The astronomical observations for azimuth and deviation of verticals carried out, at Nagarkot and other 6 stations during 1971/72&1976/77 with the cooperation of Czechoslovakia survey team. The observation for , azimuth and deviation of verticals were observed other 35 statious during 1981-84 with cooperation 19th Squadron of British Army.

The astronomical observatory, fundamental stations were established in 1972 and circum Zenithal instrument was set up in 1977 and observations were made for Polar motion at Mahadev Pokhari. Various astronomical events were observed since than. However, GPS superseded astronomical observations for establishment of control points and crustal dynamics in 1992 on word. Astronomical observations will continued to be important for precise determination of coordinates, and deviation on of verticals.

5.2 Gravity observation

Precise gravity data are necessary to adjust any precise survey measurements like levelling, GPS or study of geology. The gravity observation was carried out during Great Triangulation of India in 1800-40 with precise pendulum observations to the stations on or near the boundary and the study of Gulatee in Eastern Nepal in 1852. Gravity Division was established in 1980 and gravity measurement were made on BMs.

The gravity observations were carried out at the trig. Stations and on some bench marks during the High Trig. Survey works in 1981-84 using La Coste Romberg and Warden Gravimeters.

Absolute gravity data was transferred to Gauchar (Tribhuwan) Airport from Bangkok in 1970. It was strengthened in 1990.

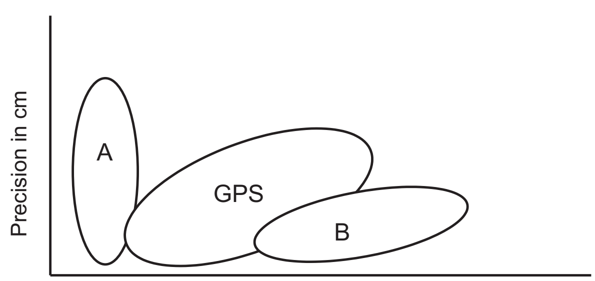
The gravity observations to milli-gal accuracy were observed in most of the first order GPS stations, crustal dynamic study and some other 2nd order GPS control stations in 1992-96 to provide control points for topographic mapping. It was also observed during the crustal dynamic study in 1990-2004 with the assistance of Colorado University.

Dept. of Mines and Geology is also conducting various types of gravimetric survey for prospecting mineral resources and seismic study since 1971 with or without assistance of friendly countries.

The absolute gravity stations at Kodari, Kathmandu, Sim Bhanjhyang , Mahadev Pokhari, Simraha, Biratnagar, Bairahawa and Tansen (8 stations) were established with the assistance of National Geodetic Survey , USA with few micro gal accuracy in 1996 using JILAG 6 Gravimeter. Western part of the country could not be observed due to lack of bridges along the highway and time constrain.

6. Present status of Technology

Precision Requirement and Methods



A= Terrestrial Method
B= VLBI/SLR

6.1 Astronomy

The present situation of Astro-geodetic surveying in developed country is as following:

Determination of deviation of verticals is the main tasks of geodetic astronomy and astronomical theodolite is replaced by digital technique such as total station/ astrolabe, charged couple devices (CCD) sensors, GPS receiver as an atomic clock and instrument to determine geodetic coordinates and computer in the field. The operations are more or less automatic. Crustal dynamics, polar motion, etc are determined by GPS observations. The regions, like Himalayan with high deviations of verticals and variation coordinates need to study for deviation of verticals at a closer interval.

The astronomy used to determine deviation of verticals, precise levelling, and cm level coordinates with gravity data in mountainous area, geophysical prospecting, validation of gravimetric modelling and GPS and gravimetric heights, precise (0.1 mm) geoidal height, astronomical positioning at sea. Fixed telescopes, space telescopes, satellites or probes carry out the study of solar system and deep space.

The instruments and techniques used in astro-geodetic works and accuracy achievable are as following as described by Christian Hirt, Hanover, Germany and Beat Burki, Zurich, Switzerland in 2006:

i) Geodetic coordinates (f,l) are easily determined by GPS on related reference spheroid. The differential positioning techniques will give coordinates (f,l,H) in some centimetres accuracy (milli arc second, mas).
ii) Star catalogues: - The 1-mas -Hypparcos star catalogue is available. The highly densified catalogue of couple of millions stars Tycho-2 and UCOC were compiled. Their accuracy level is of 0."2- 0."1. In coming 10 years time, micro arc second accuracy catalogue will be available.
iii) Image coordinates (x, y):- The digital image acquired by CCD sensors is highly sensitive and applied digital image processing. The accuracy of single pointing of star and computation will be about 0."2- 0."4 within 20 minutes observations.
iv) Refraction: - The error due to unknown factors of atmospheric refraction is yet being studied. The zenith atmospheric refraction on flat area is about 0.01" and 0."1 in mountain areas.
v) Timing: - The accurate timing will be provided by GPS, which is done synchronizing with GPS time scale and transferring to astronomical observations. The accuracy will be microsecond to nanosecond depending on the transfer device.
vi) Tilt Measurement: - The levelling of instrument is done by electronic level (tilt sensor) which has sensitivity of 0."04 - 0."05.

Gyroscopes are also developing to required accuracy.

6.2. Gravimetry:

Gravimetry along with GPS will bring the coordinates to the ground surface or geoids surface. Absolute gravimeters are miniaturized and in portable sized and weights. The accuracy of ±1 mgal could be achieved using gravimeters like potable La Coste - Romberg gravimeters. The Relative gravimeters have also improved their accuracy better than mgal to tens of m gal. The air borne or satellites borne gravimeters are also used for mineral study and global geoidal observations. Developed countries are planning to use gravimetric geoid based vertical datum like USA, Canada planning to switch gravimetric based vertical datum in 2012. Most of the developed countries are planning to establish control points 1 cm accuracy using GPS and gravimetric observations. So, it is developing very fast and software of various gravimeters are also available in the market.

7. Present Situation in Nepal

7.1. Astronomy

The astronomical instrument - Kern DKM3 are being used in Geodetic Branch. Circum Zenithal instruments are no longer used which may be used with CCD sensors, GPS and computer. Ministry Environment, science & Technology also installed 42 cm Mead Telescope at Mahadev Pokhari.

7.2. Gravimetry

Geodetic Survey Branch has Worden Gravity Meters of accuracy ± 10 m gal? and trained operators and one researcher. Similarly Dept. of Mines and geology has some instruments.

It will require one absolute portable gravimeter and relative gravimeters for observation on BMs at 2 Km interval in hill and 10 Km intervals in tarai area or as per the method establishment of control points. The branch is also required to assist graduate level courses in gravimetry observation training and education.

Education in astrometry (geodetic astronomy) and facilities are non-existence. The training materials accession and book are also not available in the market. There are few persons who can carry out the astronomical observations.

8. Future courses of actions

The digital mapping, and planning and development activities necessitated precise control point of 1cm accuracy x, y, height, which can only be provided by knowing deviation of verticals, gravimetry or precise levelling. The Geodetic Survey Branch should study the available technology and carryout the re-observation of Ist & 2nd order control points and established new accurate control points on 100 or so urbane areas of Nepal. The following actions should be taken for the development of astronomical and gravity observation:

8.1 Astronomical observation

i) Deviations of verticals should be observed in hill and mountain stations after studying requirements and available technologies and their suitability.
ii) An observatory is established to study solar system and deep space to a suitable location north of the Himalayas.
iii) Geoidal spheroidal separation to be determined in tarai and valleys 5-10 km interval using GPS and precise levelling.
iv) Survey Training and education be reform to cater the needs of astronomical and gravimetric observations.

8.2. Gravimetry

i) Gravimetric observation covering the whole country is carried out after studying the available technology, geoidal shape of the country and requirement precise and accurate plan and height control points. Possibly a set of absolute gravimeter and new sets of relative gravimeters may require carrying out the works.
ii) The vertical datum of Nepal, 1930 mean sea level of Bay of Bengal is re-defined by gravimetric datum from new observations.
iii) The absolute gravity stations also be established western and northern part of country.
iv) The branch should publish at regular interval the geoidal spheroidal separation maps /data of Nepal.

9. Recommendation

Lot of works carried out in Nepal on astronomical and gravimetric observations with or without assistance foreign donors. The technology is developing and younger educated surveyors//researchers are also needed and cater the need of modern technologies. The astronomical and gravimetric activities should lead to cater the needs of national and societal services.

The meter accuracy control points are no longer useful to digital mapping and development works of urban and rural areas. Therefore, the branch should study and direct it activities to cater the needs of development activities.

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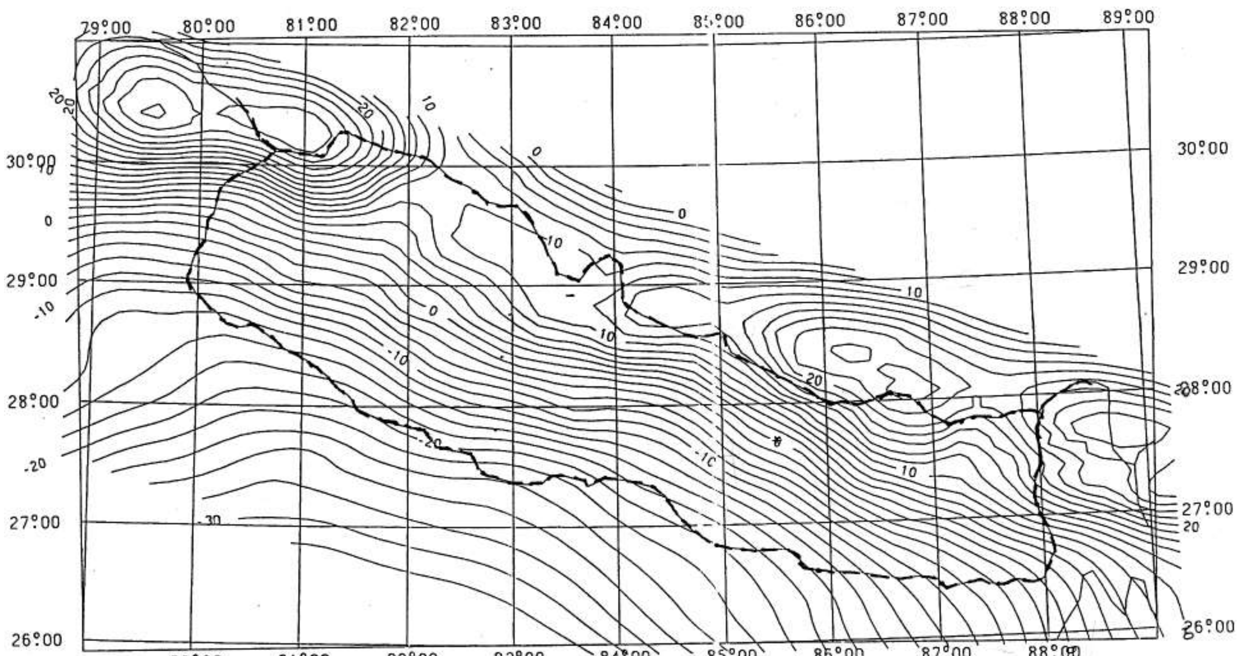
Nepal Datum Everest Spheroid- Deflection of the Verticals

Nepal Station Ref.	Station Name (*Denotes a former Survey of India station)	Nepal Datum Everest Spheroid 1830, Preliminary geodetic position		Deflection of the verticals		Geoidal Spheroidal separation N	India MSL elevation (L=leveled value)	Remarks
		Latitude N	Longitude E					
		° ' "	° ' "	Meridian " ξ	Prime vertical. " η	m	m	
	Bhadrapur Doppler 31348	26.5482	88.0906	-13.9	-15.9	3	86.84L	
	Harkate	26.8319	88.0893	-44	-12 Est.(±5")	8	1839.4	
	*Sandakphu	27.1033	88.0006	-46.4	-14.4	12	3631.6	
	Mainachuli	26.6912	87.8275	-32	-18 Est.(±5")	3	652.2	
	Batase Danda	26.9797	87.7058	-42	-25 Est.(±5")	6	2271.8	
11/166	Tinjure Danda	27.1785	87.4539	-36.8	-16.5	7	3033.0	
4/172	Dhaje (Doppler 31343)	26.8658	87.3948	-42.8	-23.7	0	2047.6	
	Biratnagar TWR, S leg	26.4611	87.2887	-15.4	-18.9	-3	73.31L	
1/171	Bopung sokope	26.9501	86.9482	-42	-20 Est.(±5")	-3	1782.1	
1/165	*Laore Danda	27.3722	86.9224	-48.9	-17.7	6	3619.6	
	Rajbiraj Doppler 31349	26.5452	86.751	-18	-20 Est. (±3")	-7	71.7	
2/171	*Chitretham	27.0201	86.6166	-38	-18 Est. (±3")	-4	2344.4	
1/164	Dimba (Doppler 31356)	27.4651	86.3661	**-48.6**	**-42.5**	4	3356.3	
2/164	Rachnetham Danda	27.1172	86.3051	-42	-25 Est. (±5")	-5	2212.5	
	Siraha Astro. stn	26.6594	86.2182	-15.1	-21.4	-11	77.8	
3/164	Lendrungchuli	27.2233	86.0338	-44	-28 Est. (±5")	-5	1898.5	
12/163	Bag Dhunga	27.5613	85.9766	-43.7	-33.1	2	3149.1	
	Janakpur Doppler 31350	26.7103	85.9269	-10	-22 Est. (±3")	-12	70.09	
13/163	Hatiyal danda	27.4348	85.5971	-47.3	-28.1	-5	2631.4	
	Malangawa astro STN	26.8634	85.5721	-11.3	-25.9	-13	82.33L	
12/157	*Nagarkot (pillar)	27.692	85.5223	-37.0	-21.6	0	2165.32	
19/108	Gairikhop danda	27.1977	85.399	-37	-25 Est. (±3")	-12	866.5	

1/108	Burichour danda	27.5104	85.1627	**-50.1**	**-32.6**	-9	2505.4	
4/102	*Kumari	27.8089	85.1412	-32	-28.2	-3	2070.1	
	Birganj M/W TWR, center	27.014	84.8811	-13	-13 Est. (±3")	-17	82.14L	
1/107	Chaure danda	27.4411	84.8124	-36.5	-23.8	-12	725.1	
1/101	Sirai chuli	27.7621	84.6335	-40.9	-34.2	-8	1945.2	
1/095	Siranchok danda	28.0837	84.6031	**-61.9**	**-33.6**	-2	1972.6	
1/094	Thaprek (Doppler 31342)	28.0837	84.1873	-48.9	-8.2	-2	1281.6	
16/100	*Deochuli	27.7673	84.1819	-43.7	-12.7	-10	1933.4	
	Mandarthan	27.4954	83.8999	-29.6	-22 Est. (±5")	-16	834.2	
20/093	Thumko ko juro	28.1448	83.7665	-53.7	-5.6	3	2266.5	
3/099	Huwakot	27.7648	83.6069	-50.1	-17.7	-13	1845.4	
	Bhairawa Doppler 31352	27.5072	83.5868	-28.6	-14.9	-18	103.83L	
1/092	Ghumti pahad	28.2479	83.3903	-63.8	-11.0	0	3163.2	
13/098	Masina ko lekh	27.8912	83.1651	-51.5	-11.3	-11	2275.3	
1/091	Siulabang	28.3598	82.9565	-57.4	-27.8	1	3626.9	
1/085	Chaitidhuri	28.4952	82.6425	-32.3	-31.6	0	3052.5	
2/091	Ranja (Doppler 31344)	28.0624	82.5751	-46.7	-26.1	-11	1707.1	
1/030	Ghartigara	28.6778	82.262	-39.9	-39.3	0	1871.4	
1/036	Nigalchula	28.3395	82.0547	**-44.8**	**-37.9**	-12	2408.6	
1/029	*Katti	28.7199	81.8167	-37.2	-41.5	-7	2791.5	
	Nepalganj (Doppler 31347)	28.134	81.5766	-20.1	-17.0	-21	143.2	
2/028	*Banspani	28.5405	81.4772	-35.1	-30.0	-15	1586.4	
2/022	Banskando	28.9918	81.3368	-36.3	-22.2	-9	2252.3	
3/028	Naulakot	28.7268	81.1668	-39.5	-25.4	-15	1554.8	
1/027	Pandon	28.8797	80.9633	-40.7	-22.9	-15	1775.1	
	Dhangadhi (Doppler 31345)	28.7055	80.591	24.9	-14.8	-20	172.6	
1992-96 Topographical Survey 1st order Control Points								
WN 131		28.59121	84.64078			7.6	3558.75	
128		28.64125	84.09138			7.7	3381.12	
127		29.18236	83.96167			4.1	3809.44	
124		28.78073	83.72463			5.7	2736.4	
121		28.4917	83.3369			-1.3	2037.33	
120		28.87196	83.31327			6	3965.13	
118		29.45013	83.1819			4.8	3900.91	
115		28.98551	82.82122			2.1	2502.88	
109		29.12114	82.59108			2.2	3034.77	
107		29.58162	82.45611			4.4	2964.88	
103		29.53918	82.08211			1.5	2979.05	

100		29.08186	82.08726			7.4	3048.16	
98		29.14113	81.72046			-5.1	3072.23	
95		29.50333	81.67016			0.4	1404.45	
92		29.97096	81.48756			9.7	2970.86	
88		29.75318	81.28777			10.1	2533.9	
83		30.1341	80.98216			23	3625.76	
81		29.84403	80.54292			6.4	886.3	
79		28.45469	82.62003			-11.3	2545.63	
EN 1/75	Chhekampar	28.4889	85.0538			7.3	3016.46	
8	Kyangjin	28.2114	85.5694			15	3857	
12	Lapche Gau	28.12	86.1656			19.8	3867.39	
19	Namche	27.7692	86.7168			19.4	3554.51	
26	Subhangdanda	27.5528	87.3389			17.1	2007.9	
28	Tinjure Danda	27.2131	87.4711			10.9	2786.68	
41	Lamosangu	27.7403	85.8214			3.6	1380.37	
42	Jiri	27.6353	86.2328			8.4	1918.95	
131	Ghunsa	27.6594	87.9353			21.4	3407.31	

Map No. 1



NB. 1. Nagarkot as datum

2. Contour v i. (Spheroidal -geoidal separation) is 2m

3. International Boundary Approximate

Cadastre In Nepal: Past And Present

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Keywords: *Cadastre, Land administration, Land information system, History, Land ownership*

Abstract

The history of land recording system is very old in Nepal. Though, the administration of land was mentioned in ancient history, it became institutionalized since Lichhabi era. There was the provision of village panchali for the administration and management of land at village level. Many improvements like classification of lands, specification for land measurements, provision measurement units (as hale, pate, kute, kodale etc.), development of special profession for land survey and measurement (Dangol), land adjudication and boundary description of land etc. were made during Malla era. Later, the cadastral maps were also realized as an important component for land administration. The chain survey method was introduced to prepare cadastral maps. Systemic Cadastral Survey was started after the land reform programme in 2021 B.S. In the beginning, the cadastral survey was done in free sheet connecting with local points. 38 out of 75 districts were surveyed on local base point where as 37 districts were surveyed with the control points connected to the National geodetic network. The primary focus of cadastral surveying was fiscal purpose to generate revenue from land tax. Later, the legal cadastre system was developed as it provides more land tenure security to the land owners. Now the concept of multi-purpose cadastre is emerging. There are nine Survey Goswaras & a Survey office under Cadastral Survey Branch for cadastral surveying of different districts. Digital technology has been introduced for re-cadastral mapping from 2062 B.S. in Banepa Municipality.

In this paper an attempt has made to review the cadastral system of Nepal from historical perspectives. This paper starts with introduction and describes about the historical context of land recording and cadastral surveying in Nepal. It then elaborates the institutions involved for the cadastral surveying in Nepal. The future vision of cadastral system is also described in this paper. Finally, it concludes with some concluding remarks.

1. Background

The history of land recording system is very old in Nepal. In ancient times, land revenue was possibly the only source from which the entire income of the Government was derived. The tax on land proved to be the primary source of the state's wealth. The land administration was one of the tools for ruler to govern the people. Various institutions were evolved and methodologies were changed for the administration of land. The spatial component of land administration was also found important for the accurate delineation of boundary and the cadastral survey was begun in Nepal. Since then, many evolutions occurred in the field of cadastre in Nepal. The evolution occurs in techniques, tools and professional. Major evolution occurs after the establishment of Survey Department in 2014 B.S. We have completed the cadastral surveying of whole country leaving some village block areas and governmental land. The digital technology is also introduced for cadastral surveying and preparation of cadastral database. This year, Survey Department is celebrating its golden jubilee. This is the right time to review our cadastral and land registration system. In this paper, an attempt has made to review the cadastre in Nepal from historical perspectives.

2. Historical context of cadastre in nepal

The history of land administration in Nepal evolves a long history. The cadastral surveying was used as a tool for the measurement of land parcel since beginning. From historical perspectives, it could be categorized into the following three historical periods as: Ancient Period, Middle Period, Modern period.

2.1 Ancient Period (Before 13th century)

Nepal has its long history on land administration from Vaidic period. The land was taken as the property of the state in ancient time. It is clearly mentioned in the various ancient books like *Artharbed, Manusmriti, Ramayan, Mahabharat and Kautaliy's* economics. The state charged taxes on the land to generate revenue. The administration and management of land was the main concern for the government. The description about the management of land is described in various ancient books. Though the history of land recording is very old in Nepal it has been institutionalized during *Lichhabi* era (13th century) ((DoLRM, 2003). The land administration was done by *Village Panchali* in Lichchhabi era. The word panchali is made from the combination of two words Pancha plus Ali and the Ali means boundary. Panchali was the territory boundary of that local level administrative unit of that community. There are many evidences of grant lands being recorded during Lichchhabi era. In those days cadastral survey was in the form of description (shresta & lekhot) for collecting land tax from the land users.

2.2 Middle Period:

The middle historical period includes the time between 18th, 19th and some periods of 20th century. A lot of improvement was done in this period for the improvement of land administration. The important of cadastral survey for the management of land was realized and introduced in this period. The main Cadastral Surveying (Napi) in this period is described in this section.

2.2.1 Preliminary Survey

The preliminary survey began at the end of 18th century. The land was categorized and granted to the public servants as an annual remuneration. King Jayasthiti Malla (1323-1385) made some efforts on land related activities like classification of lands and specification for land measurements (Paudyal, 2005). He had classified the land in four types. The technician who measure & make sketch of land was named as "*Chhetrakar"* and who measure & make sketch of the house was named as "Tachhakar". King Ram Shaha (1606- 1636) introduced land adjudication and boundary description system on land. The unit of measurement of land was defined as *hale*[1], *pate*[2], *kute*[3], *kodale*[4] , etc. The chain and laggi of 10.5 *hat*[5] and 9 hat was used as a standard tool for the measurement of land (Shrestha, 2038 B.S.). Similarly Prithivi Narayan Shah (1723-1775) introduced land recording system for tax purpose and established tax collectors and land recorders in district level (Shah, 2000).

2.2.2 Dangol Survey

A special profession "Dongol" was formed to perform the cadastral surveying in Kathmandu valley. Dongols were the famous technician having great interest for land survey and measurement of those days. They performed eye sketch survey (Dekh jacha napi) to prepare cadastral records. Later, they also involved for surveying of hilly areas and got success. In hilly areas, it called mahajach and boundary of land was recorded as verbal description.

2.2.3 Sarpat Survey

This Sarpat Napi was introduced by Prime Minister Bir Samsher JBR in 1952. The word Sarpat means chain. The standard length of chain was used in Sarpat Napi. This

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1. **The person who had one pair of oxen had to pay the land tax in hale system. Hale is the unit of land. The land which one pair of oxen could plough in a day is equivalent to one hale unit of land.**
2. **The person who had only one ox needed to share with another person's ox to make pair. He had to pay the land tax in pate system. One pate land is also equal to the land which one pair of oxen could plough in a day.**
3. **The land equal to a person could dig in a day with kuto**
4. **The land equal to a person could dig in a day with kodalo**
5. **One hat is equal to 1.5 feet (approx.)**

survey was conducted by a specially trained person. In terai region, they were called *Munsif*. The unit of the measurement was defined as Ropani-Ana in valley areas, Muri-Pathi in Hills areas and Bigha-Kattha in terai areas.

2.2.4 Compase Survey

This Compase Napi was introduced by Nepalese Army. After returning from the First World War, the Nepalese army (gurkhas) gained some knowledge on surveying and mapping and the important of maps for military strategy. A military compass school was established to train their staffs for surveying and mapping. The trainees were called compase. The First cadastral map was prepared in 1980 B.S using compass and magnet in Bhaktapur district. The plane tabling method was first introduced in Nepal for cadastral surveying. The work was headed by Colonel Ganesh Bahadur Basnet. Moths and Atsatta were prepared as attribute information for the description of land parcel. Later, the school was renamed as Nepal Government Survey Goshwara. In 1996, a great cadastral survey program was launched and to assist the programme, Amin Training School was established under army office at Sundhara, Kathmandu in 1997. This program was run for three years and then stopped (Acharya and Sharma, 2007)

2.3 Modern Period

The modern period of cadastral survey began after the termination of rana regime and changed in the political scenario in Nepal. The Bhumi Jach Commission, 2008, Royal Land Reform Commission, 2009, Land Act 2014, Birta Unmulan Act, 2016 etc. were some of the initiatives during interim government period. Survey Department and Malpot Department were established under Ministry of Finance in 2014 B.S. The Survey and Measurement Act was introduced in 2019 B.S. The sporadic and optional nature of cadastral and land registration system changed into systematic cadastral survey and compulsory land registration system. The fiscal cadastre gradually changed into legal cadastre and moved towards the concept of multi purpose cadastre. Due to the advancement of technology, the chain and sight rule are replaced by plane table and telescopic alidade. Later, modern equipments, like, EDM, Total station and GPS instruments are introduced for the cadastral surveying. According to the methodology, the cadastral surveying could be categorized into four types in modern period.

2.3.1 Cadastral Survey with local control points

In the beginning, the cadastral survey was sporadic in nature. Survey Department was brought under Ministry of Land Reform Management to support Land Reform Programme (land ceiling and land taxation). Initially, the cadastral survey was carried out with local control system and this system was applied for 38 districts. The maps thus produced are termed as island maps. Mainly, Plane tabling methodology with chain was used to prepare cadastral maps.

2.3.2 Cadastral Survey with national geodetic control points

After the establishment of Trigonometrical Survey Branch in 2026 B.S., cadastral survey was commenced based on national geodetic control points. In 2039 B.S. Cadastral Survey Branch under Survey Department was established to monitor and supervise Survey Goswara and cadastral survey activities. There are total 37 districts having cadastral maps based on national geodetic control networks. The GPS technology is also introduced for cadastral surveying (Adhikary, 2002).The cadastral survey was only focused for mapping of cultivated areas. The first round (Eaksaro) cadastral survey of whole country was finished in 2051 B.S. leaving of some village block areas, governmental lands. The government decided to resurvey on those remaining 38 districts that were not based on the national control network and the areas having high land value. At present, the resurvey is in progress mainly in 13 such districts in terai area (plain lands) including Kathmandu and Kaski. The resurvey of one district has been finished. Mainly, plane tabling methodology with telescopic alidade is used to prepare cadastral maps. The GPS technology is introduced for the establishment of control points.

2.3.3 Digital Cadastre

The digital technology has been introduced in 2062 B.S. to prepare cadastral database where the land value is very high. As a piloting, the programme has been initiated from Banepa Municipality. The field work of ward number six has been finished and the land registration work is in progress.

2.3.4 Village Block Cadastral Survey

In the beginning, the primary purpose of cadastral survey was to impose land ceiling based on the actual measurement on their land occupancy. In the village block areas, the size of the parcel was very small so they do not affect much on the land ceiling. Also, the technology at the time was inadequate for cadastral surveying in densely populated village block areas. Hence, the individual parcels of those areas were left unmapped during first round cadastral survey. Now, the Survey Department has realized that there is urgent need to prepare cadastral maps in village block areas. A working manual has been developed to complete the cadastral survey of village block areas in Nepal. Cadastral Survey Branch has given high priority to complete this task.

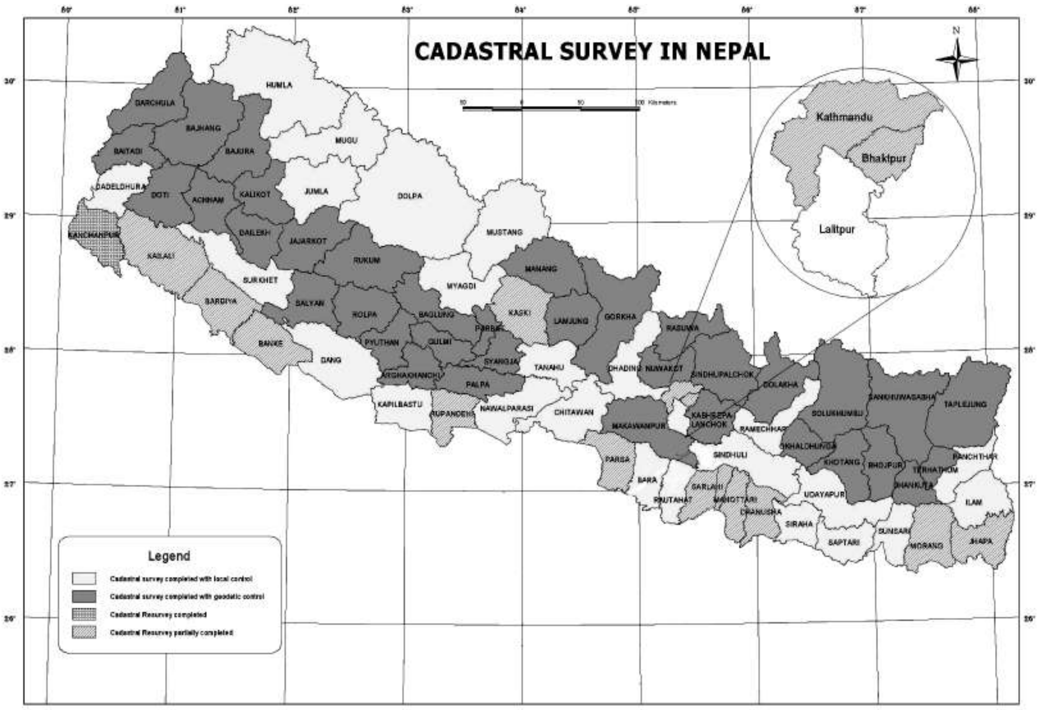

Fig1: Status of Cadastral Survey in Nepal

3. Institutions involved for cadastral surveying in nepal

The cadastral surveying was institutionalized after the establishment of Survey Department in 2014 B.S. In the beginning, there were four Survey Circles & two Chhoti Survey Goswaras under Survey Department to conduct cadastral surveying works of whole country. After that, Seven Survey Parties were established in 2017 B.S and made more responsible for cadastral surveying and initial land registration activities. After the enactment of Land (Survey and Measurement) Act in 2019 B.S., Survey Party was renamed as Survey Goswara. Maintenance Survey Section was established in 2022 B.S. There were four Regional Maintenance Survey Offices established at Biratnagar, Hetauda, Pokhara, Nepalgunj & one Regional Maintenance Office at Kathmandu which were dissolved in 2049 B.S. Eight Number Survey Goswara was established in 2032 B.S. and Nine Number Survey Goswara was established in 2033 B.S. In 2039 B.S. Cadastral Survey Branch under Survey Department was established to monitor and supervise Survey Goswara and cadastral survey activities From institutional perspectives, the cadastral surveying of Nepal could be categorized into two types; Cadastral Surveying performed by Survey Goswara and Cadastral Survey performed by Survey Offices.

3.1 Cadastral surveying by survey goswara

There are total nine Survey Goshwaras under Cadastral Survey Branch. A brief introduction with their activities has described in the following sections.

3.2 1 No. Survey Goswara:

This Goswara was established in 2021 B.S. It is located in Birgunj, Parsa district since 2053 B.S. This Goswara is charge of conducting re-cadastral survey of Parsa district as well as Bharatpur Municipality and village block areas of Chitwan district. It has handed over the land registers of 21 VDCs of Parsa district to District Land Revenue Office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Jhapa	2021	2023	In Free sheet
2	Morang	2023	2025	In Free sheet
3	Sunsari	2025	2027	This district is also surveyed by 7 No. S.G. from 2023-2025 B.S in free sheet
4	Udayapur	2028	2030	This district is also surveyed by 2 No. S.G. from 2028-2030 B.S in free sheet
5	Saptari	2030	2032	This district is also surveyed by 7 No. S.G. from 2025-2028 B.S. in free sheet
6	Dhankuta	2030	2032	In trig sheet
7	Teharathum	2032	2035	In trig sheet
8	Bhojpur	2035	2039	In trig sheet
9	Khotang	2039	2043	In trig sheet
10	Okhaldhunga	2043	2046	In trig sheet
11	Solukhumbu	2046	2053	In trig sheet

3.3 2 No. Survey Goswara:

This Goswara was established in 2021 B.S. It is located in Nepalgunj, Banke district since 2053 B.S. This Goswara is charge of conducting re-cadastral survey in Banke, Bardiya and Surkhet district. It has handed over the land registers of 22 VDCs of Banke & 11 VDCs of Bardiya district to District Land revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Bardiya	2021	2022	In free sheet
2	Bara	2022	2023	In free sheet
3	Siraha	2023	2025	In free sheet
4	Kapilbastu	2026	2028	This district is also surveyed by 5 No. S.G. in 2028 B.S. in free sheet
5	Udayapur	2028	2030	In free sheet
6	Kavrepalanchok	2032	2035	In trig sheet
7	Sindhupalanchok	2038	2048	In trig sheet
8	Rukum	2048	2053	In trig sheet

3.4 3 No. Survey Goswara:

This Goswara was established in 2021 B.S. It is located in Bhairahawa, Rupandehi district since 2055 B.S This Goswara is in charge of conducting re-cadastral survey of Rupandehi, Arghakhachi and Nawalparashi districts.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Kailali	2021	-	This district is also surveyed by 5 No. S.G. in 2030 B.S in free sheet
2	Kathmandu	2035	2038	This district is also surveyed by 7 No. S.G.from 2022-2023 B.S.in free sheet
3	Bhaktapur	2021	2023	In free sheet
4	Lalitpur	2037	-	This district is also surveyed by 7 No. S.G. from 2021-2023 B.S in free sheet
5	Banke	2023	2025	In free sheet
6	Kanchanpur	2024	2026	In free sheet
7	Chitwan	2026	2027	In free sheet
8	Ilam	2028	2030	In free sheet
9	Panchthar	2030	2032	In free sheet
10	Rasuwa	2034	2036	In trig sheet
11	Jumla	2049	2054	In free sheet

3.5 4 No. Survey Goswara:

This Goswara was established in 2021 B.S. It is located in Dhangadhi, Kailali district since 2053 B.S This Goswara is in charge of conducting re-cadastral survey of Dhangadhi and Tikapur Municipality. It has handed over the land registers of 10 VDCs of Kailali district to District Land Revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Rautahat	2021	2023	In free sheet
2	Sarlahi :	2023	2024	In free sheet
3	Mahottari	2024	2026	In free sheet
4	Dang	2026	2028	In free sheet
5	Tanahu:	2029	2032	In free sheet
6	Dhading	2032	2035	In free sheet
7	Doti:	2038	2045	In trig sheet
8	Darchula:	2039	2043	In trig sheet
9	Baitadi:	2038	2048	In trig sheet
10	Kalikot	2048	2054	In trig sheet

Note: this Goshwara was in Kanchanpur for "Resettlement (Basobas)" programme

3.6 5 No. Survey Goswara:

This Goswara was established in 2021 B.S. It is located in Malangawa, Sarlahi district since 2063 B.S. This Goswara has been shifted to Sarlahi district after the completion of re-cadastral survey of Kanchanpur district in 2062 B.S. It is also conducting re-cadastral survey of Mahottari, Sarlahi and Dhanusa districts

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Parsa	2021	2023	In free sheet
2	Dhanusa	2023	2026	In free sheet
3	Rupandehi	2025	2028	In free sheet
4	Surkhet	2028	2030	In free sheet
5	Palpa	2030	2036	In trig sheet
6	Salyan	2037	2040	In trig sheet
7	Argakhachi	2040	2042	In trig sheet
8	Achham	2043	2050	In trig sheet
9	Bajura	2049	2051	In trig sheet

Note: This Goswara was in Kapilbastu in 2028 B.S. to assist 2 No. S.G. and Kailali in 2030 B.S

3.7 6 No. Survey Goswara:

This Goswara was established in 2020 B.S. It is located in Kathmandu since 2053 B.S. This Goswara is in charge of conducting re-cadastral survey of Kathmandu and Bhaktapur (village block areas) districts. It has handed over the land registers of 5 VDCs of Kathmandu district and 3 wards of Kathmandu Metropolitan city to District Land Revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Nawalparasi	2020	2025	This district is also surveyed by 5 No,3 No,2 No. 4 No S.G. . in free sheet
2	Makwanpur	2028	2036	In trig sheet
3	Syanja	2036	2039	In trig sheet
4	Lamjung	2039	2044	In trig sheet
5	Manang	2044	2046	In trig sheet
6	Dolakha	2047	2052	In trig sheet

3.8 7 **No. Survey Goswara**

This Goswara was established in 2022 B.S. It is located in Chandragadhi, Jhapa district since 2052 B.S. This Goswara is in charge of conducting re-cadastral survey of Damak, Bhadrapur and Mechinagar Municipalities and other VDCs of Jhapa district. It has handed over the land registers of 15 VDCs of Jhapa district to District Land Revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Sunsari	2023	2025	This district is also surveyed by 1 No. S.G.from 2025-2027 B.S .in free sheet
2	Saptari	2025	2028	This district is also surveyed by 1 No. S.G.from 2027-2029 B.S. in free sheet
3	Sindhuli	2027	2030	In free sheet
4	Ramechhap	2030	2033	In free sheet
5	Nuwakot	2033	2037	In trig sheet
6	Gorakha	2038	2041	In trig sheet
7	Taplejung	2041	2046	In trig sheet
8	Sankhuwasabha	2046	2051	In trig sheet

3.9 8 No. Survey Goswara:

This Goswara was established in is B.S. It is located in Pokhara, Kaski district since 2059 B.S. This goswara was in Bardiya district from 2052- 2059 B.S for re-cadastral surveying. It has handed over the land registers of 7 wards of Pokhara sub-metropolitan city to District Land Revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Dadeldhura	2032	2034	In free sheet
2	Baglung	2034	2039	In trig sheet
3	Parwat	2039	2042	In trig sheet
4	Jajarkot	2042	2046	In trig sheet
5	Dailekh	2046	2052	In trig sheet

3.10 9 No. Survey Goswara

This Goswara was established in 2033 B.S. It is located in Biratnagar, Morang district since 2053 B.S. It has handed over the land registers of 9 VDCs of Morang district and 2 wards of Biratnagar sub-metropolitan city to District Land Revenue office after the completion of re- cadastral surveying and land registration.

The districts surveyed in first round cadastral survey (eksaro Kitta napi) by this Goshwara are:

S.N.	District	Year (B.S.)		Remarks
		From	To	
1	Kaski	2033	2036	In trig sheet
2	Gulmi	2036	2041	In trig sheet
3	Pyuthan	2041	2046	In trig sheet
4	Rolpa	2046	2053	In trig sheet

3.11 Cadastral surveying by survey offices

The importance of cadastral maps for land administration was realized by the then government and Survey Offices were established to complete the cadastral survey of whole country as soon as it could be possible. The cadastral surveying with national geodetic network was found time consuming. Hence, most of the cadastral surveying by these survey offices are based on local control networks. The organization structure of Survey Office was small in comparison to the Survey Goswaras. A brief introduction of these offices is described in the following section.

3.12 Survey Office Mustang

Survey Office Mustang was established in 2031 B.S. There were 23 VDC at the time of cadastral surveying in Mustang District. The district was completed within two years after the commencement of cadastral surveying in free sheet. The cultivated land of Mustang District is 6556 hect. and total land surveyed by this Survey Office is 11092 hect. There are 227 cadastral maps, 36470 land parcels and 3939 land owners according to the meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office are based on local control points.

3.13 Survey Office Myagdi

Survey Office Myagdi was established in 2033 B.S. There were 44 VDC at the time of cadastral surveying in Myagdi District. The district was completed within two years after the commencement of cadastral surveying in free sheet . The cultivated land of Mustang District is 19709 hect. and total land surveyed by this Survey Office is 30632 hect. There are 1302 cadastral maps, 136570 land parcels and land 25985 owners according to the meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office are based on local control points.

3.14 Survey Office Bajhang

Survey Office Bajhang was established in 2045 B.S. There were 47 VDC at the time of cadastral surveying in Bajhang District. The district was completed within nine years after the commencement of cadastral surveying in trig sheet. The cultivated land of Bajhang District is 29257 hect. and total land surveyed by this Survey Office is 161931 hect. There are 744 cadastral maps, 329344 land parcels and 25305 land owners according to the meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office are based on geodetic control network.

3.15 Survey Office Dolpa

Survey Office Dolpa was established in 2049-12-26 B.S. There were 23 VDC at the time of cadastral surveying in Dolpa District. The district was completed within six years after the commencement of cadastral surveying in free sheet. The cultivated land of Dolpa District is 7664 hect. and total land surveyed by this Survey Office is 9640 hect. There are 124219 land parcels and 6470 land owners according to the meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office are based on local control points.

3.16 Survey Office Mugu

Survey Office Mugu was established in 2050 B.S. There were 24 VDC at the time of cadastral surveying in Mugu District. The district was completed within three years after the commencement of cadastral surveying in free sheet. The cultivated land of Mugu District is 11347 hect. and total land surveyed by this Survey Office is 17001 hect. There are 253033 land parcels and 11190 land owners according to the meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office arebased on local control points.

3.17 Survey Office Humla

Survey Office Humla was established in 2050 B.S. There were 27 VDCs at the time of cadastral surveying in Humla District. The district was completed within three years after the commencement of cadastral surveying in free sheet. The cultivated land of Humla District is 9704 hect. And total land surveyed by this Survey Office is 12129 hect. There are 119690 land parcels and 12098 land owners according to the Meta data prepared by Cadastral Survey Branch. The cadastral maps prepared by this survey office are based on local control points.

3.18 Survey Office Banepa

Survey Office Banepa was established in 2063-05-05 B.S for the digital cadastral surveying in Banepa Municipality. The Nepalese Government has decided to conduct re cadastral surveying using digital technology as a piloting in Banepa Municipality on 2062-10-20. There are 11 wards in total and the cadastral surveying of ward number six has been completed. The digital cadastral database has been prepared and the land registration of ward numbers six as well as cadastral surveying of ward no five and eight is running this year.

4. Future vision for cadastral system in nepal

In this section, the future vision of Cadastral System is described. The future vision of cadastral Survey in Nepal is to develop parcel based cadastral information system for providing land tenure security and sustainable land management to achieve the goal of cadastre 2014 document. The followings will be the main activities for future cadastral system in Nepal.

4.1 Reengineering of Cadastral System

For Re-engineering of cadastral system for scientific administration, management and manipulation of land data, the following activities need to be initiated.

- Organizational restructuring of Cadastral Survey Branch
- Replacement of traditional cadastral system with digital technology
- Preparation and updating of cadastral maps and land related information using modern technology
- Digital service delivery to promote e-governance
- Geo-referencing of islands maps with high resolution imagery.
- Partnership and coordination with Municipality and Private Sectors for cadastral surveying and database preparation.
- Deployment of licensed surveyor for cadastral surveying and database preparation
- Refresher course and training programme for existing

staffs
- Development of parcel based nationwide cadastral information system
- Development of 3D Cadastre System
- Research and development in land related issues

5. Concluding remarks

In this paper, the history of cadastral survey has been described. From historical perspectives, the activities related to land recording and cadastral surveying is described in three historical periods; ancient period, middle period and modern period. The land administration activities were institutionalized since middle period of Nepal though it was initiated since Lichhabi era. The cadastral survey was sporadic in nature in the beginning. After the launched of land reform programme, the systematic cadastral survey began in Nepal. The first round cadastral survey has finished and the resurvey is in progress. Now, the cadastral Survey Branch has given emphasis for the completion of cadastral survey of village block areas and introducing of digital technology for cadastral surveying. This paper also proposed the future vision of cadastral system in Nepal.

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Customer satisfaction model and organisational strategies for Land Registration and Cadastral Systems

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Keywords: *Customer, registration, cadastre, organisation, satisfaction*

Abstract

Many land registration and cadastre offices have now tremendous pressures from various public and private sectors to improve their workflows of the systems for land registration and cadastral surveying including archiving historical documents of deeds/titles and maps. In this era of Information technology, the use of computers is seen as immediate solution for reengineering these systems and digital archiving. But the pressures have not only to do with the improvement of internal digital workflows and archiving but also to improve the customer satisfaction with the services and products offered by these digital systems.

Since the customer satisfaction and relationship are most important, it is argued that the customer satisfaction model should be an integral part of organizational strategy model to delivery efficient and effective services and products to the customer. Customer satisfaction model normally relates to the delivering superior relative perceived value, getting substantial base in the market and gaining profitability via scale economies. Moreover, the relationships with customers are strongly dependent with the roles that both organisation and customers have to play during interaction.

In this research paper, we discuss three issues on the customers and organisations relationships for the land registration and cadastral systems. First issue concentrates the elements of customer satisfaction model and second one on the perceived value. Last issue deals with how this model can be incorporated into an organisational strategy model that could be either a push strategy or a pull strategy of reengineering process.

Introduction

The main aim of this research paper is to summarize the main elements of the customer satisfaction that are important to effectively operate land registry and cadastral systems, and information requirements as a part of need assessment as a strategy of implementing organisation with respects to their customers. Instances of customer orientation with cases in Nepal and Bhutan are discussed and the traditional concept on satisfactions such as economic and non-economic satisfactions is highlighted in the section two.

Section three discusses the concept of perceived value, which plays the substantial role in getting customer satisfaction on services and products. The equation of perceived value and the effects of S-Curve are then discussed and seen as strong bases in the market orientation and gaining profitability.

Section four further elaborates on market orientation

Paper Presented at 2nd cadastral congress organized in co-operation with FIG Commission 7, Sept. 19-21, 2003, Crakow, Poland

and satisfaction model where non-coercive strategy plays the prominent roles in effective communication between the suppliers and customers. Conflict management, trust and perceived value are leading elements in achieving customer satisfaction.

Last section five emphasizes the need assessment as a part of the organisational strategies. To this end we have identified essential information that need to be derived from the relevant customers involved in the relationships with organizations.

1. Customer orientation in land registration and cadastral systems

It is generally known that in many developing countries, their land registry and cadastral systems suffer very much from the lack of customers' needs on their services and specifications. The lack of customer demands/needs probably also means the lack of meeting customer demands. These systems usually have a variety of many customers ranging from the land surveyors, real-estate officers, lawyers or solicitors, settlement officers, planners, valuers, etc. In some countries, these systems are combined under one organisation, while in other countries they are separated under the different organisations. In both case, the information exchange and cooperation between the organizations are the key issues that need to be tackled for providing information to all customers involved in the land issues.

From the operational point of view, there are countries, where land registrars are very active in land registration, while in some other countries, land registration and cadastral systems have land registrars who have only passive role. Referring to the systems in Nepal, the district land registrars play a major active role in adjudication and registering land transfers (Tuladhar, 2003). Here it is important that the systems are designed to focus towards not only to supply land information but also to provide the services such as helping on negotiation according to laws, settlement of disputes, detailed investigation of deeds and registrations. In these situations, satisfaction constitutes a construct of vital importance in the explanation of any type relationship between organisations and customers. The operations of the systems are highly dependent on the relationships that land registrars have with their customers (buyers and sellers in particular). The relationships in Nepal are normally maintained through a broker (or Lekhandas A person who helps the buyers and sellers in drawing up deeds of transfers.) who helps buyers/sellers to prepare and process deeds inside the district offices. Normally these brokers have very good relationships with the land registrars. Thus, for the quality services, these relationships between the district land registrars and customers can greatly be enhanced by making involvement with customers, information exchange and attention to customers for the final products (Forza et al, 1998). In this case, satisfaction can be considered as a positive, affective state, resulting from the evaluation of all aspects of the relationships between them.

In Bhutan, land registry office plays only a passive role in the registration processes, while the local courts and district magistrates (Dzongkhags) play the key roles in settlement and land transfers according to the land laws (Tuladhar, 2003). Land registry and cadastre systems of Survey of Bhutan maintain land records and supply land information to all customers. In this case involvement and communication with Ministry of Home Affairs, the District Magistrates, the local courts and other customers are extremely important for effective uses of land records.

In the context of cadastral systems in the Netherlands, van der Molen (2003) emphasizes six elements in order to make land registry and cadastre more structurally effective, namely the continuous awareness in customer requirements, products and services in compliance with the specifications, compliance with delivery schedule, rapid resolution of problems, settlement of complaints in a manner acceptable manner and the provision of support to customers in their use of the information they receive. He also provides a model for customer satisfaction with perception and expectations as key elements for satisfying customers of land registration and cadastre.

Traditionally, satisfactions may be divided into the economical and non-economical satisfactions of the relationships in delivering and using services and products as shown in the figure no.1 (Sanzo et al, 2003).

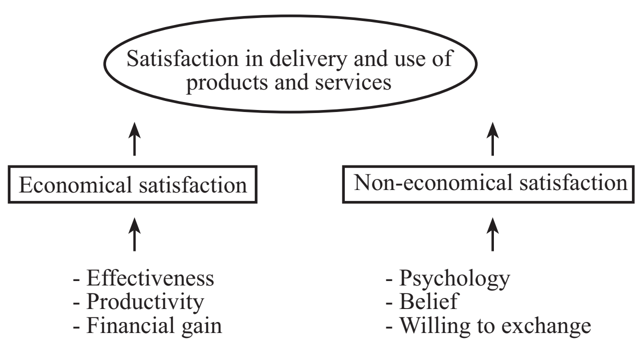

Figure No. 1: Traditional satisfaction concept

Economic satisfaction can provide a positive affective response due to the effectiveness and productivity of the relationship, and to the financial gain. On the supplier side, more productivity means more financial gain with less cost of production. On the customer side, more effective products and services mean more financial gains in using them.

Non-economic satisfaction comes from a positive psychological response that a satisfied participant enjoys working with the partner, given the belief that the latter is concerned for their welfare and willing to exchange relevant information with them. This is particularly important in land registry and cadastral systems; it comes from the social context in which market exchange is developed.

In both of these satisfactions, three main contributing factors seem important (Sanzo et al, 2003):

- Effective bidirectional communication between the parties: This implies information exchange at the multiple exchanges and domains, performed regularly and whenever necessary. It is possible that effective communication between the parties exerts a positive influence on trust.

- Satisfaction can be related to the degree of conflicts. Non-coercive influence strategy on the part of the supplier's organisation may reduce the conflicts.

- Satisfaction depends to a greater extent on the perceived value of the products and services. In the quality service models, the perceived value is considered as a determining factor in customer satisfaction.

2. The concept of perceived value

The concept of perceived value is an important element of customer satisfaction. It brings customers confidences, attractiveness, appreciations and satisfaction trends on the services and products. However, our research indicates that customer expectations depend on the features of products/services, system structures and customer relationships.

In understanding the perceived value in relation to the cadastral systems, customers expects the products and services suited to their needs of required quality, reliable, user-friendly, customized to their requirements for the uses. Customers buy information not for their features or their specific functionalities, but rather for the perceived benefits that the products deliver. Features and functions, which are often the focus of product design specifications, are simply the 'envelop' for delivering the benefits that are desired by customers. Customer perceptions are critically important. A product may meet objective of performance criteria (i.e. validated by internal tests), but an organisation only gets credit if the customers recognize that the product delivers the benefits.

Here the system structures means the structures of the information system that needs to be convenience, flexibility, efficient delivery time and required supports for the information supplied. They assess the organisation's ability to support their commitments and give customers what they need (convenience, accurate information, flexibility in ordering, etc.). For example, any tendencies to over promise and under deliver would affect on the perceived value.

The elements of customer relationships that affect perceived values as seen by the customers are based on the competence, openness, dependence, communication, trust and respect on two parties concerned. The human touch can make all the difference in customer loyalty. Competent representatives who understand what is and is not happening, and develop a bond *of trust and respect with their customers*, often form the foundation for long-term customer relationships, even informal partnerships.

Mistakes happen, and if they are handled appropriately, they have minimal effect on customer satisfaction. In fact, marketing research suggests that superior problem resolution can actually strengthen customer loyalty by improving customer confidence in the organization's ability to deliver what was promised or quickly make it right.

Normally customers make decision to purchase the products considering perceived price, which might be just the cost of producing the product. But this not necessarily reflects reality. Actual price may be calculated as the sum of total cost of production, minimum profit and price range as follows.

$$AP = \Sigma (TCP + MPR + PR)$$

Where AP is actual price, TCP is total cost of production, MPR is Minimum profit gained by organization, and PR is Price range depending upon the market orientation.

From the organisational point of view, the above equation suggests that it is possible to set minimum price ceiling and still earn acceptable profits from the point of view from the organizational strategies for maintaining various resources.

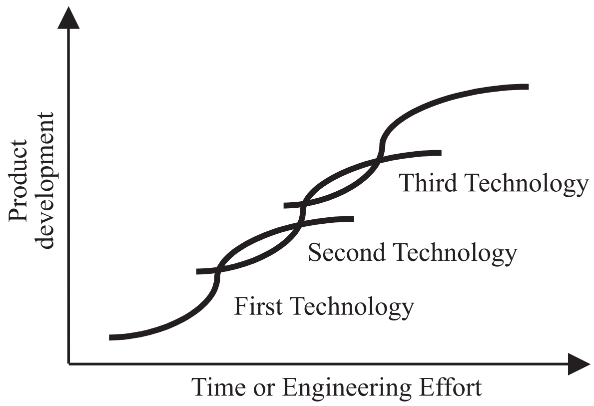

Figure no. 2: *S-curve* economics (adopted from Nolan, 1973)

The effect of S-curve economics: *S–Curve* is based on so called stage theory from Nolan (1973). According to this theory, the perceived value as perceived by the customers can be different after certain period of time due to new technological impact on the system product development. *S-curve* in the figure 2 suggests us that during initial periods of system operation the rate of performance improvement starts gradually, then accelerates and slows again as it approaches performance limits using the first available technology. During these periods, the price ceiling might have been minimum whereby the customers are already satisfied with the products and services what they get. However, in the course of time, new technology would push the organisations (suppliers and customers) to deliver the products and services in a new way. This requires huge investment in term of finance and capacity building for changing the system features and functions. Similarly in the next generation of technology also shows similar behaviours.

This suggests us that the high levels of satisfaction may be constrained by *S-curve* economics, since it may be too costly to provide the services and products required to satisfy the customers at the high level. It may also be possible that if an organisation makes delays in using the next generation, there may be risks for its survival to capture its market share. On the customer side, it is important that customers should understand why there are the difficulties on the supplier side to achieve the high level of satisfaction. Therefore, the relationships with customers are strongly dependent with the roles each party has to play in achieving satisfaction on both sides.

3. Market orientation and satisfaction model

Market orientation is considered as influential factor in the customer satisfaction, because in order to perform well, organisations needs relevant and timely information about the markets i.e. their customers and stakeholders or competitors (Otten et al, 2002). Because opportunities and threats continuously change e.g. due to the move made by stakeholders or competitors, the emergence of new technology, or shifts in customers' preferences and behaviours, the market must continuously be surveyed. In land registry and cadastral systems, similar behaviours can be seen (Oosterom et al, 2002). Therefore we argued that the continuous stream of market data need to be collected, interpreted, distributed among organisation members, and be adequately utilised and exploited to stay competitive in the market.

Market orientation promotes the acquisition of information on customers, competitors, suppliers and environmental forces in such a way that all this information can be treated collectively by the organisation, with the end of creating and maintaining an offer that generates greater value. It is also considered that effective communication between the parties possesses a market orientation culture in building satisfaction, and combination of market orientation and noncoercive strategies would require effective communications with customers as shown in the figure no. 3 (Sanzo et al. 2003).

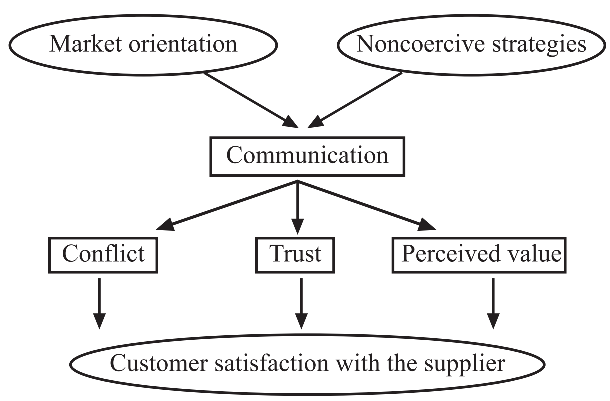

Figure no. 3: Satisfaction model relating market orientation (adopted from Sanzo et al. 2003)

In the structural building of a long-term relationship for the customer satisfaction, an effective communication system needs to be placed. The roles of each participants (including customers and suppliers must be clearly specified taking all the aspects that may potentially create occasions for conflict. Such initiative should lie with both suppliers and customers; the leaders in both parties involved in the relationship must fulfill an absolutely essential role in putting this strategy into effect and minimizing the level of conflict that may occur. To be more effective the contacts must involve all levels of organisations. Initiatives such as the creations of multifunctional teams with individuals from the both organisations, the design of training programme or the use of structured forms may be done by the specialists of suppliers' organisations, customers and/or the directors of the organisations. For all, it is absolutely essential to have efficient information management system and databases focusing on the customer needs and services e.g. electronic front door system. In addition, intra-organisational communication with each respective organisation is required for effective inter-organisational communication

As we discussed above, the value perceived by the customers increases satisfaction and similarly trust is also contributing factor to satisfaction. The maintenance of open lines of communication with the customer, a service guarantee and a higher standard of conduct contribute to the degree of trust.

Similarly, the effective communication contributes achieving higher perceived value at all the levels of organisations.

4. Need assessment as a part of Organisational strategies

In order to make organisations competitive and effective, it is essential to include the elements of the customer satisfaction as a part of the organisational strategies. Within the strategic management concept, the first way to reduce threats and weakness is to conduct need assessment regularly with all customers involved in the information flows. People performing need assessment should be able to step into a customer's role and listen carefully to the customers following the noncoercive strategies. In careful listening it is important to take into account and understand customer's background and values, map customer's problems and opportunities, and to notice unspoken concerns (Kärkkäinen, 2001). Secondly the suppliers always needs to keep informing all newly changes in the products and services including the roles that the customers' roles, the suppliers continuously gets feedbacks on the products and services. These are important organisational strategies to keep always customer satisfactory.

In need assessment programme, the following are essential information that needs to be assessed from customer's viewpoint (Kärkkäinen, 2001), and the need assessment can be part of organisational strategies to be continuous vigilant to the market orientation:

- Customers and their market segments;
- Customers objectives, problems, requirements and needs;
- Customers' business environment, requirements and needs;
- Structured picture of business chain and stakeholders;
- Customers' real needs and technical requirements, and comparison criteria;
- Information of needs that should be given special attention and target levels;
- Common, prioritized view of most important needs, competitive situation and product attributes;
- Most vital product concepts – strength and weakness of concepts;
- Most probable problem sources and customer's possible negative views of the products and rough estimate of probability;
- Estimate of product competitiveness in the market.

Need assessment for product development (such as cadastral domain model) should be seen as a broader task for organization not just seen as single activity in the beginning of the product development. It should be carried out continuously in order to get need information early enough for product development decisions.

To safeguard the continuous need assessment and satisfaction monitoring, the various levels of the organisation should be involved. First of all the day-to-day contacts with the customer should be organisationally embedded. Therefore, organisations create the account management function, providing opportunity for good customer relationships. At managerial level, directors should focus on good relationships with umbrella organisations of customers, like Associations of Solicitors. A sideline benefit is that within the umbrella organisations expectations are coordinated and communicated in a natural way. At top level (director general, board members) organisations should institutionalise good customer contacts, in the form of a user board or alike. One might even consider expanding such institutionalised meeting points to participation of stakeholders in general. At the same time, establishing customer relations at various organisational levels, requires good internal communications. Nothing will lead to more customer-confusion than different communications from different levels.

5. Concluding remarks

This paper summarizes three main issues namely traditional satisfaction concept, the concepts of perceived value and satisfaction model incorporating market orientation that are fundamental to the customer satisfaction. It also emphasizes on the conflict management, trust and perceived value as important components on the effective communication.

Need assessment with involvement of all customers for the product development cycle is a must as a compulsory item of the organizational development through noncoercive strategies.

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Data Standards In The Context Of National Geoinformation Infrastructure

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Abstract

Development of GIS related activities and acquisition of data on spatial variables using remotely sensed data as well as maps have provided new insights in the field of decision-making concerning development planning and administration of natural resources [Kayastha 1999].

With the availability of software tools collection of geographic data for a particular application has become so easy that each institution can generate data on its own. Such an approach would lead to confusion among users, owing to differences in data format, reliability of data and most of all consistency of data could not be maintained due to redundancy [Kayastha 1999].

The paper outlines importance of geoinformation infrastructure and its components, followed by outlining areas where standards can be defined on basic elements of geospatial data such as geo-referencing, data definition, metadata etc. The paper also provided an overview of NTDB.

1. Introduction

Geospatial data in the digital form are becoming an integral part of the general decision making processes relating to land and its environment. Due to diversity of users and availability of software products, creation of geospatial data has become a common practice. Depending on the requirement several forms of database may become available differing in format, content as well as resolution. Variations that may be inherent in different data sets make them less effective. Considering the amount of input required in terms of effort in creating a database, it will be necessary to see that such a product (data) is useful and available to other users as well. If data could be developed on a uniform basis, it would be very useful and would considerably lessen the duplication efforts, which at present is seemingly not common. In the context of national geoinformation infrastructure, such commonality and uniformity may be achieved by following certain standards on geospatial data.

2. Geoinformation Infrastructures

Information infrastructures have become essential element of the development of any country. In order to obtain suitable information to support decision-making concerning land and its environment, geospatial data forms the backbone of all resource data. Availability of appropriate data and access to information resources can be ascertained with the establishment of geoinformation infrastructure. However successful placement of full functioning geoinformation infrastructure is contingent upon the national policy concerning data creation and data sharing.

Traditionally central authority produces paper maps and such maps are available to the user community on demand. The users then can incorporate additional information over the base maps to derive several different products as required. In this way, the basic meaning or the semantics of the data being portrayed in a map is transferred to the subsequent users automatically and is implicitly being maintained to a greater extent. So much so that the projections systems used for the base data generation is also evident. In the digital environment, these processes require special attention and can be considerably improved.

The requirements from the users' point of view have changed in the digital environment. Lack of consistency among data from different sources, scalability, outdated data, projection systems, variations in data semantics, and data resolution are some of the problems that hinder integrated applications. Taking an integrated view on the data model and creating and following certain standards in the core processes of data modelling and implementation may help in minimizing the efforts in bringing in dissimilar data sets to a common usable format. This calls for development of National Geospatial Data Standards.

2.1 Components of geoinformation infrastructure

A geoinformation infrastructure is an organized collection of several essential components, some of which are:

- Basic spatial data
- Network and transfer mechanism
- Standards
- Metadata
- National Policy and supporting legal backup

2.1.1 Basic Spatial data

Geographic Information Systems operate on geospatial data sets. Geospatial data vary greatly in geographic area, purpose and content. The need for such data nearly always includes a few basic themes such as road network, streams and rivers, elevations etc. These provide a framework for data collection and analysis. Framework data provides a basis on which organizations can accurately register and compile other themes of data. They provide the geospatial foundation with which an organization can perform analysis and to which attribute information can be attached. Availability of such data sets is a key component.

2.1.2 Network and transfer mechanism

Geospatial data residing in several nodes need transferring. Without the mechanism of data transfer the basic philosophy of geoinformation infrastructure will be defeated. It is therefore necessary that transfer mechanism be efficient and transparent as far as possible for which a network can play a vital role. One single institution may not necessarily maintain geospatial data encompassing all data types. The mechanism of transferring geospatial data between different nodes must be so that the user may not have any difficulty in finding out what type of data is available in a particular node. Besides, there will be uniformity in data sets as well, as the data sets will be coherently integrated, because specific data sets will reside only in a particular node specific to that domain.

For instance, Survey Department may maintain basic topographic data sets that are commonly required for all other applications, while the domain specific data sets may be maintained by respective institutions. Such an arrangement however will entail massive data transfers between several nodes; the transfer standards should, therefore, be in place.

2.1.3 Standards

Standards essentially deal with basic specifications to be followed before a particular data element is accepted into a database. Standards therefore provide the user a basis to understand and evaluate the usability of data for intended application, while it provides a basis to the data producer to populate the database with data in a consistent manner.

Considering the practice of converting paper maps into digital geospatial data by virtually any organization, there is a strong need for standards in digital geospatial data to maintain transferability, and compatibility of data sets generated from diverse data sources. Standards in case of paper maps are long in existence normally set by national mapping agencies, however, in case of digital geospatial data; acceptable standards need to be worked out with the participation of possible stakeholders.

2.1.4 Metadata

To find existing maps, files and other data to use with the LIS/GIS or other technology often becomes a frustrating experience. In many a case the existing data is not discovered until it is too late to use for a project, or the data that is discovered is not described in sufficient detail for determining its usefulness. Metadata helps an individual to locate and understand data.

In the analogue domain, where geospatial data is presented in as printed maps, metadata is readily available as part of the map in the form of legend and other marginal information. Metadata is thus, easily transferred between map producers and map users. The same geospatial information, when presented in digital form, metadata becomes equally important a part as the geospatial data itself. Without which the users may not be able to derive the actual information contained in the data. The data producers, therefore, will have to put extra efforts in development and maintenance of metadata and it applies to the subsequent users who may modify the data to suit their particular needs. Thus metadata serves several important purposes including data browsing, data transfer, and data documentation.

Considering the usability of existing dataset, metadata could be maintained at several levels of complexities. In the basic form, metadata might consist of a simple listing describing basic information about available data, whereas, in other case, detailed information may be included about individual dataset.

2.1.5 National Policy and supporting legislative backup

In most cases digital geospatial data are created from paper prints. It has created few more problems such as duplication of data sets, inconsistency due to semantic differences, incompatibility of data sets due to different georeferencing, resolution and accuracy of data sets etc. Accessibility and copyrights are other problems that are very vital in the success of geoinformation infrastructure.

Many of the cited problems can be solved under a framework of national policy on digital geospatial data handling. Some may be solved through adoption of a national standard such as use of a national coordinate system for georeferencing.

3. Spatial Data Standards

Effective geospatial data standards are necessary for any efforts in collaborative data production. Standards will increase the ability to share geospatial data and preserve its original meaning, to create more complex applications, and to stimulate the business associated with GIS technology and geospatial data modelling.

Basically spatial data standards should cover among others the following key elements:

- Data definition and content specifications
- Positional accuracy /Resolution
- Attribute accuracy
- Data accessibility and exchange
- Georeferencing

A comprehensive treatment about the standards can be obtained from the series of reports and standards released by ISO/TC211. ISO/TC211 is an international body actively engaged in formulation of international standards in the field of geoinformation to support understanding and usage of geoinformation, improve accessibility and to establish geoinformation infrastructures at different levels.

3.1 Data definition and content specifications

Geospatial data, as we all know, are composed of two basic components viz. the location and the attribute. The location implies the position, orientation and extent of a particular feature in the geometric space, while the attribute describes the identity of the feature as to what it represents in the real world.

Information that is implicitly available in a printed map, need to be explicitly represented, in case of digital geospatial data. Depending on the user views and applications intended, a feature might be represented in many ways or not at all represented, which will make meaningful interpretation of geospatial data more difficult to others. In order to make a uniform representation these data need to be well defined in terms of semantics and the geometric representation.

Identification of data elements and the way of their representations may be obtained through the process of data modelling. All data items will then be explicitly defined. The collection gives us data content specifications. It should however include the relationships being modelled.

3.2 Positional accuracy/Resolution

Accuracy implies closeness of an entity to reality both in position as well as attribute value. A particular data set that may be good enough for one application may not be so for other. It is therefore necessary to lay down the accuracy requirement before the data collection itself. In the digital domain most of us have a tendency of overlooking the accuracy component due to the possibility of enhancing the data through several routines. But the end result may be completely different from what may have been expected through the use of a certain data set intended for a different kind of application. For instance a DTM created using 100-metre contours or a district area created from a regional scale map might not be suitable for large-scale applications, but one may be tempted to using such data in the case of unavailability of high-resolution data or for some other reasons. It applies to other types of data as well. Accuracy therefore plays a vital role in the data manipulation. Similarly in case of raster data one must be very careful about the data resolution. While formulating a data standard it is necessary that the accuracy/resolution level of data elements should also be specified. One should also note that a multi resolution database might be necessary to accommodate multitude of users.

3.3 Attribute accuracy

Attributes are the means to distinguish features from one another for instance distinguishing one location from other or one road from other. Attribute is a fact about some feature. Some of the attributes could be simply names or the land use class but to set the domain value for any attribute some sort of measurements would have to be made. With measurements the uncertainty creeps in depending on the type of measurements. Even a name attribute could introduce errors owing to simple input error such as text or due to uncertainty in toponymy or the transliteration rules; name of a place might be wrongly spelt. In cases like land use class there could be cases when assigning a class value entail confusion. One should therefore take into account all the aspects affecting the definition of attribute type and attribute value domain.

3.4 Data exchange format

The availability of different software products and the diversity in users' views necessitated that data created and maintained in one system should be transparently transferable to any other system. There are variations in operating platforms and the software used which cannot be regulated. The users have their own choices and preferences, yet geospatial data should be available to them to work with. In addition we know that geospatial data pertaining to specific domain may have to be created by respective agencies; such data should be shared also among the data producers as well. This requires a system independent exchange mechanism, whereby data transfer from any system could be made. Several exchange formats have been developed and being used in the world.

In our case too, data exchange format for geospatial data should be developed. It might not be necessary to start from scratch. In fact we can learn from the experiences of others and evolve a reasonable kind of transfer format for our use. In any case a comprehensive effort is still required on the part of data producers.

3.5 Georeferencing

One important component of a geospatial data element, as stated elsewhere, is position. These days it is possible to transform the coordinate system from one system to the other very easily yet considering the fact that all transformations entail introduction of errors, it will be necessary to have a common referencing system to maintain compatibility of data sets. The reference frame for the position therefore should invariably be the national coordinate system. All data developers should stick to that base which will provide a uniform basis for positioning of geospatial entities.

4. Overview of National Topographic Database (NTDB)

In an effort to provide for a uniform basis at least in the topographic data domain, Survey Department has prepared detailed specifications for National Topographic Database. The basic objective of such a database system is to provide a homogenous seamless national data on topographic features present in reality. Following is an overview of the NTDB.

There are in all nine classes by themes in the NTDB viz. Transportation, Building, Topography, Land Cover, Hydrography, Utilities, Administrative Area, Designated Area, and Control Point. Each feature class describes the collection of data by a distinct theme. Within each class, successive subdivisions are made to incorporate feature classification hierarchy down to the feature component. The specification is primarily based on the topographical maps published by the Survey Department. [NTDB 1998]

In addition to feature names numeric codes are used for referencing, as feature names are not always convenient to use for referencing during manipulations. A five-digit code for feature component is developed. The specifications also include attribute catalogue containing a list of possible attributes designated by an attribute type name and an attribute code.

The NTDB at present state may not be fully populated with the help of topographic maps alone. So it is recommended that additional data may be maintained in the respective line agencies by replicating the basic data. [Kayastha 1999]

Work has already started in the Survey Department towards the implementation of the NTDB. With time, it is expected that the specifications will be modified to accommodate the findings during the implementation process.

5. Conclusion

The utilization of digital geographic information has been growing fast in all sectors of the society. Lack of basic digital geospatial data has resulted into multiple, inhomogeneous and expensive data collection and conversion in order to ensure the needed geospatial data for different projects and activities both in public administration and private sector. This kind of uncontrolled creation of geospatial data for different purposes will lead to serious consequences when trying to combine data from different sources. It is therefore important to start work to stop this frustrating and expensive development. [NTDB 1998]

The NTDB could provide a starting point towards the standardization, however it is very important that a consensus among all stakeholders be reached. This will provide for an environment where serious deliberations could take place toward achieving the goal of geoinformation for all.

Acknowledgement

The author would like to express sincere thanks to Prof. Bengt Rystedt for critical review and providing comments on this paper.

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Kayastha, D M 1999: National Topographic Database (NTDB): Seminar on "Future Plan and Programs on National Surveying and Mapping", Jan 27-28, 1999, Survey Department.

NTDB 1998: Specifications for Geographic Information Service and National Topographic Database; Survey Department.

Calender of International Workshops/Seminar/Conference

ASPRS 2007 Annual Conference "Identifying Geospatial Solutions"
Tampa, FL, USA
7-17 May 2007
E: asprs@asprs.org
W: www.asprs.org/tampa2007/

ISPRS WG I/5, IV/3 Workshop
"High Resolution Earth Imaging for Geospatial Information"
Hanover Germany
29 May - 1 June 2007
E: karsten@ipi.uni.hanover.de
W: www.ipi.uni-honover.de

FIG XXX General Assembly and Working Week
Hong Kong China
2-6 June 2007
E: fig@.fig.net
W: www.figwww2007.hk

13th Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) Annual meeting
Seoul, Korea
12-15 June, 2007
E: sec@pcgiap.org
W: www.pcgiap2007.org

5th International Symposium on
Spatial Data Quality
13-15 June 2007
ITC, Enschede, The Netherlands
E: issdq2007@itc.nl
W: www.itc.nl/issdq2007

14th International Steering Committee for Global Mapping (ISCGM)
Cambridge, U.K.
14th July 2007
W: www.iscgm.org/

Map Asia 2007
14-16 July 2007
Kuala Lumpur Convention Centre
Kuala Lumpur, Malaysia
W: www.mapasia.org

Cambridge Conference 2007
Cambridge U.K.
15-20 July 2007
E: nmonetwork@ordancesurvey.co.uk
W: www.ordancesurvey.co.uk/nmonetwork

51st Photogrammetric Week 2007
Stuttgart Germany
3-7 September 2007
E: martina.croma@ifp.uni-stuttgart.de
W: www.ifp.uni.stuttgart.de/

Conference on Spatial Information Theory
(COSIT)
Melbourne Australia
19-23 September 2007
E: winter@unimelb.edu.au
W: www.cosit.info

28th Asian Conference on Remote Sensing (ACRS) 2007
Kuala Lumpur Malaysia
12-16 November 2007
E: acrs2007@macres.gov.my
W: www.macres.gov.my/acrs2007

ISPRS WG/I/6 Workshop on Earth Observation Small Satellite for Remote Sensing Applications
Kuala Lumpur, Malaysia
13-16 November 2007
W: www.commossion1.isprs.org/wg6

Global Spatial Data Infrastructure (GSDI) 10 International Conference
25-29 February 2008
ST. Augustine, Trinidad
W: www.gsdi.org/gsdi10/

ISPRS 2008 Beijing
The XXI Congress of the International Society for Photogrammetry and Remote Sensing
Beijing China
3-11 July 2008
E: loc@isprs2008-beijing.org
W: www.isprs2008-beijing.org

Evaluation Of Topographic Mapping Possibilities From Cartosat High Resolution Data

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Keywords: *High-resolution satellite imagery, Satellite Photogrammetry, DEM, Orthoimage,Topographic Mapping.*

Abstract

Re-surveying or mapping is usually required when user needs for up-to-date maps at various scales are not met by existing maps. Generally, the requirements are for large scale mapping and the outputs may be in digital format or hardcopy or both. Data acquisition may be from field survey, aerial photographs or satellite imagery. Nowadays, due to availability of high resolution satellite imageries, scales 1:2,500 to 1:10,000 can be mapped for large areas as an alternative to field survey. Cartosat is producing stereo satellite imageries of 2.5m spatial resolution. This paper evaluates the possibilities of mapping at 1:10,000 from this Cartosat image. Evaluation of accuracy is done for both planimetric and height mapping. Also the optimum scales that can be derived from the Cartosat stereo-pair are suggested.

1. Introduction

Maps have been valuable tools for man from time immemorial. In the early ages maps were extensively used in travel and in navigation. Today maps have broader spectra of applications and have proven to be vital tools on decision making in many organizations like; government, engineering development, explorations and tourisms industry. The conventional topographic mapping method is a rather labor intensive, time consuming and expensive endeavor, hence an alternative for a faster and cheaper topographic mapping method should be sought for.

The new technology of high-resolution satellite imagery has demonstrated its immense potential for mapping. The IKONOS and Quickbird imaging systems offer ortho-image products meeting map accuracy specifications to scales as large as 1:10,000. The cost of acquiring such mapping products is, however, quite considerable and beyond the means of many prospective international users, especially in the developing world. Fortunately, there are methods available for users with photogrammetric capability to generate high-accuracy mapping from low-cost satellite images, with the possibility of achieving stereo models for accurate mapping. This paper summarizes an experiment of digital satellite photogrammetric approach for topographical mapping using stereo pair of high-resolution satellite imagery, Cartosat-I as a sample image.

2. Satellite Photogrammetry

Satellite photogrammetry has slight variations compared to photogrammetric applications associated with aerial frame cameras. This paper makes reference to the IRS-P5 Cartosat I satellite. The Cartosat I sensor provides 2.5 meter panchromatic imagery with stereo viewing capability.

"The IRS-P5 Cartosat-1 satellite carries Panchromatic cameras which are mounted such that one camera is looking at +26 deg. w.r.t. nadir and the other at -5 deg. w.r.t. nadir along the track. These two cameras combined provide stereoscopic image pairs in the same pass. The focal length of the camera optic is 1945 mm, which is very large relative to the length of the camera (78 mm). A polar sun synchronous orbit of altitude 618km with an inclination of 97.87 deg. and an equatorial cross-over local time of 10:30 hours and the descending node has been selected based on various considerations. The sun-synchronous orbit provides the imagery collection under near-constant illumination conditions throughout the life and repetitive coverage of the same area in a specified interval. In order to revisit the same place at a more frequent interval than the repetitive cycle, an off-nadir viewing capability is provided. Using this facility any area which could not be imaged on a given day due to cloud cover, etc. may be imaged on another day. The typical revisit cycle is 5 days with the off-nadir cross-track steering facility" [1].

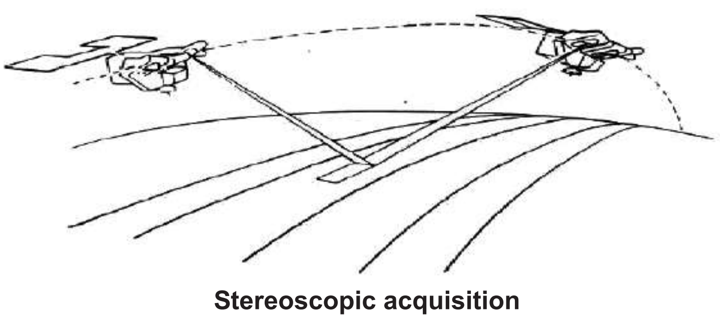
2.1 Key Parameters of the IRS-P5 Cartosat-1 Sensors [2]

	PAN Fore Camera	PAN Aft Camera
Tilt Along Track	+26 deg	-5 deg
Spatial Resolution	2.5 m	2.5 m
Swath-width	30 km	27 km
Radiometric Resolution, Quantization	10 bit	10 bit
Spectral Coverage	500-850 nm	500-850 nm
Focal Length	1945 mm	1945 mm
CCD Arrays (no. of arrays * no. of elements)	1 * 12000	1 * 12000
CCD Size	7 µm x 7 µm	7 µm x 7 µm
Integration Time	0.336 ms	0.336 ms

2.2 Stereo Imaging

The concept of stereo pair images is that two images are acquired at two different angles, left viewing and right viewing, and preferably at same time or within short time interval in order to have same features and illumination on both images. These images can be viewed stereoscopically to obtain relief impression using optical instruments, and of lately using soft photogrammetric stations. Pushbroom sensors like SPOT sensors have the capability of off nadir viewing. This means they can be pointed towards left or right of the orbit track or pointed forward or behind along satellite track. This characteristic has a number of advantages which include reduction of revisit time by observing areas not on satellite path, areas not covered by clouds can be imaged at that particular moment, and most importantly this characteristic provides good opportunity for stereo imaging. Stereo imaging with such satellites can be done across track (images taken from different satellite paths) or along track, where the second image is taken in quick succession of the first image by the same sensor along the same track. The figure below shows stereo acquisition by a satellite.

Imaging with enlarged swath width



Stereoscopic acquisition

3. Dataset Used

Cartosat Stereo images of Barcelona (provided by Nepasoft) (Copyright reserved to ERDAS Imagine India)

Spatial Resolution: 2.5m

Scene Coverage: 30km X 30km

RPC file of the sat image

- Ground Control Points:

Planimetric: extracted from the sample orthoimage of the same area

Altimetric: extracted from the sample DEM of the same area

Backward Image	Forward Image
ProductID=055056200501	ProductID=055056200601
SatID=CARTOSAT-1	SatID=CARTOSAT-1
Sensor=PAN_AFT	Sensor=PAN_FORE
GenAgency=NRSA	GenAgency=NRSA
Path=0117	Path=0117
Row=0208	Row=0208
DateOfPass=19JUL05	DateOfPass=19JUL05
PassType=SSN	PassType=SSN
OrbitNo=1116	OrbitNo=1116
SceneSequenceNumber=01	SceneSequenceNumber=01
BytesPerPixel=2	BytesPerPixel=2
GenerationDateTime=27AUG05	GenerationDateTime=27AUG05
ProductCode=STUC00GOJ	ProductCode=STUC00GOJ
ProductType=ORTHOKIT	ProductType=ORTHOKIT
ResolutionAlong=2.5000000	ResolutionAlong=2.5000000
ResolutionAcross=2.5000000	ResolutionAcross=2.5000000
Season=JUL	Season=JUL
ImageFormat=GeoTIFF	ImageFormat=GeoTIFF
ProcessingLevel=STD	ProcessingLevel=STD
ResampCode=CC	ResampCode=CC
NoScans=12000	NoScans=12000
NoPixels=12000	NoPixels=12000
MapProjection=NONE	MapProjection=NONE
Ellipsoid=WGS_84	Ellipsoid=WGS_84
Datum=WGS_84	Datum=WGS_84

3.1 Suitability for DEM generation

There are three main factors to consider if the two images are capable of forming a stereo pair:

i. The Base Height, B/H, ratio.

ii. Date of acquisition

iii. The degree of overlap.

The base/ height ratio can be calculated using the two incidence angles provided with each scene and applying the formula:

$$B/H = \tan(R) + \tan(L)$$ [3]

Where, R is the incidence angle of the right image and L is the incidence angle of the left image.

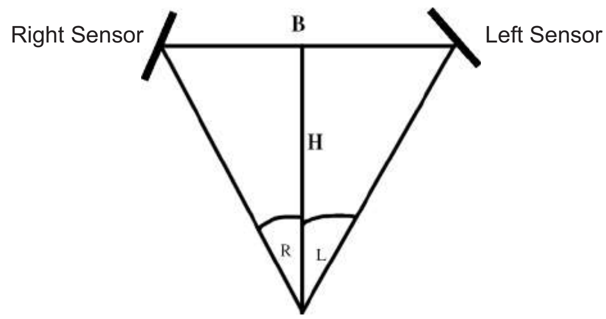


Figure : View Geometry

The B/H ratio can be chosen from the following values:

1.0 - (high value, applicable particularly for analog processing)

0.8 - (optimal value, applicable for all application types)

0.6 - (low value, useable in digital processing)

In the case of the dataset used:

B/H ratio: 0.62 [1]

Date of acquisition of satellite image: same day

This shows a good possibility of stereo restitution of satellite image pair.

4. Orientation and Triangulation

Pushbroom sensors acquire images line by line. Every scan line has different time instance and hence different perspective projection model, but orientations of neighboring lines are strongly correlated. The exterior orientation parameters; which are the attitude angles of roll, pitch and yaw and the perspective centre change from scan line to scan line. The interior orientation parameters which comprise focal length, principal point location, lens distortion coefficients, and other parameters directly related to the physical design of the sensor are the same for the entire image. For the geo-referencing of imagery acquired by pushbroom sensors many different geometric models of varying complexity, rigor and accuracy have been developed. The main approaches include rigorous models, rational polynomial models, Direct Linear Transformations (DLT) and affine projections.

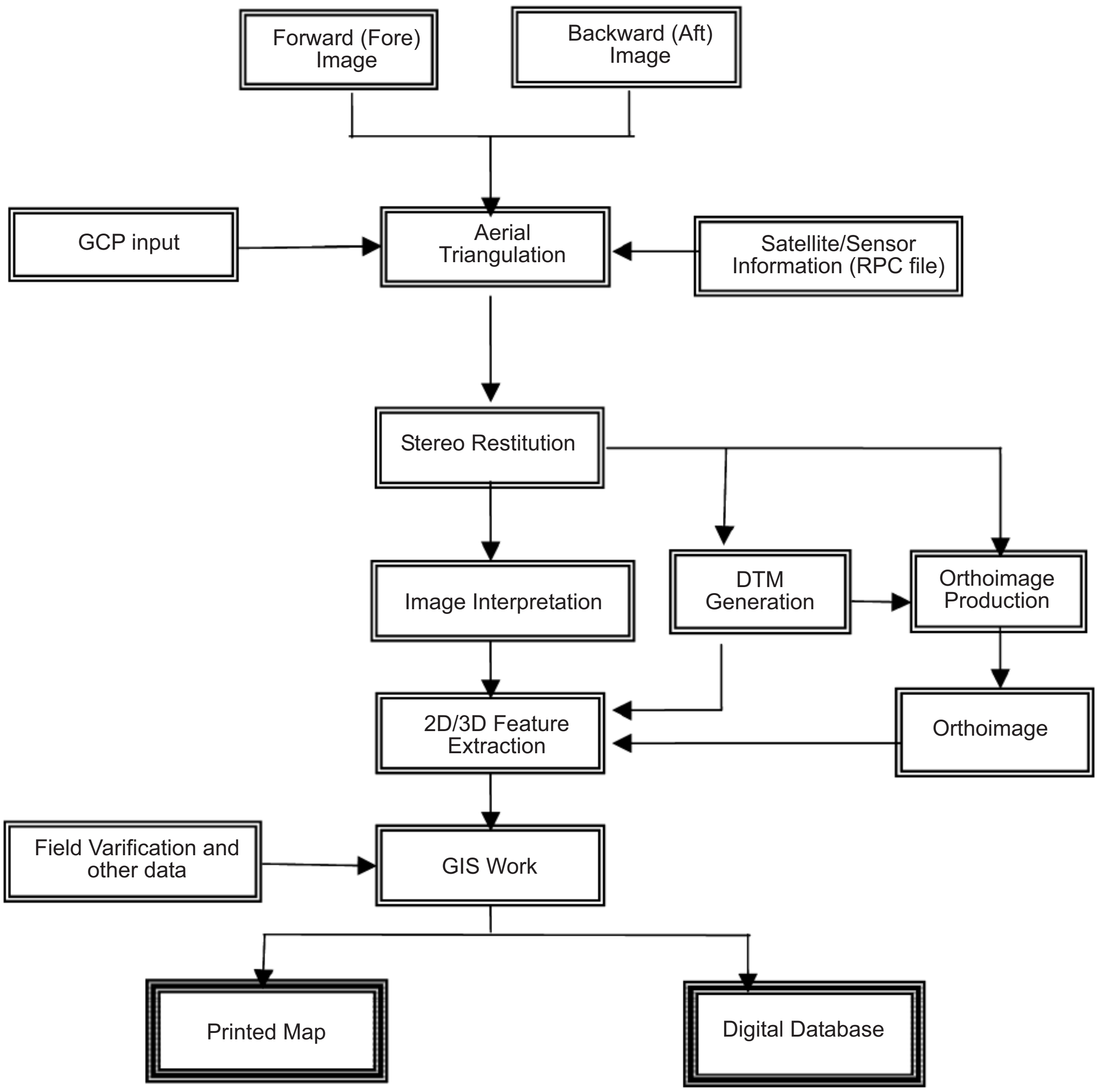
The procedure followed for the geometric processing was performed in LPS-Orthobase and the steps include automatic interior orientation, measurement of ground control points, after GCPs measurement an image matching technique which automatically identifies , transfers and measure image tie points between the two images making stereo pair was run, and finally the triangulation was run to obtain exterior orientation. From the triangulation model Digital Elevation Model was generated which was used for ortho-rectification of the images.

4.1 DEM Generation and Orthoimage Production

Stereo model was generated after aerial triangulation which was used for feature extraction, DTM generation and Orthoimage production. Satellite Images were orthorectified using the DTM to produce orthoimages.

5. Methodology

The figure below shows the workflow of the whole mapping work.



6. Feature Extraction

The topographical features extracted in different layers are:

Transportation – (lines/polygon)
Hydrographical features (polygon)
Land cover – (polygon)
Buildings – (polygon) and Built-up area – (polygon)

6.1 2D Feature Extraction

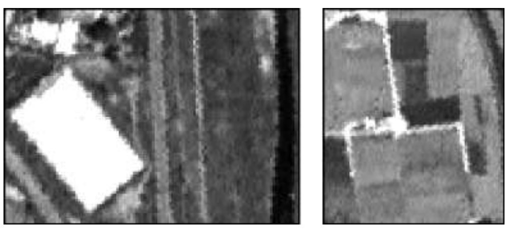
The parameters for feature extraction in 2D were as follows:

Tone, Shape, Pattern, Texture, Size, Association, Site

Tone

- Relative brightness of a black/white image
- Tonal variations depend on energy reflected

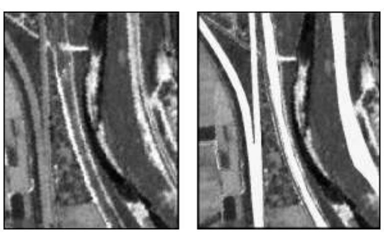
Spectral characteristics of an image - expressed as 0-255 grey levels



Tonal variations in two portions of the image

Shape

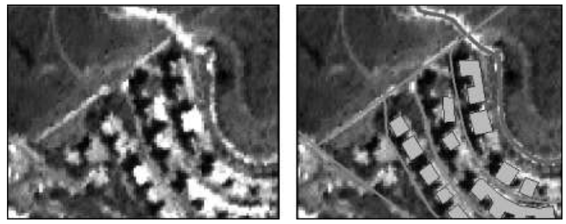
- Shape or form characterizes terrain objects
- In 3D it relates to height differences
- Useful for identifying roads, railway tracks, built-up areas, agriculture fields etc.



Linear shape assists in identifying roads

Pattern

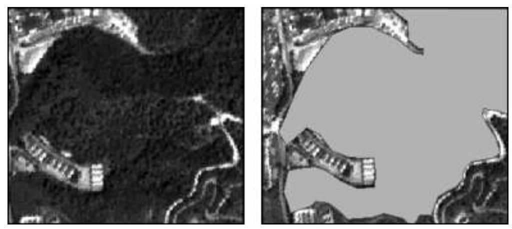
- Spatial arrangement of objects
- Repetition of certain form of relationships
- Useful for identifying man-made features like built-up ares etc, hydrological systems, geological patterns etc



Regular pattern helped to identify individual buildings

Texture

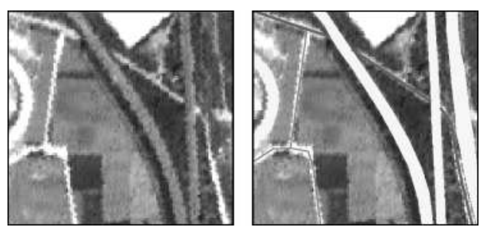
- Frequency of tonal change
- May be coarse or fine, smooth or rough, even or uneven, mottled, speckled, granular, linear etc
- Terrain roughness or smoothness
- Strongly related to spatial resolution



Grainy texture helped identify forest area

Size

- Can be relative or absolute
- Relative size can be inferred from absolute
- Relative size can assist in classifying different features (e.g. highway-district road etc)



Relative size helped to classify roads

Association/Site

- Relates to geographic location
- Combination of objects used to identify a feature

Proximity to river means either sand or marsh land

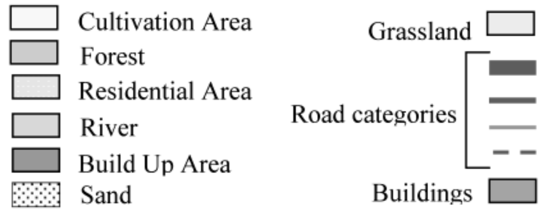
All features excluding buildings were extracted from orthoimage. Buildings were extracted from Stereo model. It is more user-friendly to extract feature from orthoimage by simply digitizing the features in the image. Uncertainties in image interpretation in orthoimage can be resolved by extracting in 3D mode i.e. feature extraction in stereo model. Stereo digitizing is more powerful to extract the topographical information since it provides the 3D view of the terrain although it is time consuming and needs expert knowledge.

Figure above shows the stereo model of the Cartosat -1 image of the study area.

Feature extraction of a small sample area of the above shown image is done. Most of the features were extracted in 2D digitization. The features which were difficult to classify like buildings were verified from stereo model. Field verification should be done to make the map complete.

Small part of the whole image

Digitization of the sample area



7. Suitability for mapping at 1:10,000

The Survey Department of Nepal has a specification of maximum Permissible error in planimetric plotting (PE) = 0.25mm * Mapping Scale

So for a scale of 1:10,000 mapping the permissible error PE = 0.25mm * 10,000 = 2.5m
Since the spatial resolution of the image is 2.5m, so theoretically the image is suitable for mapping at 1:10,000.

From the extracted features above, the line and polygon features were within the permissible error in 2D plotting. The features to be plotted as point in 1:10,000 scale can be viewed in 3D, but this particular sample image contained no such features, so the analyses was not performed for point features.

7.1 Suitability for mapping at other scales

Mapping at other scales will depend on the following:

- Permissible error (may be different from Survey Department of Nepal specifications)
- Purpose (e.g. only linear features may be needed)
- 2D or 3D (e.g. planimetric features are more accurately and easily plotted than contours)

So, if the permissible error for planimetric plotting is more than the Survey Department of Nepal specifications then it is possible to plot at larger scales. For example, since the spatial resolution of Cartosat image is 2.5m, if an organization has a planimetric PE of 0.5mm*Mapping Scale, then the scale for which it can plot is 1:5,000 (0.5mm * 5000 = 2.5m)

8. Limitation of the work

The main limitation of the work was the dataset to be used. Because of the unavailability of the satellite image of Cartosat -1 of Nepal, sample image from Barcelona was to be used. This caused limitation of control points.

Horizontal coordinates of the Ground Control points were taken from orthoimage and the vertical coordinate Z-value, was taken from sample DEM of the same area. This reason limited us from the field verification for validation of the work and to collect the incomplete information in the image.

9. Conclusion

Digital photogrammetry method was used for extraction of geo-information from Cartosat-1 image. Digital elevation model and orthoimage were produced. Distinct line and polygon features were extracted from the orthoimage. Features that were not clear in orthoimage were extracted from stereo model. Validation of the work in the ground was not possible. The image was found suitable for mapping at scale 1:10,000 using Survey Department of Nepal specifications.

Reference

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Price of Maps

S.No.	Description	Coverage	No of sheets	Price per sheet (NRs)
1	1:25,000 Topo Maps	Terai and mid mountain region of Nepal	590	150.00
2.	1:50 000 Topo Maps	HIgh Mountain and Himalayan region of Nepal	116	150.00
3.	1:50 000 Land Utilization maps	Whole Nepal	266	40.00
4.	1:50 000 Land Capibility maps	Whole Nepal	266	40.00
5.	1:50 000 Land System maps	Whole Nepal	266	40.00
6.	1:125 000 Geological maps	Whole Nepal	82	40.00
7.	1:250 000 Climatological maps	Whole Nepal	17	40.00
8.	1:125 000 Districts maps Nepali	Whole Nepal	76	50.00
9.	1:125 000 Zonal maps (Nepali)	Whole Nepal	15	50.00
10.	1:500 000 Regionla maps (Nepali)	Whole Nepal	5	50.00
11.	1:500 000 Regionla maps (English)	Whole Nepal	5	50.00
12.	1:500 000 maps (English)	Whole Nepal	3	50.00
13.	1:1 million Nepal Map	Nepal	1	50.00
14.	1:2 million Nepal Map	Nepal	1	15.00
15.	Wall Map (mounted with wooden stick)	Nepal	1	400.00
16.	Photo Map		1	150.00
17.	Wall Map (loose sheet)	Nepal	1 set	50.00
18.	VDC/Municipality Maps	Whole Nepal	4181	40.00
19.	Orthophoto Map	Urban Area (1: 5 000) and Semi Urban Area (1: 10 000)	-	1 000.00
20	Administrative Map	Nepal		5.00

Price of Control Points

Type	Control Points	Price per point
Trig. Point	First Order	Rs 2 000.00
Trig. Point	Second Order	Rs 1 500.00
Trig. Point	Third Order	Rs 800.00
Trig. Point	Fourth Order	Rs 100.00
Bench Mark	High Precision	Rs 500.00
Bench Mark	Third Order	Rs 100.00
Gravity Point	High Precision	Rs 500.00
Gravity Point	Low Precision	Rs 100.00

Evaluation of various filter kernels for extraction of linear features from satellite imagery

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Keywords: *Remote Sensing, Image enhancements, Filter kernel, Convolution filter, Zero-sum kernel, High-pass kernel*

Abstract

Edge-enhancement filters, among others, are tools for image enhancements, which provide the user with more options for delineating linear features. The aim of this paper is to study various filter kernel combinations to ascertain their value and usability for extraction of linear features in particular. Twelve different filter kernels of 3x3 matrices were studied, which included six of zero-sum kernel type and six of high-pass filter type. Eleven filters showed satisfactory result for edge-enhancement. The use of filters for extraction of linear features from satellite imagery was found to be very suitable, and it shows that other filters may be defined according to the purpose of the user.

1. Introduction

Satellite imagery is used extensively in various application fields by professionals like agriculture scientists, marine biologists or forest conservationists etc. These images are taken from different platforms and sensors with various image characteristics such as spatial, spectral or radiometric resolution. The remote sensing expert needs to adopt interpretation techniques according to the image characteristics and the results expected.

A remote sensing professional engaged in mapping work will create a digital cartographic model representing the real world in point, line or area features[2]. The level of information extracted in these circumstances, depends mainly on the spatial resolution of the satellite imagery, the required output, the skill of the interpreter and the various extraction techniques.

Economic consideration dictate that more information be extracted from relatively less expensive imagery. So techniques such as filters have to be employed to extract more information. Filtering is a broad term, which refers to the altering of spatial or spectral features for image enhancement[1]. A new image is computed from the old one depending upon the pixel values of the neighboring pixels and the kernel coefficient [2]. The most effective use of filters is in noise reduction (smoothing) or for edge enhancements (for extraction of linear features). In this paper the edge-enhancement filters are studied.

2. Objective

Numerous filter kernel matrices exist; however, they are generally not applied to their full potential because of a general lack of knowledge of when to apply what filter or what result to expect from a given filter. Filters may be used for noise reduction, speckle reduction, edge-enhancement etc. In the context of extraction of linear features from satellite imagery, the aim of this study is to:

a. Study edge-enhancement filters of two types, namely the high-pass filter kernels and the zero-sum filter kernels
b. Study standard filters and define new kernels
c. Study their suitability for linear feature extraction from satellite imagery

3. Methodology

Firstly, filters of different types are studied. Then high-pass filter kernels and zero sum kernels of 3x3 matrices of various combinations are defined. The filters are then applied on the same image for comparison. A code is written in Erdas Imagine software for implementing this. The code is run for all the filter kernels separately. Two separate decision criteria are defined for zero sum kernels and high-pass kernels. The decision criteria for zero sum kernels are: (a) visibility and interpretability of edges and (b) enhancement in a particular direction, for example, north, south or their diagonals. The judgment criteria for convolution filter are: (a) image quality (whether degraded or not) and (b) sharpness of edges. These are then compared and the best suitable kernels for each category deduced.

4. Data

Although filters can be best applied to lower spatial resolution imagery, where visual interpretation is difficult, yet, in this study IKONOS image of the year 2000 of a section of Balaju area was taken because of the following:

a. Image availability
b. Linear features such as roads, rivers and bridges in all directions, e.g. north, south, east, west, NE and SW
c. Linear features of varying dimensions available
d. Ease of identification of linear features for verification of results
e. Ability to project these results to lower spatial resolutions images

5. Filters

Filter operations are usually carried out on a single band. To define a filter, a kernel is used. A kernel defines the output value as a linear combination of pixel values in a neighborhood around the corresponding in the input image. For a specific kernel, a so-called gain can be calculated as follows: gain=1/Ý'3fki

One application of filtering is to emphasize the local differences in grey values, for example related to linear features such as roads, canals, geological faults, etc. This is done using the edge enhancing filter, which calculates the difference between the central pixel and its neighbors. This is implemented using negative values for the non-central kernel coefficients. The sharpening effects can be made stronger by using smaller values for the centre pixel.

Convolution filtering is one method of spatial filtering. It is the process of averaging small sets of pixels across an image. It is used to change the spatial frequency characteristics of an image. A convolution kernel is a matrix of numbers that is used to average the value of each pixel with the values of surrounding pixels in a particular way. The numbers in the matrix serve to weight this average toward particular pixels. These numbers are called coefficients, because they are used as such in the mathematical equations.

The following formula is used to derive an output data file value for the pixel being convolved (in the center):

$$V = \left[\frac{\sum_{i=1}^{q} \left(\sum_{j=1}^{q} f_{ij} d_{ij} \right)}{F} \right]$$

Where:

$f$ij = the coefficient of a convolution kernel at position i,j (in the kernel)

$d$ij = the data value of the pixel that corresponds to fij

q = the dimension of the kernel, assuming a square kernel (if q=3, the kernel is 3x3)

F = either the sum of the coefficients of the kernel, or 1 if the sum of coefficients is 0

V = the output pixel value

In cases where V is less than 0, V is clipped to 0.

The sum of the coefficients (F) is used as the denominator of the equation above, so that the output values are in relatively the same range as the input values. Since F cannot equal zero (division by zero is not defined), F is set to 1 if the sum is zero.

5.1 High Pass Kernels

A high-frequency kernel, or high-pass kernel, has the effect of increasing spatial frequency. High-frequency kernels serve as edge enhancers, since they bring out the edges between homogeneous groups of pixels. Unlike edge detectors (such as zero-sum kernels), they highlight edges and do not necessarily eliminate other features. The following is an example of high pass kernel.

-1	-1	-1
-1	16	-1
-1	-1	-1

5.2 Zero-Sum Kernels

Zero-sum kernels are kernels in which the sum of all coefficients in the kernel equals zero. When a zero-sum kernel is used, then the sum of the coefficients is not used in the convolution equation, as above. In this case, no division is performed (F = 1), since division by zero is not defined.

This generally causes the output values to be:

- Zero in areas where all input values are equal (no edges)
- Low in areas of low spatial frequency
- Extreme in areas of high spatial frequency (high values become much higher, low values become much lower)

Therefore, a zero-sum kernel is an edge detector which usually smoothes out or zeros out areas of low spatial frequency and creates a sharp contrast where spatial frequency is high, which is at the edges between homogeneous groups of pixels. The resulting image often consists of only edges and zeros. Zero-sum kernels can be biased to detect edges in a particular direction. For example, the following is an example of South biased kernel:

-1	-1	-1
1	-2	1
1	1	1

6. Analysis

6.1 Kernel definition

The filter kernels defined in this study are 3x3 matrices and are divided into two groups, the zero-sum kernels and the high-pass kernels, depending upon the sum of the coefficient. There are 6 kernels in each group, with two standard kernels available in text books and software and the rest designed for the purpose of this study. The kernels are numbered A through L in the table 1 below and the corresponding images obtained are also numbered similarly in sec. 7, table 2.

Zero-sum kernels:

A			B			C			D			E			F		
-1	-1	-1	1	1	1	1	1	-1	-1	1	1	1	1	1	-1	-1	1
1	-2	1	1	-2	1	1	-2	-1	-1	-2	1	1	-8	1	-1	-2	1
1	1	1	-1	-1	-1	1	1	-1	-1	1	1	1	1	1	1	1	1
South bias			North bias			West bias			East bias			Standard			Test		

High-pass kernels:

G			H			I			J			K			L		
-1	-1	-1	-1	1	-1	-1	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-1	16	-1	1	16	1	-4	21	-4	-1	9	-1	-1	10	-1	-1	12	-1
-1	-1	-1	-1	1	-1	-1	-4	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Standard (Gain=1/8)			Test			Test			(Gain=1)			(Gain=1/2)			(Gain=1/4)		

Table 1 : Filter kernel matrices

6.2 Coding and implementation of filter

The coding was done on the Model Maker of the Erdas Imagine software with the model shown below[3] .This was then run for each filter kernel and the output studied.

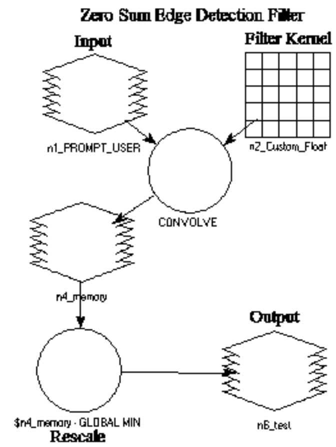

Figure 1 : Model for implementation of filter in software

7. Results and discussion

The following table shows the result of applying the filter in the image. They are placed in the same order as the applied kernel from sec. 5, table 1.

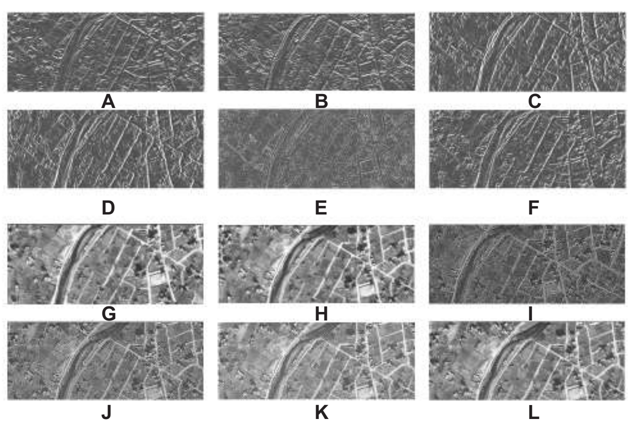

Table 2 : Images after applying the filters

7.1 Decision criteria

Zero-sum kernel: (a) visibility and interpretability of edges and (b) enhancement in a particular direction, for example, north, south or their diagonals.

High-pass kernel: (a) image quality (whether degraded or not) and (b) sharpness of edges.

Filter	Remarks
A	Edge well detected, north-south lines not visible, east-west lines more visible
B	Edge well detected, north-south lines not visible, east-west lines more visible
C	Edge well detected, east-west lines not visible, north-south lines more visible
D	Edge well detected, east-west lines not visible, north-south lines more visible
E	Edge well detected, lines generally clear
F	Edge well detected, north-east to south-west (diagonal) lines more clear
G	Image very clear, edges sharp for all directions, good image contrast
H	Image very clear, edges sharp for all directions, good image contrast
I	Edges clear, lots of noise
J	Edges clear, image degraded
K	Edges clear, image degraded
L	Edges clear, good image

Table 3 : Description of results after application of filters

From table 3, it can be seen that although certain results look promising, yet the others have there own purpose as well. As expected, the zero-sum filters, table 3, (A – F), enhance the edges at the cost of image quality. Thus, if the objective is to make the edges clear in some direction, any of these filters can be applied according to the purpose. However, if the requirement is to have the edges enhanced *and* also to view good quality images, the high-pass filters, table 3, (G – L) give good results, except the kernel I, which is a mixture of averaging filter and high-pass filter.

8. Conclusion

The objective of the study has been fulfilled. Edge-enhancement filters of two types, namely, zero-sum and high-pass kernels, have been studied in different combination of coefficient values. In doing so, it has fulfilled an intrinsic intention of this paper of making the reader aware of edge-enhancement filters, when to apply what and what results to expect from which filter. Standard kernels have been analyzed along with kernels defined for this study. The third objective of examining the suitability for linear feature has been fulfilled. Except one filter, all the filters have succeeded in giving an edge-enhanced acceptable quality image. The results show that kernels can be and should be defined and applied according to the purpose of the remote sensing expert.

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From Cadastral Survey Plan To Geographic Information Infrastructure: Fifty Years Of Evolution Of Geo-spatial Data Policy In Nepal

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Abstract

The golden jubilee celebrations of Survey Department correspond with the golden jubilee of periodic planning in Nepal. The First Plan in Nepal was initiated in 1956 and the year 2007 coincides with the completion of the Tenth Plan. In this paper an overview of the ten periodic plan documents have been made to look into the evolution of the surveying/ mapping and geo-spatial data policy and a growth of Survey Department as a cadastral survey office to a NMA to the hub of NGII in Nepal.

1. Introduction

Despite many exercises conducted and the preparation of draft policy at several occasions, no comprehensive policy document- a national surveying/ mapping policy or the national geo-spatial data policy, as such, has been approved by the Government of Nepal so far. Therefore the content of the draft policy is not the theme of this paper. The periodic Plan documents prepared by the National Planning Commission and approved by the then successive governments of Nepal clearly enunciate the sectoral policy in different areas to be undertaken during the plan periods. The establishment of Survey Department and the initiation of periodic planning process correspond together (around 1956-1957). These documents clearly define the surveying and mapping policy during the said plan periods. A look into the sectoral policy on surveying and mapping outlined in the ten periodic plan documents clearly show the transformation of Survey Department as the custodian of cadastral survey plan to the focal point of geographic information infrastructure in Nepal. The enunciation of surveying and mapping and related policies in the different plan documents have been analyzed to look into this transformation. This paper documents the growth of Survey Department as a cadastral survey office to a national mapping agency (NMA) to the hub of national geographic information infrastructure (NGII) in Nepal.

2. Evolution of Surveying & Mapping and Geo-spatial Sectoral Data Policy

2.1. First Plan (1956-1961)

The First Plan (1956-1961) document consists of 22 chapters. Chapter 22 deals with Surveys, Research, Statistics and Publicity. The document clearly emphasizes on the lack of basic information on the resources, current conditions and potentialities of growth of the Nepalese economy, as well as special types of data needed for the detailed planning and execution of the various development programmes. Survey work of specialized character are planned to be conducted entirely by the departments concerned. The Plan envisages that detailed surveys specifically related with development activities planned in the field of agriculture, forestry, irrigation, power, road building, ropeway construction, communication, industry, mining and resettlement will be taken up and aims most of them to be completed within a year or two. It expects that some surveys like the cadastral survey will take years to complete.

A separate chapter is dedicated to Cadastral Survey in the document. It states that cadastral surveys are important in clearing up confusions as to title of boundaries, in developing dependable agricultural statistics, and in providing a basis for equitable taxation. It mentions that trained technicians, equipment and funds have prevented the initiation of cadastral surveys. In the planned five years it was expected that a little less than half the country will be surveyed and maps and tabulation completed. It was also planned that the ultimate cost of the activity will be divided as between Government and landowners. It aims that this will not only pay its way but also increase Governments' revenue from the land.

2.2. Second Plan (1962-1965)

The Second Plan (1962-1965) has a total of 27 chapters and one chapter is fully dedicated to Survey and another chapter to Cadastral Survey. The Plan gives high priority to acquiring knowledge on present economic condition and the natural and human resource of the country. For this reason two types of surveys are foreseen in the Plan:

- General surveys of the natural resources of the country like forests survey, mines survey, soils survey, industrial raw materials, water resources (irrigation, power) survey, botanical survey, industrial survey etc.
- Pre-investment survey of specific projects like large waterpower, irrigation, mineral-extraction, international airports, roads, town-planning etc.

The Second Plan puts a very strong emphasis on cadastral survey. It analyses the shortcomings of the First Plan and draws up a more realistic plan to complete the cadastral survey of terai areas and the valleys (dun) areas in the mountains. This document also emphasizes on the cadastral survey management system, land registration system, resolution of conflicts, and promulgation of a Survey Act.

2.3. Third Plan (1965-1970)

This Plan is divided into 33 chapters within 3 parts: General, Development Programmes and Implementation. No separate chapters on Survey (general) or Cadastral Survey are made. But different survey plans and programmes are given in different chapters related to sectoral development programmes like agriculture development, land reform and land administration, forestry and botany, irrigation, mineral industry, power, transport, drinking water and sewage, statistics, hydrological survey etc. As an example, it explains that in order to develop irrigation, drinking water and hydroelectric power, hydrological data are very essential. To collect hydrological data for different rivers and streams, the role of Hydrological Survey Department has been outlined, for example.

The Plan once again puts lots of emphasis on accurate cadastral survey to determine the boundaries of the land and to classify the land property. The Plan analyses that the progress of cadastral survey in the past two plan periods has been slower than anticipated and that the methods were technically unsatisfactory. Making an impressive target for cadastral survey, it states that the existing capacity was relatively low and importance of developing adequate human resource was emphasized.

2.4. Fourth Plan (1970-1975)

The Plan is divided into 28 chapters. This again describes different sectoral plans like agriculture, survey, land reform and land administration, forest and medicinal plants, transport, civil aviations, geological survey and mining, power, hydrology and meteorology, drinking water and sanitation, housing and physical planning etc. As in the previous plans, related survey work has been assigned to related custodian departments. For example, some of the geological surveys assigned are: western terai petroleum investigation, gas investment in Kathmandu valley, regional geological mapping, integrated geological-mineral surveys, feasibility study of mineral based industries etc. Similarly surveying in hydrology and meteorology consist of surface water investigation, meteorological investigation, ground water investigation etc.

For the first time, additional to cadastral survey and maintenance of cadastral maps and records, the Fourth Plan discusses about trigonometrical survey and the topographic survey. The trigonometrical survey, however, is dedicated to cadastral survey alone, only a bid to provide more accurate control points to the cadastral surveying in order to improve their accuracy.

The paragraph on Topographical Survey states as following:

Government of Nepal will endeavor to obtain United Nations Special Fund to set up a topographical survey unit and entrust with the following tasks:

- To complete the topographical survey works of the areas, other than those undertaken by Survey of India and the publication of one inch maps sheets,
- To reproduce one inch maps sheets of Nepal in the required quantity now being published by the Survey of India and to keep the sheets up-to-date,
- To draw and publish up-to-date small scale maps of Nepal, e.g. 1:250,000 scale,
- To survey and produce plans of sites for development projects,
- To print, and possibly draw, maps of surveys by other department.

In the same time, the Plan also emphasizes on the availability of sufficient trained manpower on Surveying and the importance of Survey Training Centre as a dedicated institute of learning on surveying and mapping.

2.5. Fifth Plan (1975-1980)

The Fifth Plan consist of 36 chapters, separate chapters being dedicated to policies like regional development policy, population policy, employment policy, landuse policy, water-resource development policy. This also describes different sectoral programmes like agriculture, irrigation and water resources, land reform, land administration and survey, roads and other transportation, geological survey and mining, drinking water and sewerage, housing and physical planning etc.

This Plan identifies three levels of survey technical manpower: Surveyors (high-level) with a requirement of 59, Assistant Surveyors (middle-level) with a requirement of 372 and Amin (basic level) with a requirement of 1222 during the plan period. This amounts to nearly 6.8% of the requirement of all technical manpower in the country. This Plan recognizes, therefore, for the first time surveying as a profession in the country with three-tiers of its own.

During the Fifth Plan period, emphasis is again laid on the cadastral survey. A total of 18 districts are planned for completion and 6 new districts initiated for cadastral survey during the period. Importance of trigonometrical survey for cadastral survey control is also given. Progress on the topographical survey unit as planned in the Fourth Plan was made and therefore the updating/ reprinting of 1" to 1 mile topographical surveying, 1:250,000 mapping and large-scale mapping will be made as planned. A new development during the Fifth Plan is the commitment for acquiring necessary assistance in carrying out land-utilization and land-resources mapping.

2.6. Sixth Plan (1980-1985)

The Sixth Plan consist of 10 chapters, with the collection of different sectoral programmes in 4 chapters e.g. Agriculture, Irrigation, Land Reforms, Forest and Medicinal Herb (Chapter 7), Industry, Commerce, Mining and Power (Chapter 8), Transport and Communication (Chapter 9), and Social Services (Chapter 10). In the survey sectoral plan, it is stated that cadastral surveys will be conducted in those districts left out so far to identify tenants and landowners, and it is also stated that authoritative maps will be prepared on different scales. A significant policy statement is "Stress will be put on geodetic and topographic surveys" with the word "geodetic" being pronounced for the first time. Outlined in the Plan are geodetic programmes like astronomic surveys and gravity surveys.

In other sectoral programmes, similar emphasis is given on respective surveys as well.

2.7. Seventh Plan (1985-1990)

The Seventh Plan consist of 51 chapters with 15 dedicated to separate sectoral policies like Population and Employment Policy, Water Resource and Fuel Policy, Ecology and Land-Use Policy, Export Policy, Development Administration Policy, Science and Technology Policy, Urbanization and Habitation Policy, Decentralization Policy, Public Enterprise Policy, Policy on Private Sector, Regional Development Policy, Computer Policy, Price Policy, Tax Policy, and Monetary & Credit Policy. Among them the inclusion of computer policy and the science and technology policy in the national planning framework is a breakthrough, which has an effect on the surveying and mapping policy and spatial data policy development in the future. The Computer Policy states that the government, semi-government or private sector should adopt a policy for the development of computer technology in the country to make available reliable statistics and information in a short time frame. It also emphasizes on the development and expansion of suitable computer network facility for national and international use on a gradual basis. The Science and Technology policy emphasizes, among others, on the consolidation of prerequisites of science and technology, preparation of necessary groundwork for transfer of technology and increase the opportunities for upgrading the scientific capacity and exchange of information and know-how.

Going to specific policy on surveying and mapping, it states to carryout various activities such as measuring the land in a scientific manner, finding out the exact area of land, supporting the determination of survey policy and its implementation, preparing maps in different scales within the country for different purposes and producing necessary manpower for survey programmes effectively. Also it recognizes the importance of different types of mapping on different scales for administration, social and economic development of the country. It describes different geodetic survey and topographic survey activities to be undertaken to support this programme.

By spelling the importance of "survey policy" the Seventh Plan clearly recognizes the importance of Survey Department as a National Mapping Agency (NMA) rather than a departmental survey organization (basically cadastral).

2.8. Eighth Plan (1992-1997)

The Eighth Plan consists of 40 chapters with different sectoral issues discussed. One of the sectoral policy on land reform and management states, "By assembling all information received from land survey, an integrated land information system will be developed to support decision-making." This is a big break-through as a jump from the traditional surveying and mapping to the development and use of spatial information system. An ambitious plan of computerization of all land ownership records in all districts within two years has also been made. Another breakthrough in this plan is the commitment for encouraging involvement of private sector in surveying and mapping.

2.9. Ninth Plan (1997-2002)

The Ninth Plan consists of 15 chapters. The long-term concept of mapping sector spelled in the Plan document is to continue development of land-ownership, mapping and land-resources information for integrated development, and land management based on geographical information system. Specific objective in the Ninth Plan is to computerize and make available data related to land-ownership, land-resources and other topographic mapping. Specific projects and programmes outlined in the Plan are the implementation of Land Information System, land resources mapping, map digitalization, different geodetic surveys, topographic mapping etc.

2.10. Tenth Plan (2002-2007)

The Tenth Plan is another landmark in the field of surveying and mapping and Geo-spatial data policy in Nepal. The Approach Paper of the Tenth Plan states that National Geographic Information System will be gradually developed to disseminate and make easy access to spatial data in the country.

This is yet another breakthrough in the development process, from the concept of national mapping agency (NMA) to a national geographic information infrastructure (NGII).

The main document of Tenth Plan is spread into 34 chapters and 3 annexes. The survey sector lists out cadastral survey, map digitalization, topographic mapping, and various geodetic surveys, developing geographical information system as some of the projects to be undertaken. Establishment of land information system, computerization of land records, digitalization/ scanning of cadastral maps and records are other programmes outlined.

3. Assessment of the Evolution of Surveying and Mapping and Geo-spatial Data Policy

In the backdrop of the above policy developments during the fifty years of planned development in Nepal, it can be stated that the surveying and mapping and geo-spatial data policy have slowly emerged from a project based surveying/ mapping to development of a national spatial data infrastructure. The surveying/ mapping and geo-spatial data policies, programmes and projects have been guided by the user-requirements in the first place and equally important by the corresponding developments in other sectoral areas. The developments in the field of science and technology in general and in the field of ICT in particular have made a tremendous impact in the field of surveying and mapping. GeoICT is now a recognized field of learning and this technology is applied for benefiting a larger part of the society and the nation as a whole.

Surveying and mapping as a technology involved in cadastral survey in 1956 in Nepal, and Survey Department as an organization barely involved in the production of cadastral survey plans that year, the technology and corresponding policies have undergone tremendous development during the fifty years. In the same way, during this period Survey Department has undergone a complete metamorphosis from a bare cadastral survey office to a national mapping agency NMA (outlined in the Seventh Plan) to the hub of national geographic information infrastructure NGII (outlined in the Tenth Plan). Survey Department has grown from a technician department to a scientific department in these fifty years. Surveying has grown and recognized as a profession in itself. The Surveyors take pride in their profession and are satisfied that they are helping in the overall development of the country by providing necessary maps and geo-spatial information for planning and execution of different development projects. The Plan documents over the years clearly outline these policy changes. The changes have been gradual and the developments have been evolutionary. This type of evolution has created an environment in Survey Department as an organization and its Survey professionals to take ownership to the developments. This is perhaps the key to a sustainable development of Survey Department and the Surveying profession.

4. Conclusion

The periodic Plan documents spell out gradual evolution in surveying and mapping and geo-spatial data policy in Nepal. However as outlined in the Seventh Plan a comprehensive national policy document on Surveying and Mapping and Geo-spatial Data is still awaited. There have been several exercises in the Survey Department to formulate these policies and draft documents have been prepared. But they have yet to be formally indorsed by Government of Nepal and therefore the contents have not been discussed in this paper. However, with the advent of NGII it is no more a sectoral policy of Survey Department to be monitored by a singular organization. It is high time that a national geo-spatial data policy is endorsed. Before such endorsement is made, it is naturally anticipated that some consensus is built between the concerned stakeholders e.g. the producers and users of geo-spatial data. Such a policy document should include, among others, policy statement on spatial data management e.g. fundamental and framework data sets data acquisition and data management plan, technical standards and protocols on metadata clearinghouse implementation and usage, organizational and administrative arrangements including guidelines for custodianship of spatial data, guiding principles for spatial data access and pricing policy. Also important in this regard is the guidelines for financing of NGII.

It is seen that all periodic plans are guided by the policy concepts evolved in the concerned organizations and the technological and scientific developments in the related professions. With respect to surveying & mapping and geo-spatial data, formalizing such concepts through the enunciation of a National Geo-spatial Data Policy will be a formal document to give directives and guidelines in the sector for the future periodic plans.

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National Planning Commission (2004): Tenth Plan (Poverty Reduction Strategy Paper) Information CD, CD-ROM publication of NPC, Kathmandu, Nepal.

Price of Aerial Photo and Map Transparency

Prduct	*Price per sheet*
a) Contact Print (25cmx25cm)	*Rs 150.00*
b) Dia-Positive Print (25cmx25cm)	*Rs 500.00*
c) Enlargements (2x)	*Rs 600.00*
d) Enlargements (3x)	*Rs 1200.00*
e) Enlargements (4x)	*Rs 2000.00*
Map Transparency	
*a) 25cm * 25cm*	*Rs 310.00*
*b) 50cm * 50cm*	*Rs 550.00*
*c) 75cm * 75cm*	*Rs 800.00*
*d) 100cm * 100cm*	*Rs 1250.00*
Diazo/Blue Prints	*Rs 40.00*
Photo copy	*Rs 50.00*
Photo lab facilities	*US$ 200/day*

In case of the materials by the clients, the office will charge only 40% of the marked price as service charge.

Price of Digital Data Layers

LAYER	*Class*		*(C) US$*
	(A) NRs	*(B) NRs*	
ADMINISTRATIVE	*500*	*1 000*	*30*
TRANSPORTATION	*1 000*	*2 000*	*60*
BUILDING	*300*	*600*	*20*
LANDCOVER	*1 500*	*3 000*	*100*
HYDROGRAPHIC	*1 200*	*2 400*	*80*
CONTOUR	*1 200*	*2 400*	*80*
UTILITY	*100*	*200*	*10*
DESIGNATED AREA	*100*	*200*	*10*
FULL SHEET	*5 000*	*10 000*	*300*

(A) Nepalese Researchers, Students, Government of Nepal Organizations, Non-Government Organization (Non-profit), Government of Nepal Affilated Institutions.
(B) Nepalese Private Company (Consultant, Contractors)
(C) Foreign Organizations (Consultants, Contractors)

Soil Data	*Whole Nepal*	*NRs : 2000.00*

Land Administration (In A Nutshell)

Bekha Lal Shrestha
Former Deputy Director General

The Term "Land " denotes the surface of the earth, the material beneath, the air above and all things fixed to the soil both natural and man-made. It is the ultimate resource without which life on earth cannot to be sustained. The availability of land is the key to human existence and its distribution and use are of vital importance.

Countries have to manage not only the problems of feeding and giving shelter to the growing population but also for the all round development of its people with the land available to them. This needs control over land and the study of the land resources to ensure the sustainable development, which includes the question of providing security to land owners and maintaining order and stability etc.

This needs information of land and management of them. Land management is the process by which resources of land are put to good use.

Land management consists of activities associated with the management of land as a resource from both economic and environmental perspective. It can include farming, mineral extraction, property management, country planning. It also embraces aspects like environment etc. So the information of land and its management are the concern of land administration to support the country's land administration.

Cadastral survey and its map is the parcel based land information showing the demarcation of every parcel boundaries. It can be extended to the collection, processing and recording a wide variety of land information as demand by land administration, both in textual and cartographic form. Cadastral data in textual form may include land tenure, land use, land value and all other attributes of land required to the administration of land, all tied to the identifiable land parcels systematically covering parcels within a defined area. Cadastral data in cartographic form includes geometric data as co-ordinates, control points etc. Based on survey finding on the ground, cadastral survey and cadastre can be made to contain any degree of precision in accordance to the value of land and its potential development.

Information on cadastre

Cadastral information may be designed to include:

- Fiscal cadastre or a register for levying property tax, which includes, location, size and value of the property. This register is established to cover the entire taxable land of the country.
- Legal cadastre or land register meant to register legal owner of each parcel of land identifying legal rights of landowners and those having interest in land with precise parcel boundary. It may also be negotiation of concerned parties and often-judicial determination of landowners.
- Multipurpose cadastre or a register that incorporates in one, fiscal and legal data plus data of many other attributes of land parcels as the data of land use, soil, infrastructure buildings etc. required to the economic development of the country. So cadastral survey system are the source of key information system for the comprehensive land information based on plan and parcels within plan. However the term land information system is also applied to a wide range of spatial information including environment, socio-economic data and related infrastructure. Land information system acquires, processes, stores and distributes all information about land.

The role of land registration in land administration is to maintain a living record up-to-data by doing away with the dead information and adding new information. It is exclusively concerned with ownership and other interest on land. It need not be based on the complete coverage of land parcels of a country .In view of the important role of cadastre and land registration to serve the different needs of a nation and their citizen, FIG redefined the cadastre and land registration in 1995 to address environment protection, sustainable development etc. The new definitions are as follows

Cadastre

A cadastre is normally a parcel based and up-to-date land information system containing a record of interests in land (e g rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests and often the value of the parcel and its improvements. It may be established for fiscal purpose (e.g. valuation and equitable taxation), legal purpose (conveyancing), to assist in the management of land and use (e.g. for planning and other administrative purpose) and enables sustainable development and environmental protection.

Similarly the re-defined land registration is as follows:

Land registration is the official recording of legally recognized interests in land and usually part of a cadastral system. From a legal perspective a distinction can be made between deeds registration, where the documents filed in the registry are the evidence of title and registration of title in which the register itself serves as the primary evidence. Title registration is usually considered a more advanced registration system, which requires more investment for introduction, but provides in principle greater security of tenure and more reliable information. Title registration usually results in lower Transaction Cost than deeds registration systems thereby promoting a more efficient land market.

In 1996 United Nations Interregional Meeting of Experts on the Cadastral was held at Bogor in response to the problems stipulated in agenda 21 and HABITAT II Global Plan of Action. Both provided additional justification for establishing and maintaining appropriate Cadastral Systems to serve the different needs of nations and their citizens. Both the documents address environmental protection, sustainable development and better living standards for all and identify a number of key areas of responsibility for land administrators regarding access to information.

A working party on land Administration was formed in UNECE meeting on plan of action of HABITAT II summit held in Istanbul 1996 to study on it. The report was submitted in Human Settlement Committee of UNECE in 1997.

United Nations, World Bank and the International Federation of Surveys FIG held in Bathurst (Australia) in 1999 focused on the role of Land Administration for sustainable Development. This was at last adopted as Bathurst Declaration, for which United Nations Economic Commission for Europe (ECE) was working since 1993 to strengthen Land Administration Capabilities.

Land Administration Guidelines (UNECE 1996) introduced an umbrella concept for land registration and cadastre as a joint activity. The term conquers the world! The draft title "Cadastral Infrastructures for sustainable Development of Bathurst Declaration" was changed into Land Administration.

Land Administration is now defined in short as the process of determining, recording and disseminating information about the tenure, value and use of land when implementing land management policies.

Land Administration provides a means to allocate, control and enforce the rights and restrain affecting land. Effective and sustainable land management is impossible without land information.

The introduction of computer has revolutionarized information technology.

Land Information System has now expanded the horizon of Land Administration System by using computer to:

- Force standardization in the collection and processing land information.
- Decrease the cost and space required for storing land record.
- Facilitating access to land related data and improve their distribution.

These are only a few of the benefits given by computer to Land Administration. But the conversion of data into computer readable form is an expensive and time-consuming task.

The use of computer has enabled to acquire vast amount of information more than what can be used. Decision maker has to make right judgment before acquiring information and before buying hardware and software, that helps meet nations object. But there is the risk that computer becomes driver than a tool serving our need.

Land Administration and Nepal

Administration on land to collect revenue existed from the time of Lichhabis (over 2000 year back) down to the Shah-Dynasty. Land taxation was the prime source of revenue to meet the needs of money to finance state activities.

Cadastral Survey, showing parcel boundary in map began since 1980 BS. The record was simply are inventory of land parcels, land classification and landowners.

With the introduction of land reform 2021 BS , Cadastral Survey got its continuity to the present. It served the tenancy survey and revenue survey with less emphases on the usual cadastral objects. The impetus of land reform-momentum to tenancy survey slowed down to non-existence. However Cadastral survey got its continuity till to day and covered the entire country except the pockets of Tarai village settlements and inaccessible remote areas. Cadastre, Land registers, tenants registers are the contribution of Cadastral Survey to Nepal.

Modern concept of Land administration is an outgrowth of Cadastral Survey and Land Reform programme. District Land Administration offices were established under the Land Administration Act 1967 where Cadastral Survey Completed works. Revenue oriented Land Administration Office worked with collection of Land tax, Land registration work and updating Land record and tenant record. Staffed mostly by land reform office and land revenue office with no experience on Land Administration and no training programmes arranged, it could not meet the new challenges. Land Administration Act 1967 was soon suspended and the offices were re-amalgamated to Land Revenue Offices.

A small unit of survey in the name of district maintenance survey, which previously attached to District Land Administration now worked with Land Revenue Office. It helped to up-date the land record in revenue office when land transaction takes place in land requiring subdivision of parcels.

Cadastral Survey System is the source of key information for the comprehensive Land Information System that includes Cadastral mapping data, survey control data, survey record plan and parcel-identification. Land Administration without these accurate data cannot be imagined, our land information department is not yet put to working system. It is simply an archive. The challenge for the survey is to initiate reform to develop modern cadastre.

Participation in international events by the officials of Survey Department

- Land Administration for Southeast Asian Region
  Mr. Jagat Raj Paudel, Chief Survey Officer
  Mr. Khimananda Bhusal, Legal Officer
  Mr. Dev Raj Paudyal, Survey Officer
  Mr. Nab Raj Subedi, Survey Officer
  17-31 Bhadra 2063 (4-16 September 2006)
  Yogyakarta, Indonesia

- Professional Education
  Mr.Narayan Regmi, Survey Officer
  Mr. Kamal Ghimeire, Survey Officer
  1 year from September 2006, ITC, The Netherlands

- Mini-Project Training titled "Rainfall runoff modeling of Bagmati Basin and flood loss estimation of Gaur Municipality"
  Sudarshan Karki, Survey Officer
  Bhadra 2063 - Falgun 2064 (September 2006-February 2007)
  Asian Institute of Technology, Bangkok, Thailand

- GIS Development and GPS Processing Training
  National Geomatic Center of China
  Under Nepal-China Boundary Third Joint Inspection
  Mr. Ganesh Prasaad Bhatta, Chief Survey Officer
  Mr.Krishna Prasad Sapkota, Survey Officer
  25 Bhadra - 3 Aswin 2063 (10-19 September 2006)
  Mr.Niraj Manandhar,Chief Survey Officer
  Mr.Shiba Prasad Lamsal, Survey Officer
  25 Bhadra - 1 Aswin 2063 (10-17 September 2006)
  Beijing, China

- 17th United Nations Regional Cartographic Conference for Asia and the Pacific
  Mr.Toya Nath Baral, Director General
  Mr. Padma Lal Paudel, Survey Officer.
  2-6 Aswin 2063 (18-22 September 2006)
  Bangkok, Thailand

- Group of Earth Observation (GEO) III
  Mr. Tirtha Bahadur Pradhananga, Deputy Director General
  12-13 Marga 2063 (28-29 November 2006)
  Bonn, Germany

- 13th APRSAF
  Mr. Krishna Raj Adhikary, Deputy Director General
  19-21 Marga 2063 (5-7 December 2006)
  Jakarta, Indonesia

- Business GIS Conference bGIS@india
  Mr. Raja Ram Chhatkuli, Programme In-charge,NGIIP, Survey Department
  20-22 Marga 2063 (6-8 December 2006)
  Trivendrum, India

- Executive Seminar on (NMOS) National Mapping Organizations
  Mr. Toya Natrh Baral, Director General
  27-29 Marga 2063 (13-15 December 2006)
  ITC, The Netherlands

- GEOSS-AP Symposyum
  Mr.Toya Nath Baral, Director General
  25-30 Paush 2063 (9-14 January 2007)
  Tokyo, Japan

- International Can Sat Workshop
  Mr. Krishna Raj Adhikary, Deputy Director General
  11-12 Falgun 2063 (23-24 February 2007)
  Tokyo, Japan

Less Means More – NTDB At Scale 1:100 000

Suresh Man Shrestha,
Chief Survey Officer
NGIIP, Survey Department.

Since the very beginning of our childhood we always wished for more and more of many things. We wished more happiness, success, money, satisfaction and so on. Most of the times, we are satisfied if we have more of the things we are looking for. A child is much happy if he has more and more toys to play with. A student waiting for the examination result is wishing more and more marks in each and every subject. An employee naturally wishes for more and more salary from his job. Well, this can be continued for more and more cases. There are things which we always want less and less if not nil. A child naturally wants less and less comments from his guardians, a student wishes for less and less homeworks and so on. Working in the field of mapping and geospatial data, let us think, are there anything, which we want less but at the same time we get much more?

While making maps or creating geospatial data, we always tend to include more and more information as far as possible. But how much of this "more information" is sufficient to meet our desire? Practically, a map or a data storing mechanism has a certain limit to the volume of information it can hold. The first of such limits is imposed by us, by defining the use of a map or a data set. We tend to include that information, which play role in fulfilling our requirements. We can see this clearly in case of most of the thematic maps. Another limiting factor is the space available for showing the information. In case of hard copy maps, the space available is controlled by the map scale and in case of digital data, it is controlled by the space available in the data storage devices. Similarly, the ability of human eyes to discern two or more objects lying side by side also controls the possible volume of information shown in a map.

The information content of base maps is very much critical. By the very definition, a base map should offer as much details as possible. But at the same time we should not forget about the information noise in a map or data. In case of digital data, the volume of information plays a vital role in further processing of the data. Most of the softwares available in market, working with digital data, have their limit in processing the data. Huge volume of data can't be, at least very much time consuming, processed due to limitations of hardwares and softwares.

The question "How much information should be shown in a map or data?" is still unanswered. Traditionally, in different countries different volumes of information are shown in maps of different scales. The information content of maps often reveals the economic and technological achievements of a country.

In Nepal, after a gap of about 50 years, a new series of base maps have been produced during 1990s. Before the publication of these maps, the map users were compelled to use "one inch to a mile" topographical maps published by the Survey of India. The development in the field of digital mapping and geographical information system created a huge demand of digital geospatial data. Being the national mapping agency, Survey Department took the responsibility of fulfilling this growing demand of the map users. The will power of Survey Department of Nepal made it possible to convert all those base maps into the digital form and the digital data are made available to the users.

The feedback from the users revealed some inconveniences in using the data. The data file, a set of individual layers like boundaries, buildings, hydrographic features, landcover features etc., has been managed in the basis of a map sheet creating problems of edge matching between the data files. The projection and coordinate system of data file is same as that of the corresponding map sheet creating problem in displaying the data for most of the data users. This is because of the projection and coordinate system used in the preparation of those maps. For the mapping purpose modified Universal Transverse Mercator Projection (MUTM) is used in Nepal. To keep the deformations within certain limit, the whole area of Nepal has been divided into three 3° zones. For each zone, the intersection of the central meridian and the equator has been considered as the origin for the coordinates with false northing of 0 m. and false easting of 500 000 m. assigned to it. So, for the proper viewing of the data in computer screen, all data should first be converted into single coordinate system.

The data files often contain error prone features in them. During the editing of the data, some features were intentionally introduced to make the processing of the data possible. This is because of the limitation of the software (PC ARCINFO Ver. 3.4.2) used for the creation of the data file.

Survey Department has always done it's best to serve the map users and solve their problems in the field of mapping. Continuing this culture, Survey Department is working on creating data files at smaller scales. It has plan to create data files at scales 1:250 000, 1:500 000 and 1:1000 000. The data files at scale 1:100 000 are already available for the users.

Creating data files at smaller scales means generalizing the data content of larger scale data files. In essence, this means to reduce the number of features in the data files and cover larger ground area in the data file i e. getting more from the less. According to the map sheet layout in practice in Nepal, a data file at scale 1:100 000 covers the ground area covered by 16 data files at scale 1:25 000 or 4 data files at scale 1:50 000. This greatly reduces the problems of edge matching.

Due to technological and manpower constrains, not all aspects of cartographic generalization have been implemented in the data files. Most frequently applied aspect of generalization in creating data files at smaller scales is the selection of features. For example, several building clusters within a specified area defined by a circle of specific radius are represented by a single point. Different types of points present in the data file of buildings viz. residential buildings, religious buildings and other types of buildings are processed separately. Rivers of order 1 are removed if their lengths are less than specific length. Landcover polygons with area less than a specific area are dissolved into neighboring polygon of same category with largest area. Selected category of transportation lines is shown. Other aspects of cartographic generalization can be applied in future as new softwares, capable of performing cartographic generalization, become available. For example, line smoothing, making interrelated features consistent, displace transportation lines in accordance to the contour lines, rearrange administrative boundaries as per the generalized river lines and so on. Similarly, availability of additional attribute information of the features present in the data file can assist in generalizing them in more scientific way. For example, population by settlements may help us in ranking the settlements which may be the input for generalization of settlements.

The data files at scale 1:100 000 are stored in geographical coordinate system. This will solve the problem of displaying the data for most of the data users. Advanced users can display / convert the data file into a projection satisfying their needs. The Everest 1830 Spheroid is used in Nepal for mapping purposes. The major, a and minor, b semi axes radii are 6 377 276.345 m. and 6 356 075.413 m. respectively. The data files at scale 1:100 000 are in ArcView shape file format, which most users are familiar with. This format can be converted into most of the other spatial data formats.

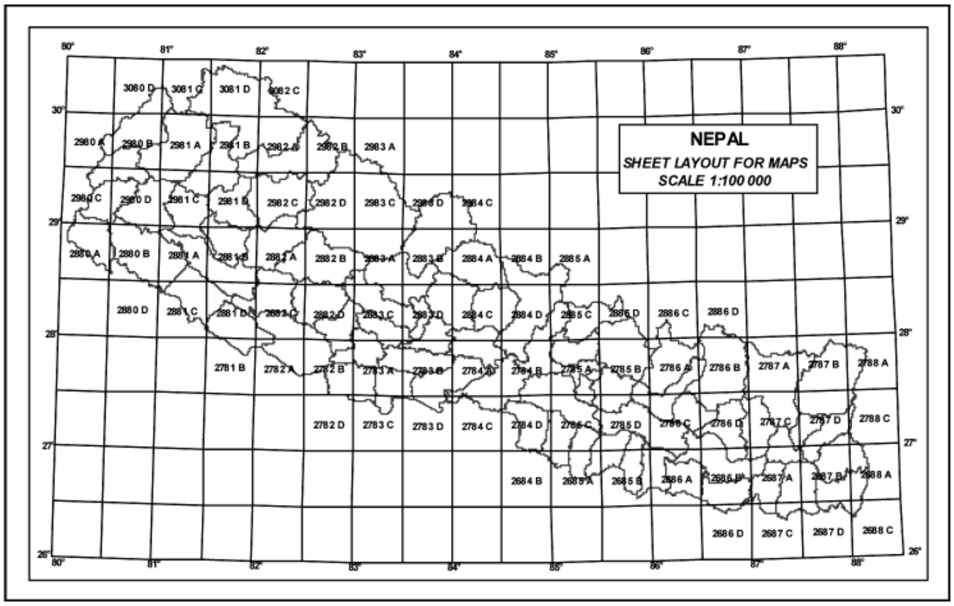
Honoring the requests from the data user side, Survey Department has decided to avail the data of each sheet (1:100 000) according to following pricing system (Table 1).

SN	DATA LAYER	DATA FILE NAME	USER CATEGORY / PRICE		
			A / NRS.	B / NRS.	C / USD
1	Administrative Boundary	ADMIN_AR	500	1000	30
2	Transportation	TRANS_LN	1000	2000	60
3	Building	BUILD_PT	300	600	20
4	Landcover	LANDC_AR	1500	3000	100
5	Hydrography	HYDRO_LN	1200	2400	80
6	Contour	ELEVA_LN	1200	2400	80
7	Designated Area	DESIG_AR	100	200	10
8	Utility Line	UTILI_LN	100	200	10
	DATA FILE		5000	10000	300

Category A: Nepalese researchers, Government organizations, NGOs, Government affiliated;
Category B: Nepalese private companies(consultants, contractors) and
Category C: Foreign organizations, consultants, contractors.

Table 1: Pricing System

The following map shows the sheet layout for data files at scale 1:100 000:



The users interested to acquire the data should write an official letter explaining purpose of data, required sheet numbers, required layers, name and official position of the person who will receive the data and sign the agreement.

The letter should be addressed to The Section Chief, Digital Mapping Unit, NGIIP, Survey Department, Minbhawan, Kathmandu.

2006-2007 at a glance

Radio broadcasting on Surveying and Mapping activities of Survey Department.

A radio program *Hamro Jamin Hamro Napi* has been continued to make aware the general public about surveying and mapping activities of Survey Department. The program is broadcast from Radio Nepal on 1st and 3rd Thursday of every month at 8.15 PM to 8.30 PM.

Third Joint Inspection of Nepal-China Boundary

Fieldwork for Third Joint Inspection of Nepal- China boundary was carried out during April-September 2006 .The main task of the joint inspection was maintenance of boundary markers, GPS observation on the boundary markers and preparation of GIS database of the Nepal-China boundary maps prepared on 1979.

Digital Cadastre Pilot Work Presentation

Mr. Dev Raj Paudyal, Survey Officer Cadastral Survey Branch presented digital cadastral survey work done in Banepa Municipality ward no. 6, on 9th July 2006.Mr. Paudyal briefed the working procedure and findings. Mr. Toya Nath Baral, Director General Survey Department thanked the team and gave directives to overcome the shortcomings.

Discussion program on Cadastral Survey

Cadastral Survey Branch Survey Department organized a discussion program on 29th Aswin to 1st Kartic 2063. The progress of the fiscal year 2062/63 was reviewed and annual program of the fiscal year 2063/64 was discussed. During the closing ceremony of the program chief guest Mr. Prabhu Narayan Chaudhary, the then Minister, Ministry of land reform and management gave directives to solve the problems occurred while establishing the right of the people on land the immovable property.

Mr. Rabindra Man Joshi Secretary Ministry of land reform and management assured that the Ministry will take necessary action to solve the problems concerning cadastral survey and instructed to work taking in to full consideration the aspirations of the general public.

On the same occasion Mr. Toya Nath Baral, Director General, Survey Department stressed in completing the cadastral survey of the remaining village block and acknowledged the necessity of technology transfer in the changed context at present.

Training Courses in GIS and Digital Mapping

Digital mapping (5 weeks duration), Basic GIS (5 weeks duration), and Advanced GIS (2 months duration) was organized by Topographical Survey Branch on 063/5/11, 063/6/24 and 063/7/10 respectively under the annual program of the fiscal year 2063/64.Survey Officers, Surveyors and Assistant Surveyors (all together 15 personnel) participated in the training.

Mini-project Activities.

Mini-Project on Flood: A Mini-Project on flood titled "*Rainfall runoff modeling of Bagmati basin and flood loss estimation of Gaur municipality – Nepal*" was conducted at the Asian Institute of Technology, Bangkok during Aug., 2006 to Feb, 2007. The project was completed in three phases, in which the participants worked in the project at AIT from Aug 28, 2006 to Sep 22, 2006, secondly, an instructor from AIT visited Nepal for field-work in Rautahat and Sarlahi districts from Dec 18, 2006 to Dec 24, 2006, and lastly the participants visited AIT for the final analysis, report writing and presentation from Jan 15, 2007 to Feb 09, 2007. The participants for the project were, Sudarshan Karki from Survey Department, Rishi Ram Sharma from Department of Hydrology and Meteorology and Rajan Shrestha from Department of Water Induced Disaster Prevention. This years Mini-project covered a large area in the field of flood disaster prevention and monitoring. Firstly, Rainfall-runoff modeling was done for the Bagmati catchment from meterological data, which was further used to predict flood levels at different places in the flood plain consisting of the two districts of Rautahat and Sarlahi. Secondly, analysis was done for satellite based rainfall prediction from TRMM (Terrestrial Rainfall Monitoring Mission) versus measured discharge, and a factor to convert between the two developed, which, combined with rainfall-runoff modeling, and would assist in real-time flood forecasting. Thirdly, various flood scenarios were developed for discharges of 2yr, 5yr, 10yr, 20yr, 50yr and 100yr return periods. Fourthly, a community-based survey was done in Gaur municipality to assess the damage from some major floods in the past 15 years. This was then used to generate 36 loss-functions for various types of buildings and land-use. Lastly, combining all these, direct flood loss estimation was done for Gaur municipality for the 50yr flood. Hazard maps, vulnerability maps, risk maps, rainfall-runoff conversion model, loss functions, an early warning system, a poster, an web page and a 90 page report were the outcomes of this study, which is expected to be an useful tool in the hands of planners, local authorities, relief organizations etc.

MOU signed

Survey Department has signed a memorandum of understanding with Joint Project Office-Sapta Koshi Sun Koshi Investigation (JPO-SKSKI) in October 15^{th} 2006 and has initiated activities under the MOU by establishing Sapta Koshi Sun Koshi Topographic Mapping Project.

Membership of International professional organization

Survey department became the JPT member of Sentinel Asia. The Membership was awarded by JAXA .

Membership of International Professional society

Program In-charge of National Geographic Information Infrastructure Programme Mr. Raja Ram Chhatkuli has been nominated as the advisory member of the newly established Trans Asiatic GIS Society (TAGS) representing Nepal. He is also member of the organizing committee of the first Business GIS Conference b-GIS @Asia to be organized by TAGS during 17-19 December 2007 at Techno park, Trivandrum India.

Monitoring Land Cover Change In Kathmandu City Using Spatial Metrics And Remote Sensing Techniques

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Keywords: *Land cover change, spatial metrics, image classification, urbanization in Kathmandu*

Abstract

This paper explores the urban land cover changes in Kathmandu city area in the past one and half decades. Multi-temporal satellite images and spatial metrics were used to quantify the land cover changes. The study area was setup to 10x10 km covering the Kathmandu metropolitan area. After pre-processing the satellite images, supervised classification with maximum likelihood classifier was applied to create thematic urban land cover maps. Random sampling method was used to create geographic points for each thematic map to assess the accuracy of the maps. Five land use classes: urban builtup area, cultivated land, orchard, water and natural vegetation were identified. For detecting land cover changes quantitatively, a land use land cover conversion matrix was computed between the year 1989-1999 and 1999-2005. Spatial metrics (patch density, largest patch index, edge density, Euclidian nearest neighbor mean, contagion index and area weighted mean patch fractal dimension index) were computed to evaluate landscape structure of the metropolitan area.0The overall result shows rapid expansion of urban built environment and shrinkage of the agriculture land. The agriculture and orchard lands were mostly transformed into urban uses. The existence of water and vegetation were found very low as compared to other land covers. The urban expansion trend was confined in the peri-urban of the urbanized territory. The overall urban landscape seems to be very complex and fragmented in later years.

1. Introduction

Urbanization is regular socioeconomic process that induces a general transformation in the landscape. Rapid urbanization is a global phenomenon, and cities require an increasing amount of land and other resources. Urban environment has emerged as a primary concern for city planners and the urban residents. Understanding the dynamics of complex urban environment and solving the real world problems necessitate robust method and technologies for urban resources managers. Remote sensing technology has great potential for acquisition of detailed and accurate land use/cover information for management and planning of urban regions. The urban environment represents one of the most challenging areas for remote sensing analysis due to high spatial and spectral diversity of surface materials (Herold et al. 2003; Maktav et al. 2005; Torrens 2006). In recent years, series of earth observation satellites are providing abundant data from high resolutions (i.e. QuickBird, IKONOS, OrbitView, SPOT, ALOS) to moderate resolution (i.e. ASTER, IRS, Landsat) for urban area mapping. However, remote sensing data from these systems have a specific potential for detailed and accurate mapping of urban areas.

With the advancement in remote sensing (RS) and geographic information system (GIS) techniques, characterizing a landscape and quantifying its structural change has become possible in recent years (Donnay et al. 2001; Maguire et al. 2005). Remote sensing provides an efficient tool to monitor land use/cover changes in and around urban areas since the past three and half decades. With time series satellite data we can monitor long-term changes (Herold et al. 2003; Thapa et al. 2005) whereas GIS provides a framework for spatial analysis and modeling based on geographic principles and seeks to integrate the analytical capabilities to broaden the understanding of the real world system (Murayama 2001; Maguire et al. 2005).

The populations and socio-economic domain have changed the urban land use pattern in Nepal significantly. The population has significantly increased within the period of 1952 to 2001 with the annual growth rate reaching 6.6% in 2001 (Sharma 2005) (Figure 1). The ever-growing demand for urban services and deteriorating urban environment in the context of limited capacities and resources pose a serious challenge for the country (Pradhan and Perera 2005; Haack and Rafter 2006; ICIMOD 2007). Rapid urban growth in Nepalese cities has prompted concerns over the degradation of environmental and ecological health (National Planning Commission 2003; Dhakal 2003). Many agricultural and forest lands have been converted into urban areas and human settlements. Visual comparison of the images also shows the increase in the number of houses between 1967 and 2001 with almost all the agricultural and vacant spaces occupied with built up areas (Figure 2).

Satellite based Normalized Differential Vegetation Index (NDVI[1]) of past 15-years presents deteriorating agriculture and natural vegetation land covers in Kathmandu metropolitan city (Figure 3). These land covers may be covered by the urban infrastructures, residential and commercial buildings in recent years. Business opportunities, commercial and social interests, and security risk created by political turmoil after restoration of democracy in 1990 have increased the people movement to the valley from other areas in Nepal (Haack and Rafter 2006). The population density of Kathmandu metropolitan city has been boosted from 8,370 persons/km^2 in 1990 to 13,235 persons/km^2 in 2001 (Figure 4). High population influx and uncontrolled momentum of urban sprawl may cause a serious pressure to the limited resources with adverse impact to the environmental conditions and livelihoods of inhabitants in the Kathmandu valley. The main objective of this paper is to

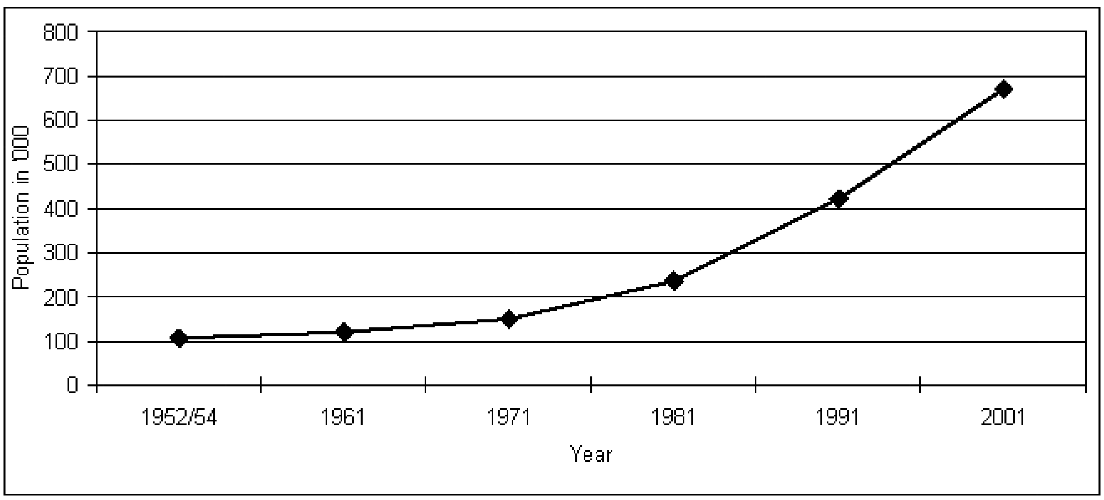

Figure 1: Population change in Kathmandu city (Sharma 2005).

Figure 2: CORONA satellite image acquired in 1967 (left) and IKONOS satellite image acquired in 2001 (right).

1. NDVI is an index that computes a ratio of coefficients based on the spectral responses reflected from land covers in red and near infrared bands of satellite sensors. High coefficients represent existence of healthy vegetation in particular geographic areas.

monitor the land cover change in Kathmandu metropolitan area using time series remote sensing data and spatial metrics.

In this study, we describe a technique to quantify spatial urban patterns from moderate resolution optical remote sensing data to describe structures and changes in urban land use/cover. Multispectral optical remote sensing allows an accurate separation of diverse urban land-cover types (including built-up areas, vegetation, and water) to derive accurate thematic land-cover maps. However, residential and commercial urban land-use categories typically cannot be accurately discriminated by applying per-pixel analysis methods. Spatial and textural context is important information for understanding urban area landscape. Therefore, we utilize spatial metrics as quantitative measures of spatial structures and pattern to describe urban land-use features.

2. Method

hree remote sensing images (Table 1), two from Landsat and one from IRS satellites, were processed for identifying the urban land use/cover changes patterns. Multi-sensor and multi-temporal data are useful for assessing change dynamics but seasonal variances could affect the images for quantitative analysis (Thapa *et al* 2005). In order to avoid the influences of cloud cover and seasonal variances, the images are selected from same season (winter). The images were processed using ERDAS Imagine 9.0 software. Remotely sensed data always experience some geometric distortions due to various causes such as earth's rotation, platform's instability, etc. (Richard and Jia 1999). A GIS based road layer was prepared for the Kathmandu valley using 1:25000 scale topographic maps obtained from Survey Department, Nepal. This road map was employed for rectifying the geometric distortions in the images. Sixteen evenly distributed ground control points were used for rectifying the images. A first order polynomial geometrical model with bicubic spline algorithm was applied to correct the geometry of the images. In order to compute the change by pixel, the LISS III image was resampled from 24-meter to 30-meter as same as resolution of Landsat images. The root mean square errors for all three images were maintained less than 0.5 pixels. The UTM, WGS84 North, Zone 45 projection system was used. The images were further resized into 10x10 km of spatial extent covering the whole Kathmandu metropolitan city.

Five land use/cover categories (i.e. urban builtup area, cultivated land, orchard, water and natural vegetation) were schemed based on NDVI index analysis, unsupervised classification (ISODATA algorithm), knowledge-based visual interpretation, and texture and association analysis. The urban builtup area class covers the commercial and residential houses, road and other urban structures. The land covered by the basic agriculture such as paddy, maize, vegetables are categorized into cultivated land. The orchard indicates the gardening near by the urban houses, horticulture, parks and bare land.

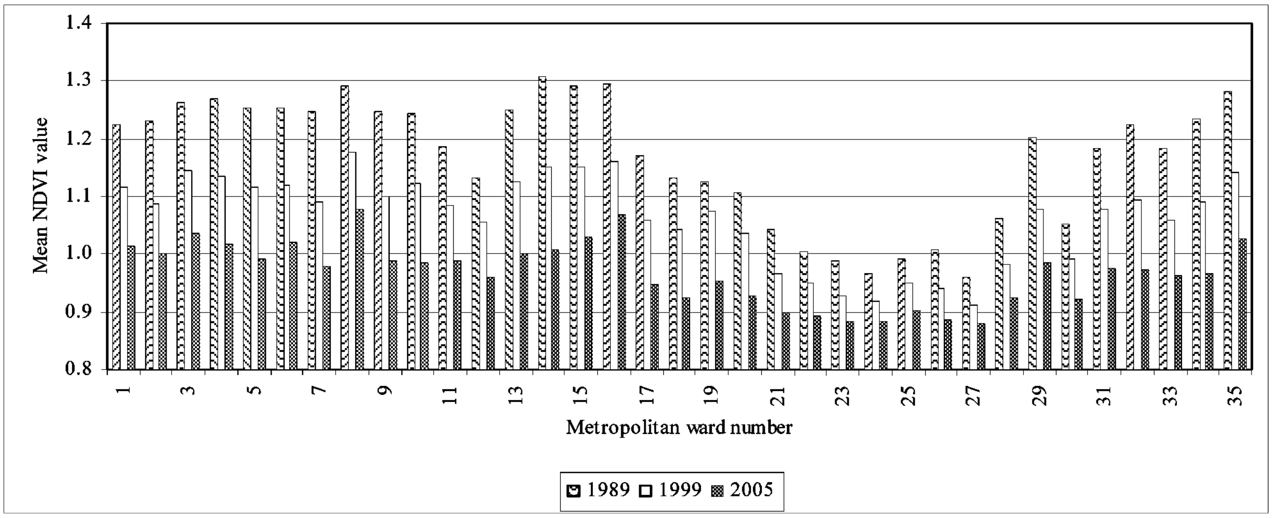

Figure 3: Land cover change in Kathmandu metropolitan area using NDVI of Landsat 1989, 1999 and LISS III 2005 images of winter season.

Table 1: Database description

Satellites	Date	Resolution
Landsat TM	31-10-1989	30 meters, 6 channels
Landsat ETM	04-11-1999	30 meters, 6 channels
IRS LISS III	18-12-2005	24 meters, 4 channels

Urban areas typically exhibit a spatially heterogeneous land cover and there is probability of similarity in spectral response from the different land cover and land uses in this environment (Johnsson 1994). Supervised classification approach tackles such problems through the statistical classification techniques using a number of well distributed training pixels. These training pixels as representative of land use class are used to calculate descriptive statistics (e.g. mean and variability) for each class (Hubert-Moy *et al*.2001, Racolt *et al*.2005). The basis of the class descriptions derived, each pixel is allocated to the class with which it has the greatest similarity, as assessed relative to the classifier's decision rules. Maximum likelihood classification, for example, labels each pixel as belonging to the class with which it has the highest posterior probability of membership (Lillesand and Kiefer 1994, Jensen 2005). The maximum likelihood classifier, often used in supervised classification which is a parametric decision rule developed from statistical decision theory that has been applied to problem of classifying image data (Richard and Jia 1999). Supervised classification technique with maximum likelihood classifier was implemented while preparing the thematic urban land cover maps for 1989, 1999 and 2005. More than 30 geographic training samples for each image were collected for the classification. After obtaining a suitable indication for satisfactory discrimination between the classes during spectral signature evaluation, the supervised classification process was run. The 3x3 majority kernel filter was used as post classification process in the classified maps in order to remove salt and pepper noises.

The accuracy assessment in remotely sensed image classification is necessary for evaluating the obtained results (Congalton 1991). This will allow a degree of confidence to be attached to those results and will serve to indicate whether the analysis of objectives has been achieved. Randomly selected reference pixels lessen or eliminate the possibility of biasness. Reference pixels represent geographic points on the classified image for which actual data are known. The reference data are often derived from field survey, high resolution satellite imageries or aerial photographs. A set of reference pixels is usually used in accuracy assessment. Hundred geographically allocated random points were created for each thematic map for accuracy assessment. These points were further verified with aerial photos, IKONOS image acquired in 2001 and Google Earth explorer. Kappa index is computed for each classified map to measure the accuracy of the results. The Kappa coefficient expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification. Kappa accounts for all elements of the confusion matrix and excludes the agreement that occurs by chance. Consequently it provides a more rigorous assessment of classification accuracy. The accuracy of classification results achieved were 91% (Kappa=0.87), 92% (Kappa=0.88) and 91% (Kappa= 0.86) for the year 1989, 1999 and 2005, respectively.

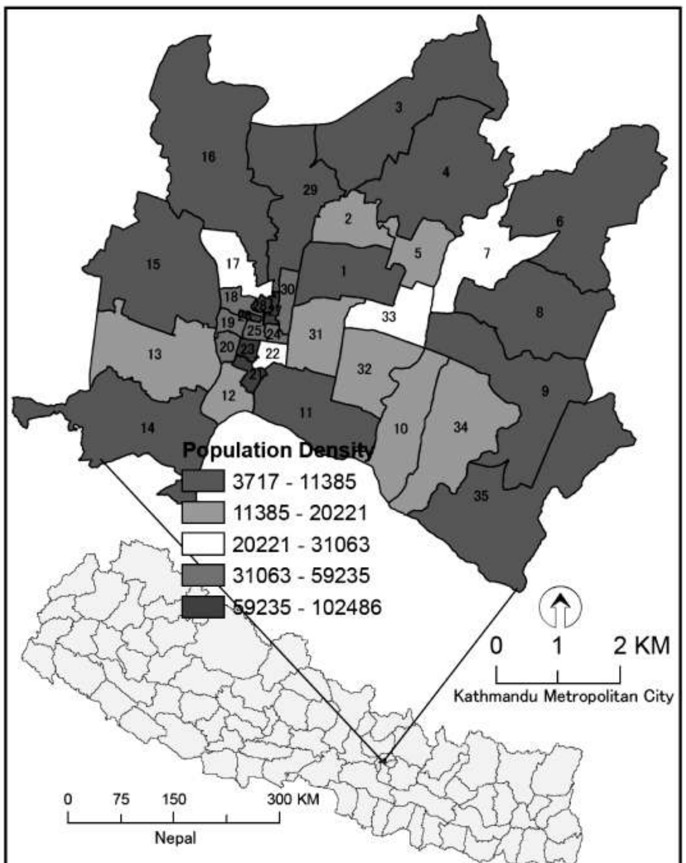

Figure 4: Population density/km^2 (2001) by ward number in Kathmandu metropolitan area.

Land use/cover conversion matrix was computed for analyzing detailed land use change patterns in the study area. The matrix is a useful tool which has been widely accepted in land use change analysis (Tang *et al*. 2005; Yu and Ng 2006; Thapa and Murayama 2006). Spatial metrics are developed based on information theory and fractal geometry. The metrics provide a means for quantifying spatial heterogeneity of individual patches, all patches in a class, and over the whole landscape as a collection of patches. Numerous metrics have been developed to quantify landscape structure and spatial heterogeneity based on landscape composition and configuration (McGarigal and Marks 1995; Herold *et al*. 2003, Torrens 2006). Important applications of spatial metrics include the detection of landscape pattern, biodiversity, and habitat fragmentation (Keitt *et al*, 1997), the description of changes in landscapes and the investigation of scale effects in describing landscape structures (O'Neill *et al*, 1996). In this study, we selected patch density (PD), largest patch index (LPI), edge density (ED), Euclidian nearest neighbor mean (ENN_MN), contagion index (CONTAG) and area weighted mean patch fractal dimension index (AWMPFD) to evaluate the configuration of the Kathmandu metropolitan landscape. The selection of the indices was based on their value in representing specific landscape characteristics as already explored in previous research on urban areas.

3. Results and discussions

The vegetation index (NDVI) has produced relative results based on electromagnetic spectrum recorded in the images. It enhances the chlorophyll properties of healthy vegetation significantly. The mean score of the index (Figure 3) was computed at ward level for Kathmandu metropolitan city to present the environmental changes in respect to the vegetation, agriculture and urban activities. The high score of the NDVI represents the majority of the vegetation covers. The index shows decreasing trend of vegetation during the last 15-years period which might be replaced by the urban built environment as the urban population density increased significantly. High speed of urbanization is observed after the political change in 1990. Therefore, the multi-spectral images (after 1989) were used to evaluate the land use/cover changes in the city. Figure 5 presents the land use/cover maps (a, b, c) and changing patterns of the land uses at quantitative level (d) for the years 1989, 1999 and 2005. The figures clearly show the small coverage of urban built-up area until 1989. In later years, shopping malls, residential house, road networks are being constructed in the city, which has consequently lead to expansion of urban built-up area over the cultivated and orchard lands which could be a breeder of many environmental consequences currently faced in the city.

Each pixel for the first year was compared to the same pixel location in the second year and similarly second year to the third year (Table 2). The most obvious changes were the conversion of orchard and cultivated land to urban [1675.3 ha, 1284.6 ha land was commissioned during the period of 1989-1999 and 1999-2005, respectively]. It seemed the areas classified as orchard near by the houses were converted to the urban structures. A mutual land conversion is observed between the orchard and cultivated land, for example, 1011 hectare of orchard land was transformed to cultivated land during the period of 1989 to 1999 then in later years, the cultivated land was used for orchard. About 111 hectare of natural vegetation area was also consumed for the urban construction during 1999. The lower rate of the natural vegetation replacement was found in later years. The water bodies also became duly dry which could be due to collapse of many aquatic functions, for instance, fish ponds in Balaju area. Some hectare of urban land was transformed to other land use/cover categories but with a very low proportion of change. However, additional 1629 hectare land has been urbanized during the last 15 years where the cultivated land has been lost by 1374 hectare.

A slight change is observed in PD, CONTAG and ENN_MN indices (Figure 6). It means the trend of land use change has remained somewhat same in the past fifteen years. However a slight change in aggregation of land use in city center may result the improvement in large patch index evidenced by showing increasing pattern of LPI and decreasing trend of mean nearest distance (ENN_MN) in later years. The LPI in 1989 was the lowest as compared to the later years. This may be due to newly developed shopping malls, residential areas, and wider roads in the city. Squatter settlement is being grown in the suburb area of the metropolitan which helps to fragment the large patch

Table 2: Land use conversion matrix of Kathmandu city between 1989 and 2005 (hectare)

Class	1989 In Total	1	2	3	4	5	1999 In Total	1	2	3	4	5	2005 In Total
1	2639.8	1999.9	354.8	238.1	31.2	15.8	3809.7	2948.6	170.8	614.4	17.9	58.0	4268.9
2	3311.2	497.4	2069.4	713.2	14.4	16.8	3523.8	885.6	1292.1	1330.7	0.9	14.4	1933.3
3	3363.5	1177.9	1010.6	1111.7	24.8	38.4	2350.9	399.0	456.8	1364.2	2.2	128.7	3406.3
4	84.7	23.6	14.7	18.0	27.2	1.3	148.0	28.9	10.7	50.9	10.8	46.6	33.4
5	1116.8	1110.9	74.3	270.0	50.3	611.3	683.6	6.8	2.8	46.0	1.6	626.4	871.1

Note: 1 = Urban Built-up area, 2 = Cultivated Land, 3 = Orchard, 4 = Water and 5 = Natural Vegetation

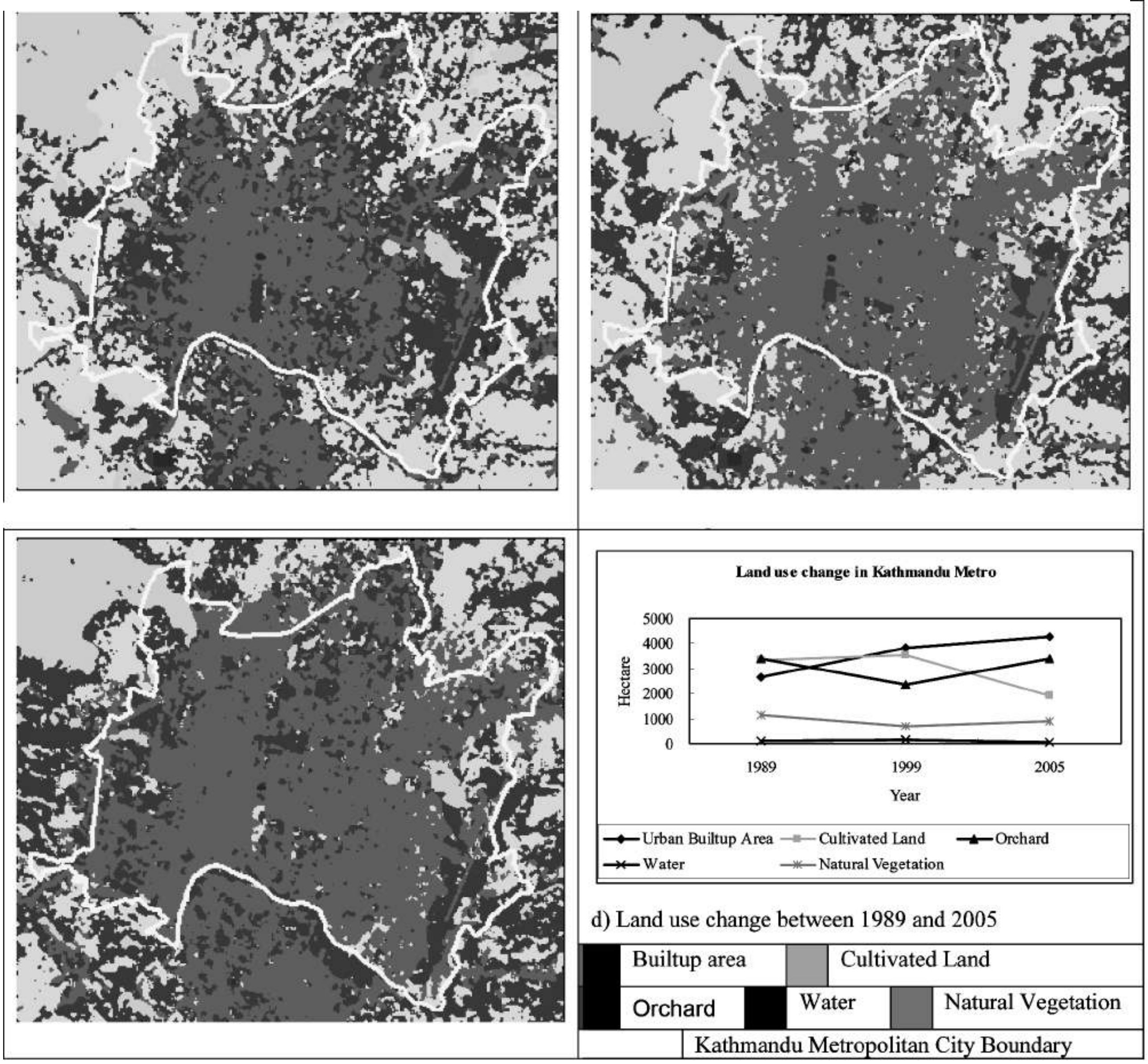

Figure 5: Land use/cover map of Kathmandu Metropolitan City during 1989-2005 (Area: 10Km X 10Km)

of agricultural land. Such activities have been observed more amplified after 1999 which was clearly measured by the AWMPFD index showing an increase in the year 2005. The ED measures the total length of the edge of the land use/cover patches that increases when land use fragmentation is heightened. Constructing more individual houses in agricultural spaces helps to enhance more fragmentation of the lands. The ED has increased in the metropolitan landscape but not as sharply as AWMPFD. The ED and AWMPFD may decline when the spaces between the individual patches are urbanized. In case of Kathmandu metropolitan landscape, still some agricultural lands are left to be urbanized in fringes. Constructing commercial and residential houses in the Kathmandu city are widely observed in the last fifteen years. Land brokers are very active to trade lands of urban fringe to individual land users which makes the large patches of agricultural lands fragmented in later years as evidenced of increasing in fractal dimension index (i.e. AWMPFD) and showing straight line of CONTAG index. However, the rate of urban fringes shaping to urban is escalating faster and faster. The urban expansion and subsequent landscape changes are governed by population growth, geographical and socio-economical factors and government policies. After restoration of democracy in 1990, there have been major changes in government policy, such as direct foreign investments, participation to the global trade, open market, opening of foreign labor market, etc.

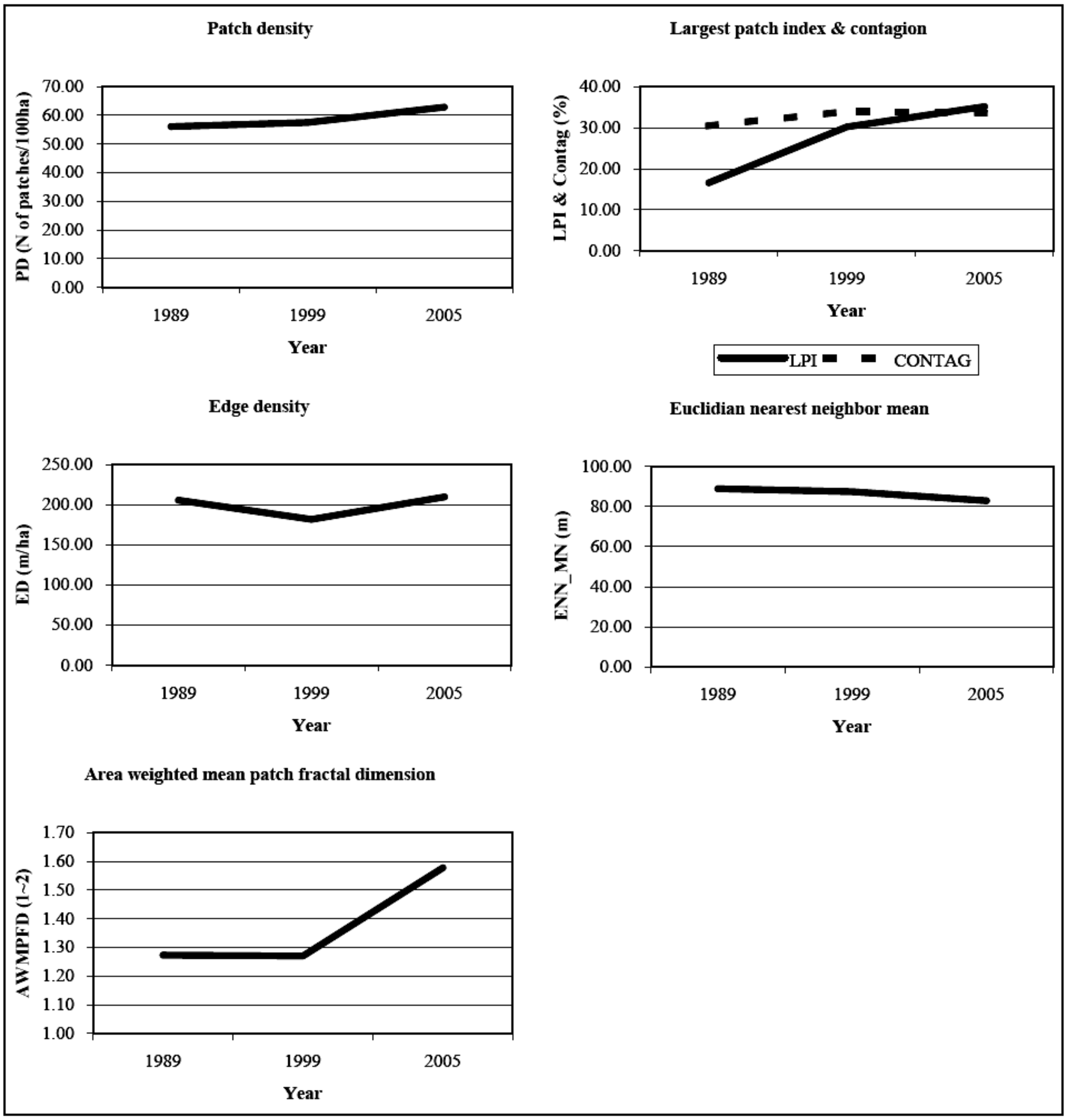

Figure 6: Landscape structure change in Kathamandu Metorpolitian Area (1989-2005)

4. Conclusions

Due to high spatial and spectral diversity of surface materials in urban area, the complexity of urban environment is one of the most challenging areas for remote sensing analysis. However, multi-temporal Landsat and IRS satellites imageries are found useful to detect the major land use/cover changes in the Nepalese capital city. The approaches allowed a separation of urban land use categories and description of its changes providing a robust quantitative measure of the spatial urban configuration. Rapid land cover change in the metropolitan area was observed in recent years. Agricultural land was significantly transformed to urban uses. The urban built environment was further stretched by additional 1629 hectare whereas 1374 hectare of cultivated land was diminished. The overall result showed rapid expansion of urban built environment and shrinkage of the cultivated land. The urban expansion trend was confined around the fringes of the urbanized periphery during the past fifteen years. Overall configuration of urban landscape seemed to be more complex and fragmented in later years. However, the aggregation of urban structures is being improved as urban builtup area expands but it may help to fragment other land use categories such as agriculture land and forest land. This extensive growth of urban area may create difficulties in the lack of adequate infrastructure and also various negative environmental impacts, for example, the most obvious changes faced in recent years are the loss of valuable agricultural lands and increased air and water pollution. Thus, the combined approach of remote sensing and spatial metrics is useful in improving thematic mapping of complex urban environment.

Acknowledgement

Two scenes of Landsat satellite image for 1989 and 1999 used in this study were acquired from Global Land Cover Facility (GLCF), University of Maryland. The GLCF program is greatly acknowledged.

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NSDI Initiatives in Nepal : An Overview

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Keywords: *NSDI, Geo-information, Clearinghouse, Metadata, Partnerships*

Abstract

Geospatial data, information and technologies are becoming more important and more common tools throughout the world because of their capacity to improve government and private sector decision making. Geospatial information is developed, used, maintained and shared in a various range of application areas. Sharing geospatial data in various applications helps to improve the management of public infrastructure and natural resources and further, it minimizes the duplication of resources invested in producing geospatial data. Many nations around the world are developing National Spatial Data Infrastructures (NSDI) to help facilitating cooperative production, use and sharing of geospatial information. In Nepal, NSDI initiatives have been taken through the National Geographic Information Infrastructure Program (NGIIP) under Survey Department, the National Mapping Organisation (NMO) of Nepal, since 2002.

Due to various reasons, the NSDI initiatives in Nepal have not come to full functional stage yet. Various issues related to the development of full functional NSDI in the country are to be taken into consideration. This paper tries to give an overview of the state-of-the-art of the initiatives to suggest better way out for full functional NSDI in Nepal.

1. Introduction

Geographic information or Geoinformation or better still Geospatial information (GI) is beginning to provide the common language and reference system to establish linkages and balance between economic, environmental and social capital in order to improve upon the basis for societal response (Adeoye, 2006). Geospatial data, information and technologies are becoming more important and more common tools throughout the world because of their capacity to improve government and private sector decision making (Lachman, et. all, 2001). The importance of GI to support decision making and management of the impacts caused by environmental deterioration has been recognized at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (in connection with the implementation of Agenda 21). A landmark effort was made to illustrate the capabilities, benefit and possibilities of using online digital geographic information for sustainable development at the World Summit on Sustainable Development in Johannesburg in 2003 (SDI Cookbook, 2004). It is, indeed, doubtless to advocate in favor of the importance of GI in sustainable development and comprehensive decision making.

Various kinds of GI are required for various purposes. Information is an expensive resource, and for this reason appropriate information and the resources to fully utilise this information may not always be readily available, particularly in the developing world (SDI Cookbook, 2004). As it requires expensive investment, a single organization cannot produce in a given timeframe all sorts of value added geo-products demanded by a user. Global scenario reveals that to solve many different problems, many different organisations are creating GI using different methods and technologies. In most of the cases, GI, created thus, are hard to find, difficult to access, hard to integrate, out of date, undocumented and incomplete (Lance, 2001).

Various efforts have been made in the GI domain to optimize its application. GI is developed, used, maintained and shared in a various range of application areas. Many national, regional, and international programs and projects are working to improve access to available spatial data, promote its reuse, and ensure that additional investment in spatial information collection and management results in an ever-growing, readily available and useable pool of spatial information (SDI Cookbook, 2004). However, the situation is not the same at every part of the world.

2. Why National Spatial Data Infrastructure?

If the benefits of the wider usage of GI within countries are to be realised then good quality and current geo-spatial information must be widely available to all stakeholders, easily accessible and interoperable with business information, applications and services. The most recognizable technique to make geo-spatial information more readily available in spatially enabled business applications and services is through a Spatial Data Infrastructure (SDI) (McLaren, 2006).

SDI is the relevant base collections of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data that provide a basis for spatial data discovery, evaluation, and application for users and providers within all levels of the government, the commercial sector, the non-profit sector, academia and citizens in general. SDI activities may be based on local, national, regional and global level.

Many nations around the world are developing National Spatial Data Infrastructures (NSDI) to help facilitating cooperative production, use and sharing of GI (Beth E. Lachman, et. all, 2001). NSDI encompasses the technology, policies, standards, and institutional arrangements necessary to acquire, process, store, distribute, and improve the utilization of spatial data from many different sources and for wide group of potential users at national level. It is a mechanism in which organisations and individuals are cooperating, using electronic technology to help finding and sharing of GI, following mutually accepted standards, and establishing policies and plans that ensure the flow of the data between different agencies (Lance, 2001).

Barriers on using Geoinformation identified by (NGII Finland, 1996) as following are also the most significant barriers restricting the use of geographic information in Nepal:

- geographic information technology is not well known
- geographic datasets are not known or the coverage of them is not satisfactory
- benefits are not explained in a concrete manner
- data cannot be reliably combined
- data is out of date or of poor quality
- clear principles for pricing, copyright and privacy protection are missing

These barriers have further restricted the availability of adequate geoinformation required for national development. One of the weaknesses of the Nepalese management process is lack of adequate geographic information in decision making thus resulting in poor management. To support this gap, the Government of Nepal initiated National Geographic Information Infrastructure (NGII) Program since 2002 (Chhatkuli, 2003). Survey Department, the National Mapping Organisation (NMO) of Nepal, is responsible for this initiative. NGII is the SDI initiative in the country at the national level (Chhatkuli and Kayastha, 2005).

3. State of the Art of the Nepalese NSDI Initiatives

As mentioned above, NSDI initiatives in Nepal have been taken since 2002. The initiatives were taken through NGII Program with one of the pronounced objectives of avoiding duplication in spatial data creation and usage through the networking of different GI Systems in the country. The overall objective of the initiatives is "To strengthen planning and resource management through the availability of geographical information necessary for decision making"(Chhatkuli, 2003). The initiatives are being handled as a project National Geographic Information Infrastructure Project (NGIIP) under Survey Department, since the beginning. Due to various reasons, the initiatives have not come to full functional stage yet.

Like many SDI initiatives, the approach undertaken in Nepal is rather a bottom-up approach, with an initiation for making the best use of already available resources: framing policies to accommodate already available data, technology and the intuitional framework (Kayastha and Chhatkuli, 2005).

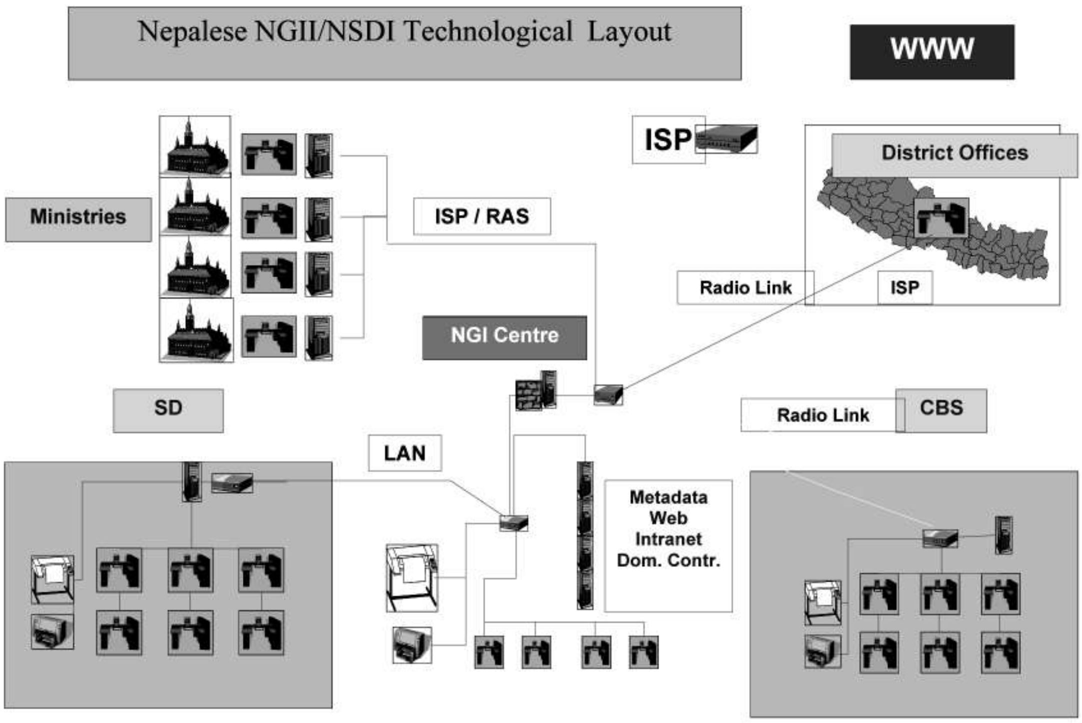

Figure 1: Technological Layout of Nepalese NGII/NSDI (Source: NGIIP Presentation Slides)

The achievement of the initiatives in terms of the core components of NSDI (as shown in figure 3) can be listed as follows:

Framework data: Framework data is also referred to a fundamental data or core data or reference data. It is a base on which other themes of data can be compiled. It includes base layer, which is a foundation to which spatial information and attributes can be added. It also includes mechanisms for identifying, describing and sharing the data using features, attributes and attribute values.

Different layers of Digital Topographic Database and nationwide geodetic control network are available at Survey Department that can be used as framework data.

Geo- Data (Geospatial / Geographic) data: Geo-data is also referred as thematic data. It includes georeferenced data and information that is used for specific purpose.

Other geo-data or thematic data produced by different organisations for their specific uses, can be regarded as geo-data in this context.

Metadata: It is a data describing the existing data in terms of holding, content, quality, condition, and other characteristics. This permits structured searches and comparison of data in different clearinghouse nodes and gives the user suitable information to find data and use it in an appropriate way.

Metadata of the National Digital Topographic Database, produced by Survey Department, has been published the NGII Web-portal or clearinghouse. Some other governmental agencies are requested to make available the metadata of their products for publishing. However, none of other organisations have made it available. The metadata, whatever is published is in FGDC, ESRI and XML format. The clearinghouse has also provided the facility of digital application for publishing the metadata.

Clearinghouse: It is a web enabled system or an interface facilitating discovery, evaluation and downloading of geospatial data or information. It usually consists of a number of servers on the internet that contain information about metadata.

An NGII Web-portal constituting an electronic clearinghouse has already been launched. It can be accessed through . Following functionalities are made available:

- Metadata System: The metadata system incorporates the facilities to metadata entry and metadata search.
- Interactive Mapping Application: Under this

functionality, interactive mapping applications can be performed. The administrative maps produced by Survey Department and Census data produced by the Central Bureau of Statistics are used for this purpose.

- Downloadable data: At present, sample data is downloadable in .jpg format
- Census Atlas: Population and Socioeconomic Atlas of Nepal produced out of the census result of 2001 is available in digital form.

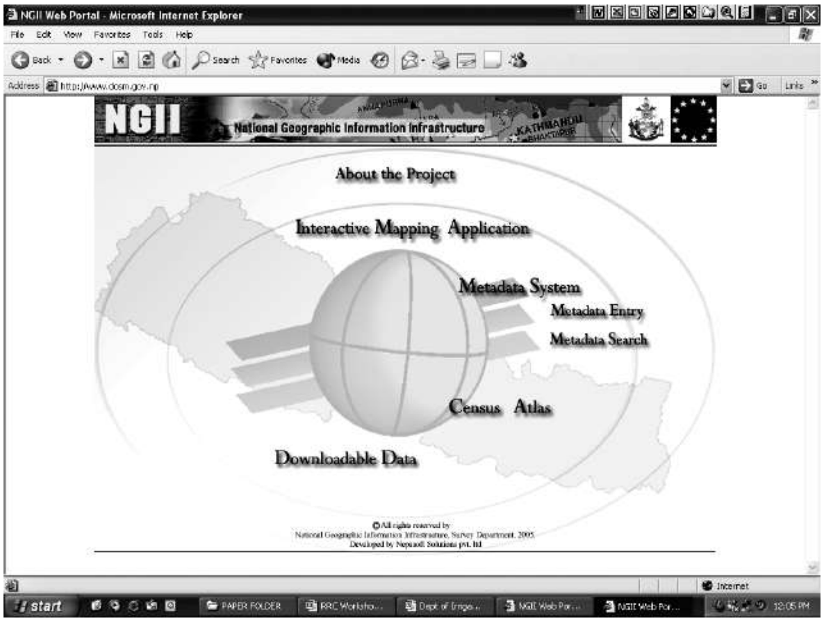

Figure 2 : NGII Web portal of Nepal / Nepalese Clearinghouse

Partnerships: Partnership is an important component of developing SDI in the country. It can contribute in avoiding duplication of efforts and the cost of production of geo-data/ information. It permits sharing and exchange of geo-data / information. The partnerships can include institutions in the government, industry, academia, societies and individuals.

In the beginning of NSDI initiatives in Nepal, six governmental agencies participated the program: Survey Department, Central Bureau of Statistics, Ministry of Local Development, the then Ministry of Population and Environment, Ministry of Agriculture and Co-operatives, and Ministry of Health / Department of Health Services. It was expected that other agencies would slowly participate the initiatives but none of other organisations have shown their interest yet. Central Bureau of Statistics (CBS) has strongly supported the initiatives since the beginning.

Standards: Standards allow NSDI to function and ensure compatibility/interoperability of GI. It facilitates the sharing of information, created and accepted at Local, National, and Global levels.

As per the Land (Survey & Measurement) Act, 1963 (8th Amendment, 2000) and Land (Survey and Measurement) Regulation, 2001 Survey Department is the responsible organisation to develop and implement norms, standards and specification of surveying and mapping activities in the country. Based on this provision, Survey Department has also developed certain standards and specifications for producing GI in digital form. The department expects these specifications and standards to be followed by all the organisations involving in GI business in the country. It would be better for such organisations to consult with Survey Department for the standards to be followed so that it would be compatible with the GI produced by other organisations.

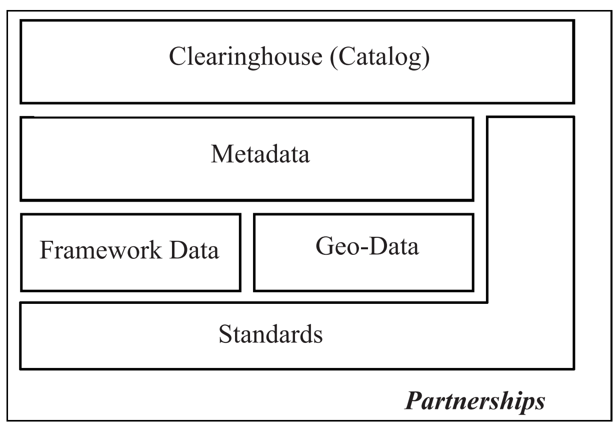

Figure 3 : Core components of NSDI

4. Efforts of Survey Department for developing NSDI

Survey Department is making its best efforts to develop appropriate NSDI set up in the country to support the activities of national development. Timely initiation through NGIIP itself is an admirable effort. Some of the major efforts in the line to develop appropriate NSDI in the country are given below:

Programs for Awareness:

NSDI initiatives have been evolved through consultations with stakeholders, high level decision makers / policy makers / bureaucrats. Various talk programs, discussion programs and interaction programs have been conducted inviting high level personalities from stakeholder organisations. These programs had two main objectives; one to aware the organisations about the essence of NSDI in the country and the other to acquire valuable suggestions for developing effective NSDI in the country. Some of the major programs can be listed out as follows as an example of the efforts:

- Discussion forum on National Geographic Information Infrastructure (NGII) (March 7, 2002)
- Workshop on the Role of Survey Department in the Context of National Geographic Information Infrastructure (NGII) in Nepal (October 20-21, 2003)
- Colloquium on the Role and Functions of Survey Department in the Context of Broader Technological Development (March 4-5, 2005)
- Consultative meeting on Metadata, Clearinghouse and National Geoinformation Infrastructure Networking (March 31, 2006)

In spite of these programs, radio programs have been broadcasted many times, through the quarterly radio program *"Hamro Jamin, Hamro Napi"* of Survey Department to aware user community on the essence and potential benefits of NSDI in the country.

Request for Participation

Stakeholders, mainly from government organisations, are being requested formally and informally for participating the initiatives from the very beginning. Especially, the stakeholder organisations are requested to make available the metadata of the GI they possess to publish on the Clearinghouse.

Exposure at International forum

Survey Department is affiliated with many international professional organisations like International Federation of Surveyors (FIG), International Steering Committee for Global Mapping (ISCGM), Asia Pacific Regional Space Agency Forum (APARSAF), Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP), Group on Earth Observation (GEO), Asian Association on Remote Sensing (AARS) and most importantly Global Spatial Data Infrastructure Association (GSDIA). Affiliation with such organisations provides opportunities to expose the initiatives in the international forum of experts so that international support in many aspects related to NSDI could be achieved. Further, with this exposure the department is, some how, in the state to introduce innovative approaches and technologies in this field.

Institutional Model Proposed:

The NSDI initiatives are under progress through NGII Project of Survey Department till the date. As the activities cannot be effectively launched through a project approach, like NGIIP, Survey Department has proposed an Institutional Model as following (figure 4). A Three-tier organizational model (Policy executive, Management executive and Implementation Executive) under the umbrella of National Planning Commission (NPC) has been proposed. It is expected that broader coverage of stakeholders could be done with this organizational model.

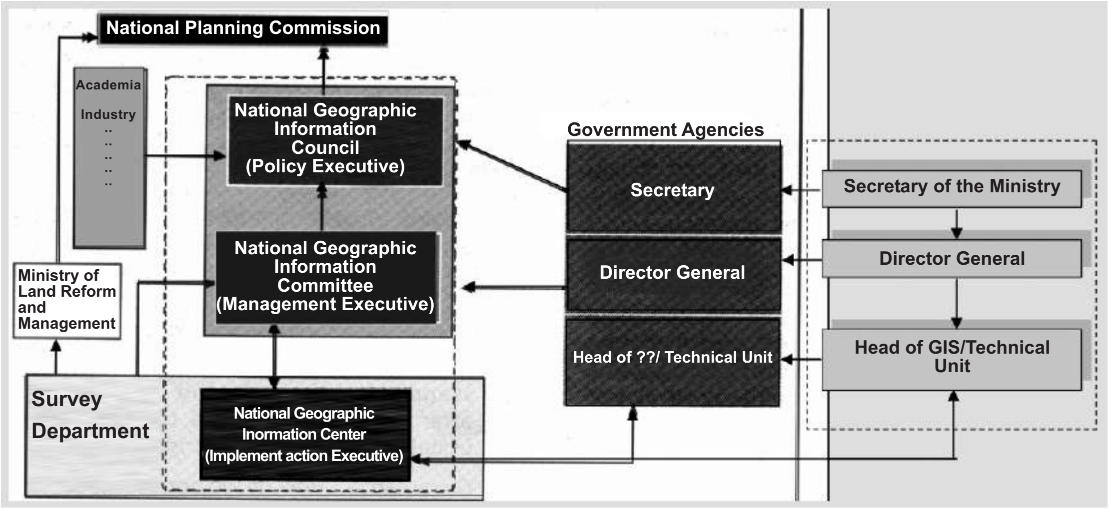

Figure 4: Proposed Institutional Model: (Kayastha and Chhatkuli, 2005)

5. Limitations of Nepalese NSDI Initiatives

Nearly, five years of NSDI initiatives in Nepal have been passed. Due to various reasons, the initiatives have not come to its full functional stage. Various limitations are affecting its timely growth. Some major of them has been identified as follows:

- Proper institutional set up with necessary infrastructure of the coordinating body is lacking. It is not an independent body, rather running as a project under Survey Department.
- Despite various efforts of Survey Department, awareness regarding the essence and benefits of NSDI is negligible among the potential stakeholders and general users.
- It seems that the publicity of the initiatives and the progress whatever has been achieved is less in the country. Vision and roadmap of the initiatives have not sufficiently been advocated.
- Comprehensive policy document and appropriate policy/legislative framework to support the NSDI activities are lacking.
- Participation of stakeholders in the NSDI initiatives is not satisfactory.
- Funding allocated for the initiatives is insufficient.
- Human and technological resources required for NSDI development is not sufficient. Programs for capacity building / development to make the NSDI initiatives sustainable have not been initiated
- Politicians and high level bureaucrats are not fully convinced on the essence of NSDI, which is a must for its timely development.

6. Key Issues of NSDI Development in Nepal

Key issues to be addressed for NSDI development in Nepal have been realized as follows:

Institutional Setup

A strong coordinating body with sufficient infrastructure is required to fully materialize the concept of NSDI. The organizational set up currently existing is not in the state to coordinate all the potential stakeholders to participate the efforts of NSDI development as it is in the form of a project under Survey Department, having limited authority and funding. An independent organisation backed by legal authorities would be the institutional setup for fully developed NSDI in the country. Survey Department must priorities its steps for establishing the proposed institutional model (figure 4) in the days to come.

Standards of GI

Adoption of commonly accepted standards of GI to ensure interoperability is one of the fundamental requirements of functioning NSDI. The stakeholder organisations are not fully adopting the common standards in Nepal, even many of them are not aware about the essence of following standards. Survey Department must develop, if not developed yet, commonly acceptable standards and make the stakeholder organisations to follow them, as the department is legally responsible in this matter.

Partnerships

Partnership is an important component of developing SDI in the country. As a single agency is unlikely to have all the resources, or even skills and knowledge required to undertake the development of all aspects of SDI, the partnership of agencies and organisations is called for. Not only does the establishment of a partnership of organisations working together to create SDI mean that a greater amount and wider range of resources can be brought to bear on its development, but having organisations working together at the outset, is vital to ensuring that SDI develops in a way that will support all the partners in their use of data. It may be appropriate to involve both public and private partners, as well as academia and individual experts in a consortium approach to developing the SDI needed by a country (SDI Africa, an Implementation Guide). NSDI initiatives in Nepal were begun with the partnership of six government organisations as mentioned above. Central Bureau of Statistics remained the strong partner with Survey Department. However, in recent days the response from these organisations is not satisfactory. Survey Department must make further efforts not only to resume the participation of those organisations but also encourage all the potential stakeholders to join the network of partnerships.

Participation of Private Sector

Private sector can equally contribute in developing NSDI in the country. In Nepal, only a few organisations from private sector are involving in GI business. None of these organisations has come into touch to participate the NSDI initiatives till the date. Duplication of efforts, mainly in publications of maps, has been seen in the market. Integrated information on the capabilities of private sector organisations in GI business is incorporated nowhere. Private sector can contribute in developing NSDI as follows:

- Supporting human resource development required for the development of NSDI
- Developing Software/System required for the organisations involving in GI services
- Conducting awareness programs so that wider range of application areas could be incorporated under the NSDI umbrella.
- Watchdog the state initiatives and pressurize the government to develop the NSDI to full operational phase.
- Supporting the government to overcome the duplication of investment in same kind of data by concentrating on value added GI rather than Framework Data
- Suggesting appropriate mechanism, policies, standards etc. for effective NSDI in the country
- Establishing strong intellectual network as it is the most important in the country like Nepal to promote the use of geospatial information for efficient / effective planning and good governance.

It can be doubtlessly state that participation of private sector in NSDI initiatives optimizes their investment in one hand and significantly contributes in developing NSDI in the country on the other hand. Thus, Survey Department must encourage private sector organisations to participate the NSDI initiatives.

Policy / Legal Framework

Appropriate policy/legal framework to govern the activities of NSDI is an essential component. In Nepal, several policy issues have been discussed at several forums, and many policy decisions have been undertaken. However, a comprehensive policy document regarding NSDI initiatives is still missing. The activities are not included in appropriate policy/framework yet. Survey Department should propose appropriate policy/legal framework incorporating all the aspects of NSDI to the government so that the lacking could be fulfilled.

7. Conclusion

Nepalese NSDI initiative since 2002, led by Survey Department through NGIIP, is an admirable job in the context of widened GI user community. However, it has not been developed as per the need of the time. Duplication of efforts in GI business is still in practice. It is essential to aware GI users and producers about the essence and potential benefits of NSDI to minimize the duplication of efforts. Stakeholder organisations from various sectors should be encouraged to join the network of partnerships. Especially, private sector organisations should be called upon to join the initiatives. An effective environment for sharing / exchanging what ever is available; data, information, technology, skill, resources, etc at stakeholder organisations should be developed. Effective institutional set up providing strong national NSDI leadership with adequate resources should be established. Appropriate policy/legal framework should be developed and appropriate initiatives should be taken for the sustainability of the system.

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Production of DTM by using the existing contour data lines

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Abstract

The topographic database in Nepal has been prepared in the national level by making use of the analogue topographic base data. Topographic dynamics in terms of other physical features changes rapidly but changes in the terrain elevation occurs negligibly. As there has been growing demand for digital height model (DHM) of the terrain in spite of the presence of the existing two and half dimensional data such as contours, work was done as to the input, methodology, and quality assessment of the DTM being generated on the national level. Some initiations taken in this respect has been highlighted in this paper.

Introduction

Digital Height Models (DHMs) or Digital Elevation Model (DEM) or synonymously Digital Terrain Model (DTMs) are computer models of the surface of the Earth and are being increasingly used by scientists from many disciplines for tasks such as estimating slope gradient and aspect to operations such as analysing the hydrological flow paths on the surface. Targeting the generation of hydrologically precise DTM may lead the product to be used in the wider domain than to produce it for other use since the former takes account of the majority of the curvature of the surface than mere interpolation of the input points.

Making the national level DTM database in the country like Nepal, where the terrain varies from the level as close as to 68 meters to the peak of Mount Everest of 8848 meters is a difficult task. Lack of the photogrammetric workstation for automatic digital terrain model extraction and at the same time absence of the spot levels in the required amount heightens the problem of the DTM creation by the stereo modelling procedures or point interpolation methods.

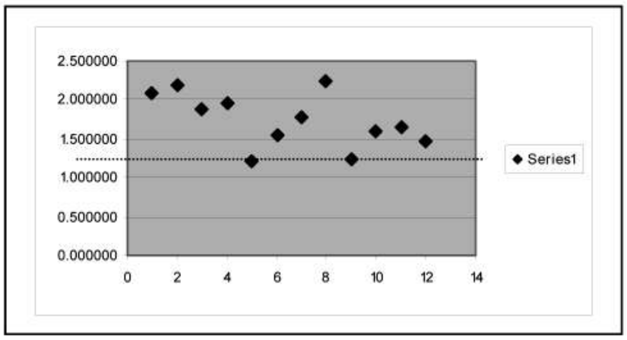
In this scenario, to consider the users' demand and at the same time to enhance the scope of framework data in the user community, a long awaited DEM is being prepared by making use of the topographic linear vector data as the major source of relief. DEM is one of the basic dataset that a general user requires. Survey Department being the National Mapping Organization, it is desirable that DEM is replaced along with NTDB. But lack of essential tools along with other technical constraints, it could not be generated at the time of release of NTDB. Presently as there is presence of tool in Geographic Information System that accepts the vector contour line data along with other break line features such as boundary and the hydro lines as inputs, it is worthy to prepare the DTM by making use of such tool in the map sheet level. Accuracy assessments are made for deciding which map-sheet DTMs are acceptable to use. Such assessment is carried out against the accepted standards.

Basis for the map sheet selection

Majority of the area falls in the mountainous region in Nepal causing majority of the map sheets of 1:25000 and all of 1:50000 to cover the elevated terrain. Out of 678 unique map sheets for the whole country, around 400 sheets cover mountainous areas. Visual inspection of these map sheets shows that most of them contains high contours density. 12-map sheets were sampled consisting of semi plain or mountain areas. Contour line density (CLD) per square meters is calculated by measuring the contour vertices within the double of the pixel area size. The statistics of the CLD calculated as the ratio of the mean to the standard error was plotted. Map sheet visually estimated to be inappropriate for the generation of DHM were found to be located at the lower position whereas those with mean higher contour density with low Standard Error were plotted at higher position.

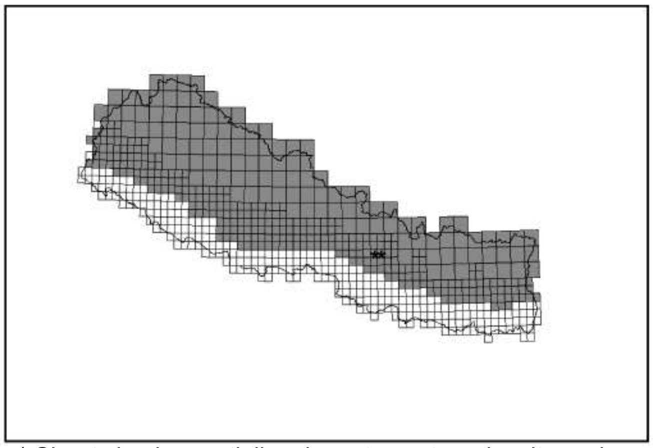
With the scatter diagram a threshold value of the ratio for the acceptance of the contour map sheet to use for DHM generation was set as 1.25 setting the rule that the sheet bearing the value greater than 1.25 will be used for the DTM generation. The following table shows the distribution list of the measured CLD values.

SN	Sheet Number	Min	Max	Mean	St. Deviation	Mean/St.Dev.	Remarks
1	2687 03C	0	0.08437	0.02838	0.0135660	2.091847	Eastern Chure Area
2	2687 03D	0	0.12388	0.03031	0.0138990	2.180589	Eastern Chure Area
3	2687 04C	0	0.08798	0.02453	0.0129990	1.887299	Eastern Chure Area
4	2785 09B	0	0.16760	0.03050	0.0156380	1.950058	Central Chure Area
5	2785 09A	0	0.11301	0.02082	0.0170260	1.222601	Central Chure Area
6	2883 16B	0	0.09426	0.02011	0.0130070	1.546244	Central Mountain
7	2782 03A	0	0.01506	0.02133	0.0119080	1.790897	Central Chure Area
8	2882 15C	0	0.09402	0.02907	0.0129720	2.240595	Central Chure Area
9	2884 13A	0	0.11701	0.01718	0.0139170	1.234677	Central Mountain
10	2884 14D	0	0.12018	0.01864	0.0116680	1.597189	Central Mountain
11	2881413C	0	0.09233	0.02339	0.0142770	1.638579	Central Mountain
12	2785 09D	0	0.08387	0.01872	0.0127884	1.463983	Central Meridian



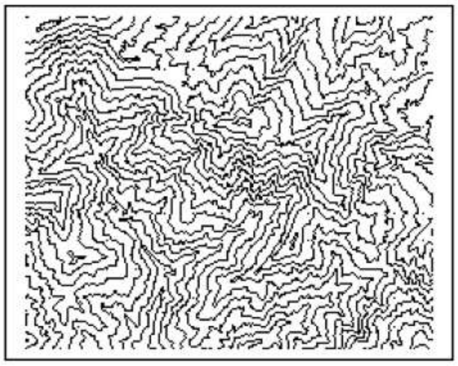
Visually observed with the contour line distribution with reference to the above sample possibly indicate the sheet layout to be used for DHM as follows (Gray shaded sheet to be used for DTM, counting to 400).

The above plot indicates that out of the 12 sampled sheets, sheet no. 5 and 9 shows values less than 1.25, which are the topo sheet number 2785 09A and 2884 13A. The highest value is from the sheet number 8, which is 2.24 approx. the topo sheet number being 2882 15C. Generalized hundred meters contour interval appearance of such map sheets has been given in the following page.

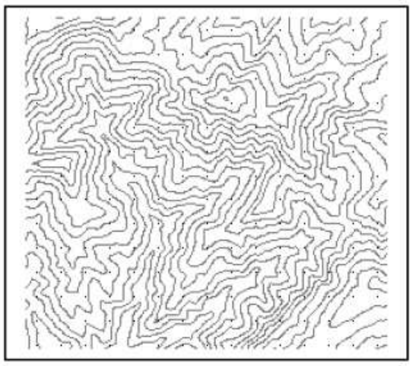


* Sheets having partially adequate contour density such as 2785 06A, 06B are ignored in the DTM Generation

(Source: Survey Department)



(Original Contour lines in the interval of 100 meters)



(Generalized Contour data in the interval of 100 meters using the DTM generalization techniques)

Methodology

The approach used in generating the DHM is the interpolation of contour line data. Contours from the map sheets are used as the main source of the input data. The output will be the raster in ESRI grid format of 10-meter spatial resolution. The tools used in the generation of the DHM are the interpolation tools of ArcGIS "Topo to Raster". Topo To Raster is an interpolation method specifically designed for the creation of hydrologically correct digital elevation models (DEMs). It is based upon the ANUDEM program developed by Michael Hutchinson (1988, 1989).

The interpolation process

The interpolation procedure has been designed to take advantage of the types of input data commonly available such as contours, stream ordered hydro features as the known characteristics of elevation surfaces. This method uses an iterative finite difference interpolation technique.

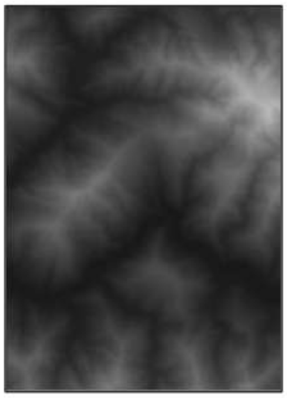
It is optimized to have the computational efficiency of local interpolation methods such as Inverse Distance Weighted interpolation, without losing the surface continuity of global interpolation methods such as Kriging and Spline. It is essentially a discretised thin plate spline technique, where the roughness penalty has been modified to allow the fitted DEM to follow abrupt changes in terrain, such as streams and ridges (Wahba, 1990). It is the ArcGIS interpolator designed to work with contour inputs. (www.esri.com)

Most landscapes have many hill tops (local maximums) and few sinks (local minimums), resulting in a connected drainage pattern. Topo to Raster uses this knowledge about surfaces and imposes constraints on the interpolation process that results in connected drainage structure and correct representation of ridges and streams. This imposed drainage condition produces higher accuracy surfaces with less input data. The quantity of input data can be up to an order of magnitude less than normally required to adequately describe a surface with digitized contours, further minimizing the expense of obtaining reliable DEMs.

The program acts conservatively in removing sinks and will not impose the drainage conditions in locations that would contradict the input elevation data. Such locations normally appear in the diagnostic file as sinks. This information is correct data errors, particularly when processing large data sets. (www.esri.com)

Quality assessment

Data without indication of their quality are almost as worthless as no data at all. Is a given DHM good enough for my application? : A question every DTM user asks. Contour lines for topographic maps are usually plotted under the criterion. E.g. 90% of the checked value should be in error by more than half the contour interval.



(a) Part of a DTM generated from contour lines (Source: Survey Department)

(b) Hillshade of Part of (a)

All DEM's data grid will be tested with reference to the spot height points generated photogrammetrically and those exist on the topo sheets. Corresponding vertical RMSE for each sheet will be specified in a header text file and will be delivered along with the DEM data to the user. It is proposed that the Meta data pertaining to the DEM will be launched via the NGII platform

Because of practical limitations inherent in all collection systems (DEM source data are always treated as a sample data) there will always be some artifacts such as patches, or some other anomaly in the data set. Some of these artifacts, although falling within normal DEM vertical error tolerances, can coalesce with valid surface features. This coalescence should not be tolerated to the point where valid surfaces become unintelligible to the users of the data (Specifications, Standard for Digital Elevation Model, USGS). For example:

- Isolated tops must be depicted with their approximate size and shape.
- Flat trending surfaces must be depicted as generally flat trending without confusing patterns or striations.
- Water bodies must be flat, be lower than the surrounding terrain, and have shorelines clearly delineated.

Corrective actions have been taken to minimize these artifacts; all DEM's must be viewed and edited before being submitted to the NTDB.

It is quite common to use as an accuracy measure the root mean square error (RMSE). The root mean square indicates the error we can expect on an average when computing elevation at an arbitrary point. The most widely applied method to assess the accuracy of a DTM is to compare elevation computed from the DTM with check values at randomly distributed points and to calculate the RMSE.

Coming to the point, for our task, the checkpoints were taken as the spot elevation point vectors from the NTDB, which were not used in the DHM generation themselves. Spot elevation from the two map sheets namely, 2785 11A and 2785 09D (both of which are within the threshold for the map sheet selection) were used. Excluding the spot heights, which are positioned wrongly, the RMSE were observed as 5.81 and 6.68, which are inside the tolerance of 7 m. In either case around 80% of the points are with in the half of the counter interval.

The DTM generated using the TIN data model gave the standard error of 6.63 for the sheet of 2785 11A and 9.31 for the sheet of 2785 09D. Comparing to this result, it can be said the DTM produced by using interpolation of the contour lines is of better accuracy than the same produced using the TIN data model. The points used in the calculation for the sheet of 2785 11A and the related parameters of the products has been attached in the appendix of this paper.

The tables below shows some parametric values of the analysis.

Sheet Number	RMSE wrt Tin	RMSE wrt DEM
2785 09D	9.31	6.68
2785 11A	6.63	5.51
2786 16 **B**	8.54	5.92

Specifications

Specifications for the DEM includes its structure, format, resolution, projection and coordinate system. Prior to the DEM data generation by Survey Department, study had been carried out to the specification standard of the DEM produced by USGS. The following are the standards of the DEM produced by Survey Department.

Terms	DEM by Survey Department	DEM by USGS (LEVEL 1)
1. Storage Format	ESRI GRID	ASCII Characters
2. Spacing (Spatial resolution)	10 meters	30 meters
3. Acquisition Methodology	"Topo to Raster Interpolation tool" using contour data as the primary source	Stereo Profiling or image correlation
4. Spatial domain of availability	7.5' or 15' (coordinates of extent depending upon the topo map sheet)	7.5'
5. Vertical Accuracy	80% of the tested points within half of the contour interval (10 meter)	7 meters RMSE but maximum RMS error 15 meters
6. Absolute Error tolerance	v25 meters	50 meters (w. r. t. true elevation)
7. Coordinate system	Rectangular	Rectangular
8. Projection	MUTM	UTM
9. Ellipsoid	Everest 1830 (Nepal Standard)	NAD

Use of DTM

DTM is used in the following fields of application.

- Hydrological modeling and estimation of run off.
- Ground water modeling
- Flood Hazard modeling.
- Urban Planning
- Real visualization of surface
- Agro pocket area findings.
- Forestry and Road alignment
- Study of Geomorphology
- Irrigation and Hydropower
- Erosion Hazard modeling
- Defense Mapping
- Marketing and Business analysis
- Mapping of Obstacle Clearance Surface for Approach and Departure of Airplanes
- Mapping and Maps updating etc.

Conclusion

DTM is an important source of spatial information which form an important data layer in the NTDB. NTDB in any country must have a dataset regarding DTM which can be applied seamlessly in one's spatially related analysis. The existing infrastructure does not permit to model terrain surface for the whole country (except the mountain or higher mountain areas) it is recommended to develop digital photogrammetric system for generation of automatic digital terrain model extraction for the remaining flat areas. The generated DTM using the counter lines as the primary input in the mountainous areas is not the completion but the beginning of developing 3d dataset in Nepal. More research and study is required for further findings as to the corrections pertaining to the roughness of the surface, smoothing mechanism of the data etc.

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Karel, Pfeifer, Briese -DTM Quality Assessment

USGS, Standard for Digital Elevation Models

Appendix for the observed spot points for the error calculation

2785 11A

ID	SEL	NEW_HGT	TOPOG_PT_	TOPOG_PT_I	FCODE	SEL	TINZ	DELTINZ	NEW_DELZ
1	2395	2387.39	1	0	20400	2395	2380.00	15.00	7.61
2	2029	2026.23	2	1	20400	2029	2020.00	9.00	2.77
3	1463	1459.98	3	2	20400	1463	1460.00	3.00	3.02
4	1482	1487.61	4	3	20400	1482	1480.00	2.00	-5.61
6	2542	2545.93	6	5	20400	2542	2540.00	2.00	-3.93
7	1895	1888.09	7	6	20400	1895	1880.00	15.00	6.91
8	2533	2524.69	8	7	20400	2533	2520.00	13.00	8.31
9	2284	2283.10	9	8	20400	2284	2280.00	4.00	0.90
10	2702	2701.63	10	9	20400	2702	2700.00	2.00	0.37
11	2709	2708.81	11	10	20400	2709	2700.00	9.00	0.19
12	2805	2805.40	12	11	20400	2805	2800.00	5.00	-0.40
13	2567	2566.94	13	12	20400	2567	2560.00	7.00	0.06
14	2768	2765.20	14	13	20400	2768	2760.00	8.00	2.80
15	2551	2546.33	15	14	20400	2551	2540.00	11.00	4.67
16	1846	1841.20	16	15	20400	1846	1840.00	6.00	4.80
17	2306	2307.10	17	16	20400	2306	2300.00	6.00	-1.10
18	2290	2283.74	18	17	20400	2290	2280.00	10.00	6.26
19	2695	2686.90	19	18	20400	2695	2680.00	15.00	8.10
20	2327	2330.77	20	19	20400	2327	2321.25	5.75	-3.77
23	2064	2058.96	23	22	20400	2064	2060.00	4.00	5.04
24	2101	2102.09	24	23	20400	2101	2100.00	1.00	-1.09
25	2529	2522.24	25	24	20400	2529	2520.00	9.00	6.76
26	2769	2765.60	26	25	20400	2769	2760.00	9.00	3.40
27	1852	1854.08	27	26	20400	1852	1847.54	4.46	-2.08
28	2585	2581.68	28	27	20400	2585	2580.00	5.00	3.32
29	2515	2509.51	29	28	20400	2515	2500.00	15.00	5.49
31	2108	2107.35	31	30	20400	2108	2100.00	8.00	0.65
32	2615	2609.23	32	31	20400	2615	2600.00	15.00	5.77
33	2502	2502.74	33	32	20400	2502	2500.00	2.00	-0.74
35	2612	2602.97	35	34	20400	2612	2600.00	12.00	9.03
36	1635	1625.02	36	35	20400	1635	1625.24	9.76	9.98
37	2583	2581.59	37	36	20400	2583	2580.00	3.00	1.41

(Source: Survey Department)

Space Education And Awareness Activities In Nepal

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Keywords: *Space technology, Remote Sensing, Geographical Information System, Orthophoto, Global Positioning System, Institutional Framework, Education and awarness.*

Abstract

The advancement in space technology has presented the modern world with many opportunities for collection, analysis and dissemination of information. The information of space technology could be used on various activities of development projects for economic growth and sustainable development of any country. In Nepal, the use and application of space technology has been brought into practice since 1970's. Government of Nepal has given the priority for the application of space technology to fulfill the national objective of poverty reduction and sustainable development of the country.

This paper describes the various organizations involved on the application of space technology together with the space education and awareness activities in Nepal. Finally, it describes about the constraints and future prospectus of space technology application in Nepal.

1. Country background

Nepal is a small mountainous land locked country surrounded by China in North and India in South, East and West. Geographically, it is located between 26 degree N to 31 degree N latitude and 80 degree E to 88 degree E longitude. The elevation ranges almost from 60m to 8848m, the highest peak of the world, Mount Everest (Mount Sagarmatha). The length in the east-west direction is about 885 km. and the width in the north-south direction varies between 145 km to 245 km. The area of the country is 147 181 sq. km and a population of about 23.5 million. Depending upon the elevation, the country is divided into five physiographic regions namely: Terai (Plain area) 60-300 m, Siwalik Hills 200-1500m, Middle Mountains 800-2400m, High Mountains 2200- 2400m,and Himalayas 5000- above. Due to a wide variation in the topographical characteristics different climatic variations are available in Nepal. Accordingly, Nepal offers tropical, sub tropical, temperate, and alpine and sub artic types of weather depending on the elevation. The mean temperature is about 15^0 celcius; however summer temperature reach over 45^0celcius in some places in the Terai. About 80 % of the precipitation occurs during the monsoon season from June until September. It has a rich human culture and natural biodiversity with more than 61 ethnic groups and almost 70 spoken languages.

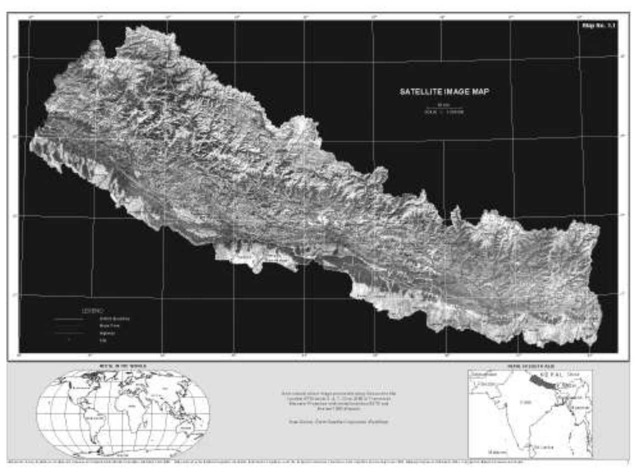

Fig. 1: Location of Nepal

Paper presented in the Thirteenth Session of the Asia-Pacific Regional Space Agency Forum
5-7 December, 2006 Jakarta, Indonesia

2. Introduction

The application of space technology has been brought into practice since 1970's where satellite imagery was used for the land use mapping purposes. The application of space technology has always been the concern of Nepalese Government to fulfill the national objective of poverty reduction and sustainable development. Nowadays, the application of space technology is in practice in Nepal to solve various issues like environmental degradation, resources management, population growth, urbanizations etc. is in practice in Nepal. Government of Nepal has given emphasis to introduce space technology in its Ninth and Tenth Five Year Plan for poverty mapping and preparation of land use maps. Several organizations are involved in the application of space technology to achieve their organizational goal. Governmental organizations, non-governmental organizations (NGO), International Non-Governmental Organization (INGO's), academia, private sectors and local authorities are the main stakeholders. In Nepal, there are basically three types of products (Global Positioning System (GPS) Data, Remote Sensing Imagery and Aerial Photographs) used through space technology application. Global Positioning System (GPS) is used for establishment of ground control points; Remote Sensing (RS) technology is used for updating as well as classification of spatial datasets, change detection, weather forecast and disaster management; Aerial photographs are used for the preparation topographical base maps and orthophoto production.

3. Institutional framework

There are various organizations in Nepal involved on the use and application of space technology. They can be categorized into four main groups.

(a) Governmental Organizations

1. Ministry of Science and Technology
2. Ministry of Land Reform and Management
3. Ministry of Agriculture/ Department of Agriculture
4. Survey Department
5. Department of Forest
6. Department of Urban Development and Building Construction
7. Department of Mines and Geology
8. Department of Hydrology and Meteorology
9. Department of Water Induced and Disaster Prevention
10. Land Management Training Centre

(b) Academia

1. Central Department of Geography (Tribhuwan University)
2. Institute of Engineering (Tribhuwan University)
3. South Asian Institute of Technology (Purbanchal University)
4. School of Environmental Management and Sustainable Development (SchEMS), (Pokhara University)
5. Himalayan College of Geomatic Engineering and Land Resource Management (Purbanchal University)
6. Kathmandu University
7. Department of Geography/Geology Trichandra Campus, (Tribhuwan University)

(c) Private Sectors

1. Auto Carto Consult (P.) Ltd.
2. Genesis Consults (P.) Ltd.
3. World Distribution Nepal
4. Others……..

(d) International Organizations

1. United National Development Program (UNDP)
2. FAO
3. WFP

Paper presented in the Thirteenth Session of the Asia-Pacific Regional Space Agency Forum
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4. UNEP (United Nations Environment Program)
5. International Center for Integrated Mountain Development (ICIMOD)
6. Others…….

A brief description of the main organizations involved on the use and application of space technology has given below.

3.1 Survey Department

Survey Department is the National Mapping Agency and one of the important departments, which is using space technology in different sectors. Satellite imagery was used for the first time for land use mapping project during 1970's. It has been using Global Positioning System (GPS) for last 12 years for strengthening National Geodetic Control Network and International Boundary Survey. It also has been using Satellite Data (IRS 1c/1d, IKONOS etc.) for updating topographical base maps. The digital Orthophoto maps are also prepared and made available for the development projects.

3.2 Department of Forest

Department of Forest is pioneer in Nepal in the application of satellite imagery for forest mapping. Remote Sensing Centre was established in Nepal under this department in collaboration with USAID. It has been using satellite data for forest classification, land use, land cover classification and change detection. This Department is using IRS, Landsat and SPOT images for above mentioned applications.

3.3 Department of Urban Development and Building Construction

Department of Urban Development and Building Construction has been using the space technology to produce the base maps of municipalities. This department has been using high resolutions satellite imagery such as IKONOS, Quick bird, IRS 1c/1d etc.

3.4 Department of Mines and Geology

Department of Mines and Geology is using satellite data (Landsat, SPOT, IRS etc.) for geological mapping, classification of rocks, earth quake prediction, damage detection, and mineral exploration. This department is also using GPS for field work.

3.5 Department of Hydrology and Meteorology

Department of Hydrology and Meteorology is using satellite data (Landsat and IRS) for weather forecasting. The weather forecast information is made available to the users which are based on the data down loaded through web after manual interpretation.

3.6 Land Management Training Centre

Land Management Training Centre is under the Ministry of Land Reform and Management and actively involving for human resource development in space technology and land management field. It conducts the training of different level such as Basic, Junior and Senior level to produce skilled manpower in surveying, mapping and space technology field. It also conducts short-term training programme and refresher courses in the application of space technology. This training centre is also using GPS, aerial photographs, Orthophoto and satellite data for its training purposes.

3.7 International Center for Integrated Mountain Development (ICIMOD)

One of the main objectives of ICIMOD is to establish and promotes a decentralized network of partner institutions in the Hindu –Kush Himalayan Region. This organization is organizing different types of training, workshops and awareness program in the space technology application sector. It also provides guidelines to enhance capacity of national institutions to use GIS and RS technology for sustainable mountain development.

3.8 Central Department of Geography

Central Department of Geography under Tribhuwan University conducts various training programme in the field of space technology. It conducts RS/GPS training programme and teach RS/GIS for Master's Degree (Geography) students. It also conducts research activities to provide scientific contribution in various space technology application fields. It uses satellite images (Landsat, Spot, IRS etc.), aerial photographs/Orthophoto, GPS data for teaching and research works.

3.9 Institute of Engineering

This is the oldest engineering college in Nepal in the field of engineering and conducts academic programme in Bachelor's and Master's Degree level. It uses satellite imagery (Land sat, Corona and NOAA etc) for teaching and research works. It also conducts short training programme in RS/GPS.

3.10 South Asian Institute of Technology

This institution provides technical education and training programme both for national and international level in the urban mapping, environmental mapping and resources mapping, development and planning fields using RS/GIS. This institute also provides consultancy services in the field of space technology application. The main products used by this institute are satellite image, aerial photographs, and Lidar data etc.

3.11 Himalayan College of Geomatic Engineering and Land Resource Management

This college provides Bachelor's Degree academic education in the field of Geomatic Engineering and Land Resource Management in Nepal. It also conducts various short – term training programme as well as research works in space technology sector (RS and GPS).

3.12 School of Environmental Management and Sustainable Development (SchEMS)

SchEMS under Pokhara University conducts B.Sc. Degree and M.Sc. Degree course in Environmental Management (EM). GIS and RS are the core modules for graduate courses in EM students under Pokhara University. It conducts various research works and short-training programme using GIS/RS tools. It also organizes international training program in application of RS/GIS in environmental management sectors.

3.13 Kathmandu University

Kathmandu University is using RS/GIS tools for Engineering students as well as Environmental Science students. It also uses the space technology products like aerial photographs, orthophoto, satellite imagery and GPS data for teaching as well as research works.

4. Space education and awareness activities

Although some work is being done in the field of space technology in Nepal, yet much remain to be done. There are various themes and one of the most important themes is space education and awareness activities. A study has been done in different institutions involving for the use and application of space technology in Nepal. The result has tabulated below.

INSTITUTIONS	EDUCATION (Training/Academic Course)	AWARENESS
A. Government Organizations		
1. Ministry of Science and Technology		a. Workshops b. Discussion Program
2.Survey Department	a. Short term training in RS/GIS b. Setup remote sensing lab	a. Organized ACRS 2002 conference b. Organized Seminar on Space Technology Application in 2005
3. Land Management Training Center	a. Conduct Basic, Junior and Senior level training in surveying and mapping b. Short term training and refresher course in RS/GIS	a. Workshops
4. Department of Forest	a. Short term training for staffs in RS/GIS	a. Workshops
B. Academia		
1. Central Department of Geography	a. Conduct short term and advanced training in RS/GIS b. Teach GIS/RS/Surveying for M.A. level students (Geography) c. Research works	a. Pamphleting b. Curriculum development
2. Institute of Engineering (Tribhuwan University)	a. Conduct short term training in RS/GIS b. Tech GIS/RS/Surveying for Diploma Course, B.E., Master's Degree in Water Resources/Environment	a. Workshop
3. South Asian Institute of Technology (Purbanchal University)	a. Application of RS/GIS in planning, management and development b. School level RS/GIS	a. Workshops b. Seminars c. Talk Programs
4. School of Environmental Management and Sustainable Development (SchEMS), (Pokhara University)	a. Teach GIS/RS/Surveying for B.Sc. and M.Sc. Degree in Environmental Management b. Short term and international training programme in GIS/RS	a. Workshops b. Seminars
5. Himalayan College of Geomatic Engineering and Land Resource Management (Purbanchal University)	a. Teach GIS/RS/Surveying for B.E. level students b. Short term and refresher course in RS/GIS c. Research works	a. Workshops b. Seminars
6. Kathmandu University	a. Teach GIS/RS for Bachelor's and vMaster's level students in Civil Engineering and Environmental Science b. Research works	a. Workshops
C. International Organizations		
1.ICIMOD	a. Training on RS/GIS for Natural Resources Management, GLOF etc. b. Decision Support Systems (DSS) c. Research works	a. Workshops b. Discussion Program c. Seminars and Exhibition
D. Private Sectors	a. Short training programme in RS/GIS/GPS and digital Photogrammetry b. Hardware/Software development for space technology application	a Seminars and Exhibition b. Workshops

Paper presented in the Thirteenth Session of the Asia-Pacific Regional Space Agency Forum
5-7 December, 2006 Jakarta, Indonesia

5. Constraints

It is clear that, space technology is applied in several organizations in limited sectors. Some of other sectors, besides mentioned in the above table could be telecommunication, wildlife habitat mapping, watershed management, tectonic movement, natural disaster prevention, control and monitoring, cadastre and land management etc. Though the government has given priority in it's policy document for the use and growth of GIS/RS, there are more opportunities and potential to apply space technology in proper way. The main constraints to harness the potential of this technology have listed below.

- Lack of availability of space image data and affordability
- Lack of networking and coordination among the users and producers of GIS/RS tools
- Lack of stakeholders participation for the use and application of RS/GIS tools
- Lack of awareness to work together in a common technical platform
- Lack of proper education and awareness in the field of space technology
- Lack of proper human resources and expertise
- Lack of financial support at different level such as data acquisition, data processing and data dissemination
- Lack of data sharing policies

6. Future prospectus

From the above description it is seen that the space technology application in Nepal is not in the matured condition. Institutions working on space technology and its application sectors need to change their working strategy and develop the system to accommodate the latest technology as far as possible. Some of the future prospectuses in space technology applications in Nepal are as follows.

6.1 Agriculture

Nepal is a country where most of the people are based on agriculture. The agricultural products are the main tools to enhance economic growth and sustainable development. Space technology could provide suitable tools to various agricultural crops, yield forecasting and monitoring agricultural areas.

6.2 Education and Research

In the field of education space technology educate school children, university students and general public on the issues of environmental awareness and for their practical assignment through better illustrations. The products could be also used for various research works.

6.3 Poverty Reduction Programs

The national objective of government of Nepal is poverty reduction. Space based technology could help indirectly to reduce the poverty as it could be used as a better planning tool for various natural resources and land 6se.

6.4 Forestry

Application of space technology in forest sector could help in better inventory of forest resources, sustainable use of forest resources, reforestation activities and helping the management of community forest.

6.5 Tourism

It is also an important sector to earn foreign currency for our country. The use of space technology could improve the industry with better planning of tourism infrastructures, generation and dissemination of information such as by virtual reality, better quality maps, and better facilities for tourists etc.

6.6 Disaster Management

Space technology could help in various measures for prediction, mitigation and management of disasters such as earth quakes, avalanches, land slides, floods etc.

6.7 Biodiversity

Space technology also helps in better management of biodiversity through better mapping of resources and strategies for biodiversity conservation.

6.8 Transportation and Utilities

One of the important application sectors for space technology is transportation and utilities. There is a growing demand of space technology application in utilities like telecommunication, water supply and electricity. The satellite imagery and RTK GPS data could be used for transportation as well as utilities sectors.

6.9 Cadastre and Land Management

The space technology could be used in cadastre and land management sector. The Orthophoto and RTK GPS data could be used for cadastral information updating and LIS development in Nepal. It could be a quick tool for renovation of damaged land information due to conflicts during last decades in Nepal. Its application will help for effective service delivery and finally promotes for good governance in Nepal.

7. Conclusions

The application of Space technology is in practice for various themes in Nepal. Different organizations are using space technology products for service delivery and system development. It has realized that space technology could be an important tool to make strategy for national development activities. There are some constraints like lack of technical expertise and financial constraints, lack of networking and coordination among organizations, lack of data sharing policies etc. But also there are various future prospectus areas for the application and use of space technology. The education and awareness programme need to be enhanced and all stakeholders need to work together in a common technical platform. Survey Department should lead for the development of space technology in Nepal. The national and regional co-operation is also the most possible solution to get the optimal benefit from space technology application sector.

Paper presented in the Thirteenth Session of the Asia-Pacific Regional Space Agency Forum
5-7 December, 2006 Jakarta, Indonesia

Surveying: Profession And Professionalism

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Abstract

Surveying profession has been very dynamic in nature in recent times.. Like other professions such as medical, engineering, teaching, pharmacy etc., surveying profession has acquired its own dimension guided by functionalities and specification plus standard. A surveyor is a surveyor irrespective of nationalities, race and origin. Though development of technologies in the domain of surveying has of course necessitated surveyors of modern world to be more frequently updated in terms of skill and capabilities to adapt him/herself in the new environment, the basic objectives yet remains the same in the profession of surveying. Today anyone can assume him/herself being as a surveyor by just using the latest tools of earth observation but prior to proclaiming oneself as a surveyor, one must rethink whether the proclaimer inherits or holds the basic qualification in terms of education, professional requirement and his/her state's rule and regulation or law pertaining to the profession.

Introduction

It is very hard to say which is the derivative of what in between Profession and Professionalism. Professionalism may be the consensus developed through the gradual development of a profession. It may also be true that a vocational discipline required for the betterment of the society might have to be adopted for which there was necessity of certain criteria to be fulfilled for which the world professionalism might have been used prior to the former. In any case, for maintaining sustainable existence of a career in a scientific field, professionalism in regard to that career must be established so that the profession becomes standard, less ambiguous thereby making more people satisfied by giving better service to the clients.

Muzondo and Hodza have this view on a profession: A profession is built on a policy of admitting educated person to small, self-governing bodies of their social equals, to whom they will personally be known and by whom their fitness would be judged. It derives from the phenomenon of division of labour, but having special power, prestige and knowledge specially importance to society.

To make a discipline as a profession, state's jurisdiction must declare it as a profession. State must set certain terms and condition for someone to be labeled as a professional. It can either be achieved through by defining certain academic standard in specific faculty or more effectively establishing a licensing system along with other requisites. Nevertheless, different countries have adopted their own different styles for defining somebody as a professional of a certain profession.

Land Surveying must be a licensed profession. Licensing and subsequent registration of Land Surveyors must be the subject of law of a profession. This must be availed in the governing law of the profession which must contains pertinent definitions and a code of ethics. It should not mere repository of guidelines for the practice of land surveying: causing to be a mere manual of practice.

In the modern society where many disciplines have overlapping activities, it must be precisely defined to recognize a surveyor, which must comes through the sense of professionalism. In the realm of engineering, an engineer pretends to be a surveyor but may not be by the constraints of terms in the definition. In this context the question "What is Survey?" comes prior to identify a Surveyor. The simplest answer may be "A survey helps to locate upon the ground that land which somebody's deed describes." It is because people recognize surveyor more by relation to land property than by other causes.

Then, immediately the next question rises? Who is a surveyor? The answer of this question must be met prior to the establishment of professionalism in land surveying. A surveyor is the person who practices surveying and is required to have certain academic degree by passing through the defined examination related to the subjects. The surveyor must show the result of the subject such as licenses or other necessary documents at the time of demand by others while surveying.

International Federation of Surveyors (FIG) defines a surveyor as a professional person with the academic qualification and technical expertise to practice the science of measurement. The definition assumes surveying profession basically to be supported by skilled at the same time academically qualified human resources.

Background of Surveying Profession in Nepal

Surveying as a profession began in Nepal at the time when the present day's Survey Department was established as a mobile survey office as a section of Land Registration office as an organization just to support on the cases of land related issues in 1957. By 1964, the unit had crossed a long profile when it had been institutionalized as Survey Department. The government of the time imposed the revolutionary Land Reform Programme when department at least recruited technical personnel trained by a short-period training course as demanded by the cadastral mapping. Since then the scope of surveying gradually expanded and has reached to highly diversified level within the sector till date. The credit for the evolution of 'Surveying and Mapping Profession' basically goes to Survey Department, which had Survey Training Centre (STC) under its umbrella, established at the time for generating field survey expert for cadastral surveying. The training centre conducted Land Surveying related course by bringing expert from Survey of India.

Basically, the training comprised of chain surveying, compass surveying and plane tabling which are the classical approaches of surveying. The training centre only focused to generate manpower to fulfill the requirement of human resources within the Survey Department.

Later as the concept on land changed from simply agro-based to other land use based, people become more aware on the precision and accuracy of the measurement. In this scenario, the technical expertise generated by the classical courses of survey training Centre did not meet the demand of skilled human resources. Recognizing this fact, Survey Training Centre started to conduct three level courses to generate different level of surveyor in terms of expertise such as basic Surveyor (Amin), Junior Surveyor and Senior Surveyor.

By then, the STC produced many Senior Surveyors who were capable in this field and helped to replace entire existing alien survey expert. To enhance the scope of the surveying practice, later the survey-training center was changed to Land Management Training Centre (LMTC) as a central organization and became independent from the survey department, which is giving training to trainees from different organization in different disciplines such as surveying, GIS, Land Administration etc. There have been courses up to Master Level in the Faculty of Geography in Tribhuwan University which somewhat has become supportive in Surveying. Academic Engineering Sectors such as civil, etc. comprised surveying courses in their curriculum. There have been many other government registered educational organizations in geo-informatics discipline in different parts of the country which are producing basic and junior level surveyors which indicates silver lining for better future of surveying profession in the country. Recently, Himalayan College of Geomatic Engineering of four academic years has been established to produce survey engineers in Kathmandu under Purwanchal University.

By the time, Survey Department widened its wing into many branches. Topographical, Geodetic and Cadastral survey branches remained as the major components of the survey Department. Nowadays, some more organizations such as National Geographic Information Infrastructure, Land Use Project, Department of Land Information and Archive have been established which are related to surveying profession.

Many Hydropower companies, government Agencies such as Department of Irrigation, Water Induced Disaster Prevention, Water and Sanitation, Forestry, Road, Land registration, Minesand Geology, Judicial agencies, real estate, municipalities etc demand for surveyors in Nepal. There have been many private organizations, which demand professional surveyors for land surveying and mapping. Apart from the existing base map of medium and smaller scales, we do have to make avail large scale maps since topo maps at large scale are used in micro level studies and are useful in the actual implementation of project assignment. For this, there is a growing demand of surveying profession. Moreover, Survey Department has planned the establishment of digital cadastral system, which will demand many more surveyors. It is no doubt that with more peaceful environment prevailing in the country, more scope of survey profession become. By now, many of the Nepalese expert surveyors are working abroad in their profession lured by the motivative conditions offered by their respective organizations.

Modern Days of Surveying Profession

Surveying is one of the oldest professions, known to be originated in the Babylonian times 2500BC. It has been found that in 1400BC, Egyptians used surveying to accurately divide land. With the industrial revolution in 1800AD, surveying was brought into prominent position with demand for 'accurate' boundaries and for public improvements (Muzondo et al).

Impact of changes in Information and communication technology has made rapid changes in the techniques and procedures of Land Surveying. Today's Surveying is not only limited to measuring tape, theodolite and plane table. Scenario has changed form the ground data acquisition from actual field observation to spatial database management through different spatial data and database modeling techniques. As a result, the proper definition of surveying profession has seen a shift towards incorporate changing requirements in technology and procedures. The greatest impact in the surveying profession has been made by development of spatial information system by making easy acquisition of spatial data and their processing.

When the Author asked to the Assistant Professor Dr. Arbinda Tuladhar of International Institute For Aerospace Survey and The Earth Sciences (ITC), the Netherlands, in 2001: "Why the Institute is not emphasizing studying on real ground observation and surveying as in the past during these days?", the answer was "Due to change in technology and profession, it has been necessary to accommodate all those new things developed from ground to Space. Data has not simply been data but now database and its management. There is not coordinate of points but voluminous amount of data in Remote Sensing imagery and raster files." And while these answers are still reverberating, the maps of bygone days now turned into elements of Geo-information Infrastructure. And there are less desktop GIS more towards a corporate GIS [6].

Everywhere in Surveying, there is digital. Even if we force to limit Surveying to Field Observation and Map making, we must have to face digital Total Station, GPS and remote sensing for which one must have knowledge more than the of classical approaches. Then there comes the stage of data processing, data analysis and visualizations and finally data storage and serving or dissemination. To simplify procedures within different steps, many technologies has been incorporated.

Present status of surveying profession in Nepal

Nepal cannot remain untouched with the changes in the outside world. It has also accommodated new technology in data acquisition methods by incorporating GPS and total station. Updating of data is being done using remote sensing imagery in the survey department. Topographic maps are being disseminated in the form of spatial database as well. Concept of Meta Data has been totally applied while serving the data. General people and specific users are more interested to the result of new technologies than the mere analogue maps. Many laymen who do not know about surveying have been found to be interested on Google Earth website just by virtue of its web page displaying Satellite imagery. Most of the organizations have possessed GIS tools for turning data into information efficiently.

Piloting of NGII with 39 stakeholders (Including CBS's district level offices) in the initial stage at least proves that there has been a shift in the vision as to the profession of Surveying simply from the ground work. Large numbers of surveyors are seen to be updating themselves by having professional training in GIS, GPS and remote sensing nowadays in Nepal.

Whatever be the modern technology, we have not been able to discard the classical approaches of data acquisition totally. In one hand, we have at least stepped for NGII whereas on the other hand we are using plane table for data acquisition in cadastral mapping. This seems to be paradoxical. There are many surveyors who are working remote areas either in government job or in the private form. For this, all of the survey professional organizations should initiative steps not only to upgrade the system with view of adapting new technology for better measurement, precision and result but also to maintain the integrity of the surveying profession.

Organization involved in surveying job

There are many organizations those generates survey products either for their clients or for general users. In most of these organizations, they appoint surveyor or hire for surveying purpose only. Government organizations, Private sectors, NGO's and INGO's have their own specific jobs related to Surveying profession in some way. Some of the organizations offering surveying or survey related performance have been indicated below.

i. Survey Department
ii. Land Management Training Centre
iii. *Tribhuwan University and others (Geography, Geology, Civil engineering Department)
iv. *School of Geomatics and Himalayan College of Geomatics Engineering and others
v. Land Registration Department
vi. National Planning Commission
vii. Department of Irrigation
viii. Department of water Induced disaster and prevention
ix. Municipalities
x. Department of Housing and Urban Development
xi. Department of Mines and geology
xii. Department of Road
xiii. Department of Forestry
xiv. Judicial organizations (Courts)
xv. Nepal Electricity Authority
xvi. Department of Soil Conservation
xvii. Department of Tourism
xviii. Department of Local Development
xix. Nepal Army
xx. Nepal Police
xxi. All Civil engineering Projects
xxii. All Hydro Power Projects
xxiii. All Hydro Power Agencies(Sanima Hydro power, Butwal Power Company, Chilime Hydropower etc.)
xxiv. Central Department of Statistics
xxv. Nepal Water Supply Corporation
xxvi. Nepal Telecom
xxvii. UNDP
xxviii. ICIMOD
xxx. JICA
xxxi. DFID
xxxii. FUND BOARD
xxxiii. Road Board
xxxiv. GTZ
xxxv. Care Nepal
xxxvi. IRAD
xxxvii. ICON
xxxviii. AutoCarto Consult
xxxix. GeoSpatial Nepal…….. etc.

There exist many other academic survey institutes and some universities, which have incorporated surveying profession along with other disciplines in their faculties.

Manpower

Although the number of organizations involving with survey related tasks have been indicated significantly in the above list of organizations, the major organization for the surveying professionals have been only the survey department in Nepalese context. Most of the manpower has been produced by Land Management Training Centre (Previously, Survey Training Centre) whereas majority of those in the managerial level have acquired academic degree from different international institutions abroad. But due to lack of academic courses in the academic institutes, the profession of surveying has not gained that attraction, as it has to be with other engineering profession. If Survey Department implements the attractive long-term programme as indicated in the Logical Framework submitted by the Think Tank, then definitely it needs more number of survey professionals to materialize the envisaged plan. The total number of postings available in the Survey Department for surveying profession is 2701 starting from the Director General to the Basic surveyor.

Provisions in Nepalese Law Regarding Survey Profession

Nepal has done many things in the field of surveying for developing it as a profession. More needs to be done for making this profession recognized betters. There is a separate line for surveying professional in the government service. Surveying expert having specified qualification can compete for the survey related job where they can be assigned their job in the surveying sector within engineering service.

The provision in the Land Survey and Measurement Act / Regulation allow for licensing of Surveyors in different categories. However, the implementation has not yet been completed.

Recently, government of Nepal has recognized newly emerging technologies such as GIS, digital Cartography, and remote sensing as inherent part of the surveying profession. Personnel of the survey department having acquired their degree in GIS, Geoinformation Management, Land Administration and Cartography from abroad has been recognized for further competition in their profession in the government service.

Professional Associations

There have been many professional organization established to secure and promote the surveying profession in Nepal. These organizations are also seen to be engaged to highlight the research findings through the medium of conferences, workshop and seminar. They have categorized their membership into general member, life member and executive members. These organizations more or less conduct functions of survey aware activities. Following are the major organizations related to surveying.

i. Nepal Surveyor Society (NSS)
ii. Nepal Surveyor Association (NSA)
iii. Nepal Remote Sensing And Photogrammetric Society (NRSPS)
iv. Nepal GIS Society (NEGISS)
v. Action Group for Geoinformation Nepal (AGGIN)

Out of these organizations, some discussions are going onto merge the Nepal Surveyor Society and Nepal Surveyor. But it is unfortunate that Nepal Surveyor Society has remained dormant for a long period. Nepal Surveyor Association has at least shown some activities that at least call for surveyor into a platform. It is realized Nepal Surveyor Association perform more activities to preserve the integrity and enhance dignity of surveyors working in different parts of the country. Nepal Remote Sensing And Photogrammetric Society has recently organized a seminar to raise awareness about the profession. There are around 1500 members in Nepal Surveyor Association as obtained from the source of the organization where as NRSPS has only about 50 members within its organization.

Nepal Remote Sensing And Photogrammetric Society has also acquired membership from international Organizations such as ISPRS respectively. Survey Department has acquired membership from FIG. National Geographic Information Infrastructure, Survey Department is the member of Global Spatial Data Infrastructure Association.

Ethics and code of conduct

A profession sustains if it possesses ethical values and code of conduct. Famous Pennsylvania Society of Land Surveyors assumes the following practices are supposed to be unprofessional and such action is against the professional dignity of a Land Surveyor, which is relevant for all land surveyors.

a. To act for his/her client or employer in professional matters other than as a faithful agent or trustee, or to accept any remuneration other than his stated recompense for services rendered.
b. To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects or business of anyone.
c. To attempt to supplant another land surveyor after definite steps have been taken toward his employment.
d. To compete with another land surveyor for employment by the use of unethical practices.
e. To review the work of another land surveyor for the same client, except with the knowledge of such land surveyor, or unless the connection of such … land surveyor with the work has been terminated.
f. To attempt to obtain or render technical services or assistance without fair or just compensation commensurate with the services rendered: Provided, however, the donation of such services to a civic, charitable, religious or eleemosynary organization shall not be deemed a violation.
g. To advertise in self-laudatory language, or in any other manner, derogatory to the dignity of the profession.
h. To attempt to practice in any other field in which the registrant is not proficient.
i. To use or permit the use of his professional seal on work over which he was not in responsible charge.
j. To aid and abet any person in the practice of land surveying not in accordance with the provisions of this act or prior laws.

It has been studied that a profession is said to have six characteristics, each of which is in fact true of land surveying:

1. A theoretical base—measurement theory (the "science" of surveying) and boundary law (mainly the rules of construction).
2. A practical need—jurisdiction over the land by means of a cadastral system and its orderly development by means of land and geographic information systems.
3. A competence to satisfy that need—the knowledge, skill and experience acquired by formal education, informal training and the imitation of expert practice.
4. A legal sanction for the competence—licensing and registration, primarily by a state's Bureau of Occupations and Professions.
5. A standard of practice—the common use of the competence, to which a manual of practice prepared by a professional society may serve as a guide.
6. A code of ethics —a tabulation of beliefs, responsibilities or values either enacted into statute or advocated by members of a professional society

Technology and Challenges

The advancement in technology in the field of Geospatial data acquisition and data handling has been so rapid that is very difficult to keep pace with them by virtue of lack of resources in terms of human resources, finance and others. Technology has gone to space, which are not easily affordable to be adopted. Gradually the existing hardware components become useless by non-compatibility with the latest one. The process model, data structure along with the product structure is being changed as a result of the technology, which have been the major constraints for adaptability. It seems majority of the professionals are always out of date by the speed of change. In this situation, surveying professionals have to be very alert and very competitive to secure the professionalism. Especially, the scope of profession has become wider and has given more space by the impetus of the Geo-spatial Information technology and definitely has carried out the change in the identity of a surveyor and the very definition of surveying profession. In the present day, a surveyor is also assumed to have knowledge on

Web technology	: for spatial data dissemination,
Database management	: for managing the spatial data,
GIS	: for Geo-information analysis,
Cartography	: for digital visualization of the information,
Programming	: for self-suited mass generation of geo-product out the data they acquire.

Hence, there is big challenge ahead of present day surveyor. But thanks to the ICT, it indeed have helped more to recognize a surveyor and enhanced surveying profession by facilitating tools of observation and analysis of the information than ever.

Conclusion

Surveying should be a licensed profession. No person without surveying license should accept as surveyor. Code of conduct and ethical principle must be made prevailed among all of the surveyors. Surveyors must have flexibility of being changed with the change in the technology of their profession.

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Tissot Indicatrix: A Means To Map Distortion Analysis

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Tissot's Indicatrix

In 1859, N.A. Tissot published a classic analysis of the distortion which occurs on map projection. Tissot showed the relationship graphically with an ellipse of distortion called an indicatrix. An infinitely small circle on the earth projects as an infinitely small ellipse on any map projection. If the projection is conformal, the ellipse is a circle, an ellipse of zero eccentricity. The ellipse has a major axis and a minor axis which are directly related to the scale distortion and to the maximum angular deformation. The values for a and b, the two axes of an ellipse on projection can be computed using the following
expression:

$$a = \frac{1}{2}\left(\sqrt{m^2 + 2mn\cos\varepsilon + n^2} + \sqrt{m^2 - 2mn\cos\varepsilon + n^2}\right)$$

$$b = \frac{1}{2}\left(\sqrt{m^2 + 2mn\cos\varepsilon + n^2} - \sqrt{m^2 - 2mn\cos\varepsilon + n^2}\right)$$

Here,

m = scale along meridian at a point
n = scale along parallel at a point
ε = deviation from right angle of the intersection (parallel and meridian) $(i - 90^o = \varepsilon)$

Computation of m, n, e
<u>Gauss coefficients</u>

$$e = \left(\frac{dx}{d\phi}\right)^2 + \left(\frac{dy}{d\phi}\right)^2,$$

$$f = \frac{dx}{d\phi} \times \frac{dx}{d\lambda} + \frac{dy}{d\phi} \times \frac{dy}{d\lambda},$$

$$g = \left(\frac{dx}{d\lambda}\right)^2 + \left(\frac{dy}{d\lambda}\right)^2$$

Distance on projection plane

$$ds' = (ed\phi^2 + 2fd\phi d\lambda + gd\lambda^2)^{\frac{1}{2}}$$

Along the meridian (at constant l) and parallel (at constant Ø) dimension of an infinitesimal segment may be computed as follows:

$$ds'_m = \sqrt{e}d\phi, \; ds'_p = \sqrt{g}d\lambda$$

Angle *i* between the meridian and parallel on the projection computed as follows:

$i = tan^{-1}(h/f) = cos^{-1}(f/\sqrt{(eg)}) = sin^{-1}(h/\sqrt{(ge)})$
where $h = \sqrt{(eg - f^2)} = x_\lambda y_\varphi - x_\varphi y_\lambda$
$\varepsilon = tan^{-1}(-f/h)$
where $\varepsilon = i - 90^o$, the deviation of i from a right angle on the projection.
When $\alpha = 0$
$m = \mu_{\alpha,0} = \sqrt{e}/M$ (scale at meridian)
When $\alpha = 90$
$n = \mu_{\alpha,90} = \sqrt{g}/r$ (scale at parallel)

Convergence along meridians and parallels.

$\gamma_m = tan^{-1}(x_\varphi/y_\varphi), \; \gamma_p = (x_\lambda/y_\lambda)$
angle *i* is considered to be clockwise from north, and its quadrant is determined by the sign of *f*.
If $f > 0$, i is in first quadrant
If $f < 0$, i is in second quadrant
If $f = 0$, $i = 90^o$ (parallels and meridians are orthogonal)

<u>Required condition for</u>

a) <u>conformal projection</u>

i. $\beta \approx \alpha$
ii. $f = 0$ and $(e/h) * (r/M) = 1$
iii. $m = n$ and $\in = 0$
iv. $\sqrt{e}/M = \sqrt{g}/r$ and $f = 0$

Cauchy - Riemann conditions
$(1-e^2 \sin^2\phi)\, dx/(1-e^2)d\phi = -dy/(\cos\phi\, d\lambda)$

b) Equal area projection

$$s = \int_{\phi_0}^{\phi_2}\int_{\lambda_1}^{\lambda_1+1} Mr\,d\phi\,d\lambda \text{ (Ellipsoidal)}$$

$$A = \int_{\phi_0}^{\phi_2}\int_{\lambda_1}^{\lambda_1+1} h\,d\phi\,d\lambda \text{ (Projection Plane)}$$

(i) $s \approx A$

(ii) $h = Mr$

Opening it in series,

$s = b^2 (\sin\phi + (2/3) e^2 \sin^3\phi + (3/5) e^4 \sin^5\phi + 4/7\, e^6 \sin^7\phi)$

(area from equator to ϕ, and width of 1 radian)

$$\frac{dx}{d\lambda}\frac{dy}{d\phi} - \frac{dx}{d\phi}\frac{dy}{d\lambda} = Mr$$

$$\frac{dx}{d\lambda}\frac{dy}{d\phi} - \frac{dx}{d\phi}\frac{dy}{d\lambda} = R^2 \cos\phi$$

For small scale mapping an ellipse is taken as sphere, then,

$mn \sin i - mn \cos \varepsilon = 1$

$ab = 1$

For ellipsoid

$$\frac{dx}{d\lambda}\frac{dy}{d\phi} - \frac{dx}{d\phi}\frac{dy}{d\lambda} = (a^2(1-e^2) \cos\phi)/(1-e^2 \sin^2\phi)^2$$

c) Equidistant projection

If $m = 1$ then $x^2_\varphi + y^2_\varphi = M^2$

If $n = 1$ then $x^2_\lambda + y^2_\lambda = r^2$

Azimuth β of linear elements ds' on the projection

$\tan\beta = (m\, h \tan\alpha) / (er + m f \tan\alpha)$

$\tan\alpha = (n \sin i - m)/(n \cos i)$

$M = a (1-e^2)/(1-e^2 \sin^2\phi)^{3/2}$

$r = a \cos\phi / (1-e^2 \sin^2\phi)^{1/2}$

α = ellipsoidal azimuth

β = projection plane azimuth

e, f are gauss coefficients

m,n are scale at a point along meridian and parallel

a is the semi major axis of the earth ellipsoid.

Linear scale

$\mu = [(e/M^2) \cos^2\alpha + (f/Mr) \sin 2\alpha + (g/r^2) \sin^2\alpha)]^{1/2}$ (any direction defined by α)

Areal distortion

$P = mn \cos\varepsilon = mn \sin i = ab$ (P is area).

Maximum angular distortion (Vitkovskiy)

$\sin(\omega/2) = (a-b)/(a+b)$, $\cos(\omega/2 = (2\sqrt{(ab)}/(a+b)$, $\tan(\omega/2) = (a-b)/(2\sqrt{(ab)})$

Extreams of Local Linear Scale

Ellipsoidal extremes of local linear scale occur at the direction

$\tan 2\alpha_0 = 2mn \cos 2i / (m^2-n^2)$ (ellipsoid)

Direction in projection

$\tan 2\beta_0 = n^2 \sin 2i / (m^2+n^2\cos 2i)$

Above two equations produce two directions a_0 and a_0 + 90 ^{O}, b_0 and b_0 + 90^O in azimuth in both ellipsoid and the projection, along those direction the extreme value of a and b (of Tissot Indicatrix) falls. These two directions are orthogonal and are called BASE DIRECTION. In conformal projection or where meridians and parallels cut at right angle, the base direction falls on them.

A study was made at Bhadrapur 26^{O}32'N, 88^{O}04'N to examine the deformation due to projection using Tissot Indicatrix for Bonne pseudoconical equal area projection. The study was made on scale at meridian and parallel, axis dimension a and b of tissot indicatrix ellipse, areal and angular distortion, azimuth at which the maximum deformation occur etc.

Bhadrapur

α_0 = -0.762436092 radian

β_0 = -0.762422093 radian.

At Bhadrapur the following table gives the deformation character:

a. Parallel and meridian intersect at an angle 89^{O}59'54.22"
b. Maximum angular error = - 5' 30.89"
c. Azimuth at which the maximum over all error occur is - 43^{O}41'3.77" (North West)
d. Base directions 43^{O}41'3.73" and 133^{O}41'3.73"
e. Areal scale (a * b) = 1 (equal area)

f. Scale at parallel = 1, scale at meridian 1.00000128

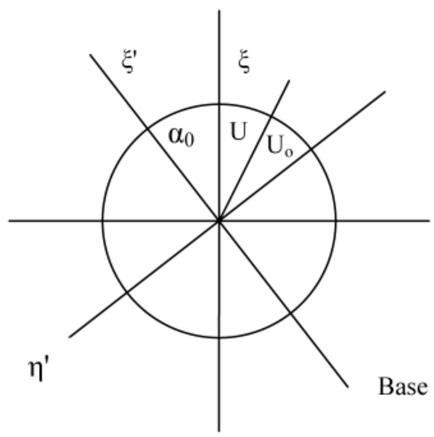
g. The ellipse axis diameter a = 1.0008024, b = 0.999198222

h. The values of angle at which angular distribution is maximum, u_o= 0.7857992092056535, v_o = 0.784997117859243.

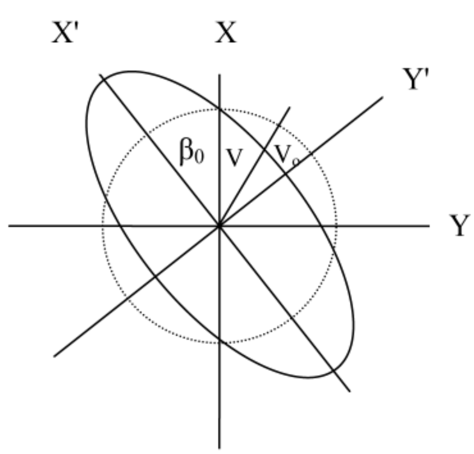
m = scale along meridian
n = scale along parallel
ai = angle of intersection between meridian and parallel
ep = deviation from right angle
omg = angular distortion
alpha = base direction in ellipsoid
beta = base direction in projection plane

<u>BHADRAPUR</u> (Tissot Indicatrix parameters computation)

1.000001286701646	1. 0000000000000000 m, n		
1. 000802413463986	9. 99198228871476E-001	1.00000000000000 A,B,AR	
1.604183232763055E-003	1.570768328533692	1.604182200711559E-003 OMG, AI, EP	
-1. 604182200657523E- 003	- 1.604180063880593E-003 ALPHA, BETA		
- 7. 624360922924287E- 001	- 7. 624220931708325E- 001 ALP0,B0		
7. 608319100917712E-001	7.6081791310069519E-001 U, V		
7. 857992092056535E- 001	7. 849971178592431E-001 U0, V0		



Ellipsoid



Projection Plane

alpo = extreme of local liner scale
bo = corresponding azimuth to projection plane
uo = at this direction omg will be maximum distorted (ellipsoid)
vo = at this direction omg will be maximum distorted (projection)
alpha (omg) max=alpo+uo
beta (omg) max=bo+vo

Conclusion

In Nepal UTM projection is used since 1970, due to the pattern of error distribution three grid zones have been selected. A small country like Nepal has three sets of grid zones and co-ordinate, this situation has posed problems while mosaicing all three grids at margin. Either we have to transfer the grid zone to the other grid system, however some accuracy may be lost while doing so, on the other hand transformation of grid is not a suitable means to solve the problem. Present day computer cartography, digital mapping, GIS etc. are the popular technologies which may be utilized in solving this type of problem.

Taking consideration of the geographical position of the country, its shape after projection, distortion of area, angle, azimuth etc, I came to a conclusion that projection of conic and pseudo-conic family is best suited for the country. I found conic conformal projection with a minimum scale factor of units along parallel 28^{o}N (Central parallel of Nepal) gives least areal distortion.

For equal area projection Alber equal area conic projection and Bonne Pseudo-conic equal area projection (Normal) were studied. Bonne projection gives low distortion than Alber projection.

Survey Department should setup a working group to come up with the recommendation after thorough study the problem and suggest a suitable projection for the country (Conformal, equal area, equidistant). Also technical map and general maps should be dealt separately because technical map requires high degree of accuracy and general map should give some what true picture of the country.

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Twenty-five years in

Nepal-india Border Demarcation

Buddhi Narayan Shrestha
Former Director General

India is a close neighbor of Nepal in terms of geographical proximity. The physical configuration of the border between the countries does not present natural barrier. Nepal-India relation has developed from time immemorial in cultural, religious and social aspects. India is very close for Nepal in respect of increasing volume of trade. In the same way Nepal is important to India in many aspects, as Nepal is situated between emerging nations, China and India. India could increase trade volume with China through Nepal, as a transit country.

Various treaties, agreements and memorandums have been carried out between Nepal and India since the British India period. Supplementary Boundary Treaty of 1 November 1860 is one of them. This treaty has delineated the last borderline of present Nepal. After the treaty, border demarcation was made with *Junge* pillars. However, clear-cut demarcation was incomplete in many places including the riverine segments. To complete the remaining works, Nepal-India Joint Technical Level Boundary Committee (JTLBC) was formed and started to work from 15 November 1981. The terms of reference of the JTLBC is to erect subsidiary markers in bending line, to repair wrecked pillars, to prepare strip-maps and to maintain no-man's land. JTLBC has completed more than 98% of new strip mapping of Nepal -India boundary, which are on the process of making database and printing. About 97 % of boundary line identification is completed based on base maps of Nepal - India boundary prepared after Sugali Treaty, which were recognized by both countries and agreed principle of fixed boundary in reverine segment and watershed principle in hilly sector.

The committee has completed 25 years by now. There may be a question: whether this duration is too long to complete the work or normal due to the nature of work. To answer this, we have to evaluate the activity of JTLBC, field program of joint teams, diplomatic initiative, feeling of sensitivity of international border and role of the head of government to solve the border issues.

There is a provision to organize joint meeting alternately in Kathmandu and New Delhi, as stated in the terms of reference of JTLBC. As such, fifty meetings should have been taken place during the period of twenty-five years. But the meeting has been held twenty-eight times. The last meeting is held on 21-22 December 2006 in Kathmandu. With this, the progress of joint meeting is counted as only 56 percent. In the mean time, committee leaders have been changed frequently, twelve times in Indian side and eight times from Nepal. Occasional transfer of committee leaders might have hampered the progress of the joint committee, in some extent.

Next, lack of appropriate diplomatic initiative is one of the main reasons to spend twenty-five years in demarcating Indo-Nepal border. There are spots of claims and counter-claims. Kalapani and Susta are notable spots.

Indo-Nepal international border demarcation work has been on shadow due to frequent political changes. Heads of government have been changed 20 times in Nepal in 25 years period. As a result, border demarcation work could not get priority. Less attention has been given to settle the remaining issue of national border.

It seems that head of government of both countries do not have sufficient time to deal on border issues. It has pulled on the duration of border demarcation between Nepal and India. They provide general instruction to JTLBC. But they have no time to resolve the issues put forward by the joint technical committee. Since the committee has its limitation and it has to deal on technical matters. But the crux of the border problem, especially on claim and counter-claim is of political and diplomatic nature. The heads of government level should have settled the problems. But they are not yet in action to solve the problem.

However, they know the problem well including the Kalapani issue. It may be relevant to mention that IK Gujaral has said in his prime ministerial tenure "As regards Kalapani, the technicians from both sides are engaged in the demarcation of border. If their reports conclude that the area belongs to Nepal, we will immediately withdraw from there" (Gorkahpatra Daily, 24 February 1997).

In the same way, Krishna Prasad Bhattarai as prime minister has said "Kalapani is in Nepali territory and Kalapani is ours according to the maps of that area" (Kantipur Daily, 24 July 1999). From this version, one has to realize that heads of government know well the problems. But they have not put this matter on the agenda during face-to-face meeting. Instead, they spell directions to junior officials to study the problem further more.

When we prick the directives provided by the prime ministers, one could recall the joint statement published during the visit of neighboring country. Article 25 of Nepal-India Joint Press Statement released on August 3, 2000 during PM Girija Prasad Koirala's visit to India states: "The two Prime Ministers direct the committee to complete its field work by 2001-2002 and final preparation of strip-maps by 2003. They also directed the JTLBC to expeditiously complete its examination of the facts relating to the alignment of the boundary in the western section, including the Kalapani area, and in other pockets, where there were differences in perceptions of the two sides."

Similarly, Article 6 of the joint statement issued on September 12, 2004 during the then PM Sher Bahadur Deuba's visit to India states: "The Prime Ministers expressed satisfaction at the progress made by the JTLBC and directed the committee to complete the remaining mandated tasks by June 2005." But this directive also could not get materialized. Instead, the time period has been extended to June 2007 by exchanging letters. It is memorable that the previous deadline of JTLBC was fixed as 1991, 1995 and 1997. Here lies the question: why the joint instructions of two Prime Ministers could not get materialized? Is it possible to complete the remaining tasks in due time? Let us have a look on the remaining works.

It is commendable that JTLBC has completed 98 percent of the demarcation work with the establishment of additional subsidiary border pillars. But two percent of the total work has been entangled for long. There are many claims and counter-claims at some places within 2 percent on the spotted span of 36 km and Kalapani and Susta are the major issues. Regarding Kalapani issue, India and Nepal differ as to which stream constitutes the source of the River Mahakali, whether it is originated from Limpiyadhura, Lipulek or an artificial pond. As a result, DPR of Mahakali Treaty has not yet formulated, since eleven years have been elapsed, the treaty was signed by two governments. As regards the Susta case, there is a controversy on the original course of the River Narayani flown during 1816 Sugauli Treaty between the British East India and Nepal.

Here lies the question again: how those differences could be resolved amicably! The answer may be, trained and experienced diplomatic channel should be utilized, which have sufficient knowledge on the subject matter. Secondly, mature politicians should be assigned to talk jointly with fixed agenda. After this, border problems must be handled and resolved in the Prime Ministers' level, as channelised by the experienced diplomats and mature politicians, findings the ways and means to resolve the problems satisfying both the sides. Border problems must be negotiated with mutual discussions in respect of friendship, brotherhood and equality with the background of historical maps, related facts and supporting documents.

Role of civic society is to make aware and create pressure to the government authorities highlighting the facts and figures. Executing power lies in the hands of government authorities. So the head of the governments must demonstrate skill for the settlement of claimed and counter-claimed portions of the national territory once and for all.

Nepal-India JTLBC has elapsed 25 years, as it has crossed the year of Silver Jubilee. However, let us hope the border demarcation between Nepal and India will be completed in a very near future and boundary protocol will be signed in due time. Resolving the border issues, relation between the two countries will be further strengthened in the days to come in a consolidated manner.

Surveying, Survey Department and the Future Mission

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Newer Roles in the Surveying Profession

Changed roles of Surveyors and the recent development of technology guided the Survey Department to engineer in the enhancement of surveying profession and its future mission. This paper tries to identify the activities of the future mission and sort out the list for institutionalization of effective and functional organizational framework of Survey Department.

Though Surveying was recognized as a profession centuries ago, it has still to establish itself as ethically sound and socially respected profession. Previously, The Civil Services Act and Regulations recognized Surveying as part of Miscellaneous Services. It was only in 70's that Surveying was recognized as a profession in itself being classified as Nepal Engineering Service Survey Group. The Fifth Plan (1975-1980), for the first time, identifies three levels of survey technical manpower: Surveyors (high-level) with a requirement of 59, Assistant Surveyors (middle-level) with a requirement of 372 and Amin (basic level) with a requirement of 1222 during the plan period. This amounts to nearly 6.8% of the requirement of all technical manpower in the country. This Plan recognizes, therefore, for the first time surveying as a profession in the country with three-tiers of its own. Today, Survey Department alone has a total strength of around 2000 Surveyors of different categories serving in different positions and specializations. The major fields of specializations in Surveying profession in the Survey Department are: Land Surveying, Topographic Mapping, Geodetic Surveying, Satellite Geodesy, Geo-physical Surveying, Cartography, Photogrammetry, Remote-sensing, LIS, Land Administration, Land Management, Geomatics, GIS, Geoinformatics, Spatial Data Infrastructure, Spatial Database Management and many more.

With the advent of information technology, Surveying is no more limited to the science, technology and skill in the measurement and mapping of the features on the surface of the earth, but acquisition, processing and handling of all geo-related data and information. Therefore the scope has highly enhanced.

In Survey Department, our traditional scope of work was geodetic and other control surveys, cadastral surveying, and topographic mapping. Additionally, as a national mapping organization (NMO) regularization and coordination of all mapping work was also one of its main tasks. The newer roles of Survey Department in the changed scenario is the adoption of changed technology and fulfill the changed aspirations of the users in those fields: geodesy, cadastre, topographic and other national mapping and the enhanced role of NMO as the hub of geo-information infrastructure at the national level.

Mission for the future

The mission of Survey Department for the future could be very elaborate and theoretical in nature. But we need to consider only those points which could be achieved or which should be achieved so that the survey department could serve for the people and ultimately to serve for the nation. In the following, few sectors as the mission of Survey Department for the near future are enunciated. These are practical or unavoidable the attention of all Survey professionals and other decision-makers are necessary to fulfill them:

- Cadastral Survey role
    - Land Ownership Certificate to all legal land-owners
    - Accurate parcel-based information based on numerical cadastre and adjudicated boundary markers
    - Operational Land Information System for reliable and current information on land-ownership and land-holdings
    - E-governance in cadastral maps and records maintenance and related public services
    - Adoption of Cadastre 2014
- Supporting in land administration and land management
    - One-door services in land administration
    - Surveying for better land management like spatial planning, land-use zoning and land consolidation
    - Custodianship in public and government land

- Geodetic Survey role
    - Development of appropriate Geoid for geodetic purpose.
    - Allocation of all control survey work to related Survey Units themselves
    - Development of dedicated Geodetic and Research Branch
- NMA role
    - More of a regulatory body
    - Periodic map updating
    - National coverage of large scale mapping e.g. 1:10,000
    - Focal organization for geographical names, national and international boundaries
    - National Atlas service
- NSDI role
    - Hub of NSDI
    - Availability of multi-resolution database 1:10,000 to 1:1 Million
    - Mandatory adoption of national standards and central clearinghouse for metadata
    - Data sharing through distributed clearinghouse and electronic data transaction

Institutionalization of effective and functional Survey Department

The above mission cannot be achieved without an effective and functional organizational framework of Survey Department. Therefore the institutionalization of the following is necessary:

- Issue related to trimmed and functional organization
    - More of a regularatory body rather than a production organization
    - Public-private and public-public partnership in mapping and GIS
    - Improvement of professionalism in surveying and mapping
    - Services of licensed surveyors in cadastral maps and records maintenance
    - Trimming and gradual reduction of basic and medium level positions and creation of qualified specialized higher-level Surveyor positions
    - Creation of specialized mapping and geo-information centers at the center and regions
    - Creation of regional Survey Directorates and decentralization of authority
- Policy Issues
    - Development of National Land Policy, Survey Policy and Geospatial Data Policy
    - Creation of specialized Land Administration Service
    - Creation of Department of Land as a custodian of public and government land
    - A consolidated cadastral survey, land registration and land information department for land administration
    - A consolidated land consolidation, spatial planning, land-use zoning and land use planning department for land management
- Human Resource Issues
    - Enrollment of members qualified in the respective profession in Land Administration and Survey Service
    - Gradual upgrading of all Amin an Kharidar posts to non-gazetted Class I and consequently to Officer Class III level within five years
    - Systematic plan for periodic and continuous support like on-the-job orientation, training, higher studies for members of Land Administration and Survey Service
    - Systematic plan for recruitment and career development for members of Land Administration and Survey Service
- Professionalism in Surveying Profession
    - Enactment of Survey Council Act
    - All members of Land Administration and Survey Service to hold membership of Survey Council
    - Survey Council to enunciate the clauses and monitor the adherence to the Morality and Ethics of Surveying professionals
    - Co-ordinate with the professional societies such as Nepal Surveyor's Association, Nepal Remote Sensing and Photogrammetric Society, Nepal Surveyor's Society, Nepal GIS Society etc to enhance the activities of the department.

Conclusion

All Surveyors belong to the profession of Surveying. Survey Department alone cannot and should not take all responsibility for surveying and mapping in the country. It can only play a facilitator and a regularatory body. The Surveying profession has so many specializations that Survey Department can be more effective when it can create an environment for public-private and public-public partnerships based upon capacity, capability and necessity. It is necessary that Survey Department adopts newer technology to fulfill the user needs and the organizational and institutional developments are made accordingly. Lot has to be done and some are practical while others are inevitable to meet the pace of time. The mission for future of Survey Department has a long list of policy intervention and activities to be undertaken. It is important that we take to the direction.