

NEPALESE JOURNAL ON GEOINFORMATICS

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INTERNATIONAL WORKSHOP ON THE MEASUREMENT OF THE HEIGHT OF THE MT. EVEREST (SAGARMATHA) AND GNSS APPLICATIONS

11-12, DECEMBER 2017
KATHMANDU, NEPAL



SURVEY DEPARTMENT
Ministry of Land Reform & Management
GOVERNMENT OF NEPAL





Director General, Mr. Ganesh Prasad Bhatta handing over Population & Socio-Economic Atlas of Nepal to Prof. dr. ir Tom Veldkamp, Rector/Dean of the faculty of Geoinformation Science & Earth Observation, ITC;University of Twente, the Netherlands on June 30, 2018

The Nepal-India Joint Field Inspection Team inspecting the joint field works in Nepal-India border area. Among different tasks performed by Field Teams we can see the first ever boundary pillars constructed along the riverine boundary sector.



Survey officer of Survey Department, Mr. Khim Lal Gautam participating in a program "Way Forward: Survey and Mapping Practice In Malaysia" 6-19 august, 2017 organised by Malaysian Technical Cooperation Program (MTCP)

Participants of the International Workshop on the Measurement of the Height of The Mt. Everest (Sagarmatha) and GNSS Applications conducted on 11-12 Dec. 2017, Kathmandu, Nepal.



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Nepalese Journal

on

GEOINFORMATICS

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Number 17

Product Price

Maps

Page 14

Control Points

Page 14

Aerial Photographs and Map Transparencies

Page 15

Digital Data Layers

Page 15

SOTER Data

Page 15

Digital Orthophoto Image Data

Page 15

Publications

Page 62

News

Obituary

Page 48

Cover Page

*Sagarmatha at Background
& inaguration Ceremony of
International Workshop on The
Measurement of The Height Of
The Mt. Everest (Sagarmatha)
And GNSS Applications.*

Features

Articles

- 1 **Pixel to Picture and Picture to Person**
Rabin K. Sharma
Page 1
- 2 **Geoid Determination and Gravity Works
in Nepal**
Niraj Manandhar & Shanker K.C.
Page 7
- 3 **Positional Accuracy of Online
Geocoding Services: Case Study of
Bhaktapur District**
Er. Amrit Karmacharya
Page 16
- 4 **Status of Land Tenure
Security in Nepal**
Harisharan Nepal & Anil Marasini
Page 22
- 5 **The Importance of RRR In Cadastral
System**
*Sanjaya Manandhar, Bijaya Kumar Manandhar
Pradeep Sapkota Upadhyaya-PhD,
Tanka Prasad Dahal*
Page 30
- 6 **Spatial Distribution and Temporal
Change of Extreme Precipitation Events
on the Koshi Basin of Nepal**
Sanjeevan Shrestha & Tina Baidar
Page 38

Contents

Nepal Surveyor's Association (NESA)

Page 70

Professional
Organization
Pages

Nepal Remote Sensing and Photogrammetric Society

Page 71

Editorial

Page vi

Regular
Column

Forewords

Page x

Messages

Page vii-ix

Participation in International Events

Page 47

Calender of International Events

Page 61

Articles in Previous Issues

Informations

Page 63

Call for Papers

Page 72

Instruction and Guidelines for Authors Regarding Manuscript Preparation

Page 72

Contents

7 **Cadastre 2014: Performance of Nepal**

Susheel Dangol & Ganesh Prasad Bhatta

Page 49

8 **GNSS Practice In Survey Department**

Sushmita Timilisinga & Bibek Nepal

Page 55

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EDITORIAL

Since 2058 BS (2002 AD) Survey Department has been publishing "Nepalese Journal on Geoinformatics" which has been an important asset as well as a means to propagate professional knowledge, skills and expertise in the field of Surveying, Mapping and Geo-information. Continuing its commitment to share knowledge, Survey Department is publishing the 17th issue of "Nepalese Journal on Geoinformatics".

In last sixteen issues more than 100 articles in a variety of themes related to Surveying, Mapping and Geo-information have been published. I would like to express sincere thanks to all those incredible authors for their contributions and members of Advisory Councils and Editorial Boards of all those issues of the journal for their persistent efforts to publish the journal.

This seventeenth issue of the journal contains a wide variety of interesting and worth reading articles on different topics viz. "Pixel to Picture and Picture to Person" by Rabin K. Sharma, "Positional Accuracy of Online Geocoding Services: Case Study of Bhaktapur District" by Er. Amrit Karmacharya, "Status of Land Tenure Security in Nepal" by Harisharan Nepal & Anil Marasini, "The Importance of RRR In Cadastral System" by Sanjaya Manandhar, Bijaya Kumar Manandhar, "Spatial Distribution and Temporal Change of Extreme Precipitation Events on The Koshi Basin of Nepal" by Sanjeevan Shrestha and Tina Baidar, "Cadastre 2014: Performance of Nepal" by Susheel Dangol and Ganesh Prasad Bhatta and "GNSS Practice in Survey Department" by Sushmita Timilisina, Bibek Nepal.

At this point, I am very much thankful to the Survey Department for entrusting me with the responsibility of the Editor-in-Chief for this seventeenth issue of the journal. Following the advice and suggestions of Advisory Council, we, the members of Editorial Board have been able to bring forth the seventeenth issue of the journal. On behalf of all the members of the Editorial Board, I would like to express sincere thanks to all contributing authors, members of Advisory Council and all others who have contributed for the publication of this issue of the journal.

Before I stop, on behalf of the Editorial Board, let me humbly request all of you to contribute your valuable thoughts, articles, research papers, success story and the like for the upcoming issue of this journal.

Suresh Man Shrestha
Editor-in Chief
Jesth, 2075



नेपाल सरकार

मा. चक्रपाणी खनाल "बलदेव"
कृषि, भूमि व्यवस्था तथा सहकारी मन्त्री



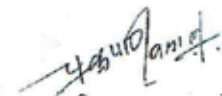
शुभकामना

नापी विभागको ६१ औं वार्षिकोत्सवको पुनित अवसरमा १७ औं अंक "Nepalese journal on Geoinformatics" प्रकाशन हुन लागेको जानकारी पाउदा हर्षित तुल्याएको छ। यस प्रकारका प्रकाशनले पेशागत विकासमा महत्वपूर्ण भूमिका निर्वाह गर्ने भएकोले विभागको यो प्रयास अत्यन्त सद्धानिय रहेको छ।

लामो प्रतिक्षापछि जनअपेक्षा अनुरूप मुलुकले स्थिर सरकार पाएको छ। यस अवसरलाई सम्पूर्ण जनताको वृहत्तर हितमा उपयोग गर्नु आवश्यक रहेको छ। यसका लागि हामी सबैले परम्परागत प्रवृत्ति, कार्यशैली लाई रुपान्तरण गरी राष्ट्रिय आवश्यकताको सोच बदल्न जरुरी रहेको छ। यसै सन्दर्भमा हालै "कृषि, पशुपंछी, भूमि व्यवस्था तथा सहकारी क्षेत्रको रुपान्तरणको मार्ग चित्र २०७५" जारी गरिएको छ। मार्गचित्रमा नापी विभागलाई तोकिएको जिम्मेवारीलाई दृष्टिगत गर्दा समुचित भूमि उपयोगको लागि वर्गीकरण तथा व्यवस्थित जग्गा विकास, आधुनिक प्रविधिको उपयोग मार्फत नापी कार्यालयहरूबाट हुने सेवा प्रवाहलाई विचौलियाहरूको प्रभावबाट मुक्त गर्ने आधारभूत पूर्वाधारयुक्त एवम् सेवाग्राहीमैत्री कार्यालयहरू, टोकन प्रणालीको अवलम्बन, नक्सा श्रेस्ताहरूको भरपर्दो अभिलेख लगायतका विषयवस्तुहरू समेटिएका छन्। विभाग अन्तर्गतबाट उल्लेखित मार्गचित्रका विषयवस्तुको प्रभावकारी कार्यान्वयनबाट सर्वसाधारण जनताले परिवर्तनको महसुस गर्ने विश्वास लिएको छु। सर्वसाधारण जनताको अचल सम्पत्तिको अभिलेखिकरण गर्ने, विकास निर्माणका लागि अत्यावश्यक पर्ने नक्सा तथा भौगोलिक सूचनाहरू तयार गर्ने तथा नेपालको अन्तराष्ट्रिय सिमानाको अभिलेख तयार गर्ने जस्ता महत्वपूर्ण एवम् सम्बेदनशील जिम्मेवारी प्राप्त गरेको यस विभागबाट वितरण हुने सेवा आगामी दिनमा अझ बढी गुणस्तरीय, प्रभावकारी एवम् जनमुखी हुनेछ भन्ने आशा लिएको छु।

अन्त्यमा, राष्ट्र निर्माणका विभिन्न आयामहरूमा आफ्नो क्षेत्रबाट विशिष्ट योगदान पुऱ्याउदै आएको नापी विभागले स्थापनाको ६१ वर्ष पुरा गरेको अवसरमा सबै कर्मचारीहरूलाई हार्दिक बधाई व्यक्त गर्दछु। र विभागलाई यस अवस्थासम्म पुऱ्याउन प्रत्यक्ष तथा परोक्ष रूपमा योगदान पुऱ्याउनु हुने कर्मचारी लगायत सम्पूर्णलाई विशेष धन्यवाद दिन चाहन्छु। साथै वार्षिकोत्सवको पूर्ण सफलताको कामना गर्दछु।

जेठ १४, २०७५


मा. चक्रपाणी खनाल "बलदेव"
मन्त्री

विजी सचिवालय सिंहदरबार, काठमाडौं, फोन नं.: ४२११५२५, फ्याक्स: ४२११५३५



नेपाल सरकार

मा. रामकुमारी चौधरी "रोजिना"
कृषि, भूमि व्यवस्था तथा सहकारी राज्य मन्त्री




शुभकामना

सर्वप्रथम नापी विभागको ६१औं वार्षिकोत्सवको अवसरमा विभाग अन्तरगतका सबै कर्मचारीहरूलाई हार्दिक बधाई तथा उत्तरोत्तर प्रगतिको शुभकामना व्यक्त गर्दछु । स्थापनादेखि आजको दिनसम्म आइपुग्दा विभागले गरेको प्रगति तथा राष्ट्र निर्माणमा पुर्याएको योगदान उल्लेखनीय एवम् प्रशंसनीय रहेको छ । विभागलाई यस अवस्थामा ल्याइ पुर्याउन प्रतक्ष्य वा अप्रतक्ष्य रूपमा योगदान दिनुहुने सम्पूर्ण महानुभावहरूलाई धन्यवाद दिन चाहन्छु ।

कृषि, भूमि व्यवस्था तथा सहकारी मन्त्रालयमा जिम्मेवारी सम्हाले पश्चात नापी विभागको समय जिम्मेवारी यस अघि मैले सोचे भन्दा बृहत रहेको मैले पाएको छु । यस विभाग अन्तर्गतबाट सम्पादन हुने कार्यहरू अत्यन्त महत्वपूर्ण एवम् सम्वेदनशील रहेकाले विभागको कार्य सम्पादनले सुशासनको अवस्थालाई प्रभावित पारेको हुन्छ । जनता संग नजिक रही काम गरेको अनुभवबाट सर्वसाधारण जनताले नापी विभाग अन्तर्गतका कार्यालयहरूबाट प्रवाह हुने सेवामा सुधारको अपेक्षा राखेको पाएको छु । देश गणतन्त्रात्मक व्यवस्थामा गई राजनैतिक स्थायित्वको धरणमा प्रवेश गरेको वर्तमान परिप्रेक्षमा सर्वसाधारण जनताले राज्य संयन्त्रबाट सुधारात्मक परिवर्तनको अपेक्षा राखेका छन । यस सन्दर्भमा विभागले जन-अपेक्षा एवम् समयको आवश्यकतालाई मध्यनजर गरी आगामी दिनमा सुधार सहितको परिवर्तनका लागि पाइला चाल्नेछ भन्ने विश्वास लिएको छु ।

यस वर्षको वार्षिकोत्सव समारोहमा विभागको वार्षिक पुस्तिका प्रकाशन "Nepalese Journal on Geoinformatics" को १७ औं अंकको लोकार्पण हुन लागेको जानकारी पाउँदा खुशी लागेको छ । यस प्रकाशनले आगामी वर्षहरूमा निरन्तरता पाईरहोस भन्ने शुभकामना व्यक्त गर्दछु । धन्यवाद!

१४ जेठ २०७५


मा. राम कुमारी चौधरी "रोजिना",
राज्य मन्त्री

निजी सचिवालय सिंहदरबार, काठमाडौं, फोन नं.: ४२११५२५, फ्याक्स: ४२११५३५



Government of Nepal

Ministry of Agriculture, Land Management and Cooperatives
Singh Durbar, Kathmandu

Ref. No.....

Date:



Message from the Secretary

I feel very happy to recall the days I used to work in the Survey Department during the starting phase of my career. Now, I feel very much satisfied to chalk out a few words for the seventeenth annual journal being published by the department since 2058 BS (2002 AD).

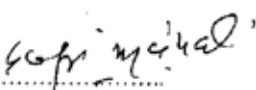
During last few decades I have noticed that the department has achieved a commendable progress in the field of Surveying, Mapping and Geo-information creation, sharing and dissemination contributing towards the overall national development. Surveying, Mapping and Geo-information being the infrastructure of infrastructures play a vital role in the society. I feel equally proud to see that the department has initiated the field works for the measurement of the height of Mount Everest (Sagaramāthā) and is determined to publish the results within two years. I am very much impressed by the achievements of the department's staff to construct the first ever riverine pillars along the riverine boundary sector between Nepal and India.

I have a very positive impression that the department of confidently moving ahead together with the developments of technology and sciences to cater the Surveying, Mapping and Geo-information requirements of our society. In capacity of the Secretary at the Ministry of Agriculture, Land Management and Cooperatives, I do assure the full support from the ministry to the department's undertakings.

Going through the contents of the journal, I feel enlightened in a few more aspects of Surveying, Mapping and Geo-information. I strongly recommend all professionals in the field of Surveying, Mapping and Geo-information to read the articles and get benefited. Additionally, I would like to request you all to contribute and share your experiences in the coming issues of this journal.

I honestly appreciate the efforts made by the Advisory Council and Editorial Board of this journal to bring out the seventeenth issue of "Nepalese Journal Geoinformatics". Taking the opportunity, let me extend heartiest congratulations to the Survey Department and its entire staff members on the occasion of 61st Anniversary of the establishment of Survey Department.

Thank you and enjoy reading.



Gopi Nath Mainali
Secretary,
Ministry of Agriculture, Land Management and Cooperatives

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FOREWORDS

It is indeed a matter of immense pleasure for me to present the Seventeenth issue of "Nepalese Journal on Geoinformatics" on the Sixty-First Anniversary of Survey Department. Let me take a moment on this special occasion of the Sixty-First Anniversary, to congratulate entire staff of the Department and extend sincere thanks to those who have contributed, in the past in different capacities for the betterment of the Department. I invite everyone concerned to join this glorious celebration of the anniversary.



I feel proud to mention that Survey Department, as the only National Mapping Organization of Nepal, has been tremendously contributing in the sector of land administration and management of the country by providing essential maps and geoinformation products which are also crucial for the infrastructure development and international boundary management. I presented a brief overview of the evolution of the Department in the sixteenth issue of this journal that was published on the occasion of the Diamond Jubilee of the Department.

After assuming the office of the Director General, I have been trying to invest all my energy in the endeavours aimed at strengthening the Department, its staff and the profession as a whole. My colleagues, especially Deputy Director General Mr. Suresh Man Shrestha, Deputy Director General Mr. Niraj Manandhar, Deputy Director General Mohammad Sabir Hussain and Deputy Director General Mr. Prakash Joshi, including entire staff of the Department from their respective positions, have been together with me in every efforts taken to enhance the Department. While acknowledging the tremendous contributions of my predecessors, I made a commitment last year to follow the footprints left by my predecessors and work harder to propell the Department towards better position. This commitment has been and will be the guideline i will follow in every effort I undertake. In the mean time, let me also accept the fact that despite the best efforts from everyone from respective sides, we are yet to see the Depatment at its best. However, I am confident that we will be successful in showing the tangible results if we continue our efforts sincerely in the days to come.

Some initiatives taken this year have the potential to leave a historic legacy of the Department. Initiatives taken by the department to scale the Mt. Everest has drawn attention of the international community . We consider this initiative to be not only a matter of pride for our profession but also an opportunity to enhance our capacity to cope with the challenges that has come alongside. There were apprehensions about the existence of the Department in the new organizational restructuring but we succeeded to retain the Department with even wider scope. Devolution of cadastral survey remains due for some years to come. We will keep on making our best efforts to ensure respectful professional identity at each of the government level; federal, provincial and local. For the first time in history of the Department, we have come out in the media to put forward our

side of story in the controversies surrounding the issue of border management. The higher authorities instructed us to handle the case based sensitization of the technicalities related with the Nepal India boundary.

We are firm in our belief that without the foresightedness, dedication and devotion of our respected predecessors, this department would not have come to this level. As an attempt to recognizing and appreciate their invaluable contribution, we wish to felicitate the predecessors on special occasions. Previous year, on the special occasion of the Diamond Jubilee of the Department, we felicitated the former Director Generals and Deputy Director Generals. This year, on the special occasion of the sixty first anniversary, we have decided to felicitate those who have contributed to the Department as the Chief Survey Officer or equivalent. We will keep on felicitating everyone who has served the department in different capacities in the upcoming occasions too. Similarly, we will also felicitate the colleagues having served for more than twenty five years in the Department.

Finally, let me express my sincere appreciation to the fellow colleagues, the members of Advisory Council, and entire team of the Editorial Board for their invaluable contribution in this issue. Deputy Director General Mr. Suresh Man Shrestha, the Editor-in-Chief, and Chief Survey Officer Mr. Ram Kumar Sapkota, member of the Editorial Board, deserve special thanks for their tireless efforts in bringing this issue in the stipulated time. More importantly, I extend sincere gratitude to all the authors for their resourceful professional contribution. I would expect such kind of support and professional contribution in the upcoming issues too. At the same time, I encourage fellow colleagues from the Department to contribute to the journal by providing quality articles.

I am confident that you will find this journal a 'to be read' one.

Enjoy Reading!

Thank you!

Jesth 14, 2075 (May 28, 2018)
Kathmandu, Nepal

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Director General,
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Pixel to Picture and Picture to Person

Rabin K. Sharma

KEYWORDS

Pixel, Picture, Person, Resolution, Remote Sensing, Social Benefit Areas

ABSTRACT

*Remotely sensed data are related with the words pixel and resolution as the picture is formed from the pixel having the size defined by the value of resolution of the data. There are unlimited sectors where remote sensing technology can be applied to uplift the social status of the people. In order to make best use of this system, Regional Workshop on Himalayan GEOSS was organized in Nepal. The workshop developed a concept “**pixel to picture and picture to person**” based on the technology related to Earth observation. The concept to be used for the several sectors identified by the workshop which are also related with the Social benefit areas of the Global Earth Observation System of Systems (GEOSS) of Group on Earth Observation (GEO). Therefore, this paper tries to summarize the result of the workshop in this particular theme.*

1. INTRODUCTION

Earth observation system provides the remotely sensed data which are used in many applications. Earth observation (EO) can be made either using airborne platform such as aircraft, helicopters or space borne platform such as artificial satellites. Using such system, data are collected as pixels to form a picture. The pictures thus formed are used by the persons for their corresponding applications whether the person is a professional in this field or a user. The professional creates the picture from the pixels using appropriate technology and the users make use of such pictures for their corresponding activities after interpreting the picture. So, this concept “**pixel to picture and picture to person**” became the slogan for the community of earth observation. This concept was materialized during “Regional Workshop on Himalayan GEOSS”, which was

jointly conducted by International Centre for Integrated Mountain Development (ICIMOD) and Global Earth Observation (GEO) from 10-11 August, 2017 in Lalitpur, Nepal.

The workshop also identified the priority sectors for the sustainable development of the country using the earth observation technology. The sectors are agriculture and food security, water resources, disaster risk reduction, land use, land cover change and ecosystem services. Furthermore, it is also mentioned that these are not only the themes to be considered but also other themes could be included if the country recognize some particular theme(s) to be prioritized.

2. HIMALAYAN GEOSS

Before explaining the Himalayan GEOSS, it is worthwhile to provide brief introduction

of the related initiatives of this subject. They are International Centre for Integrated Mountain Development (ICIMOD), Group on Earth Observation (GEO) and Global Earth Observation System of Systems (GEOSS).

ICIMOD is a regional intergovernmental learning and knowledge sharing centre situated in Nepal. The member countries of this organization belong to the Hindu Kush Himalayan regions and they are Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. It was realized that globalization and climate change have an increasing influence on the stability of fragile mountain ecosystems and the livelihoods of mountain people. Therefore, ICIMOD aims to assist mountain people to understand these changes, adapt to them, and make the most of new opportunities, while addressing upstream-downstream issues. [6]

The Group on Earth Observations (GEO) is an intergovernmental organization working to improve the availability, access and use of Earth observations for the benefit of society. GEO works to actively improve and coordinate global GEO systems and promote broad, open data sharing [5].

A central part of GEO's Mission is to build the Global Earth Observation System of Systems (GEOSS). GEOSS is a set of coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth. It facilitates the sharing of environmental data and information collected from the large array of observing systems contributed by countries and organizations within GEO. Further, GEOSS ensures that these data are accessible, of identified quality and provenance, and interoperable to support the development of tools and the delivery of information services. Thus, GEOSS increases our understanding of Earth processes and enhances predictive capabilities that underpin sound decision-making: it provides access to data, information and knowledge to a wide variety of users [5].

Therefore, GEOSS community activity will build a platform for regional collaboration by bringing together all GEO members and participating organizations with thematic line agencies from the region working on Earth observation (EO) and geospatial technologies. As it is clearly mentioned that some of the initiatives of ICIMOD are to build capacity and promote Earth Observation and geo-information applications in the Hindu Kush region. So, based on the approaches of GEOSS and the scope of ICIMOD, ICIMOD realized to initiate **Himalayan GEOSS** for the region to address the issues related to the specific working areas.

This endeavor is meant to develop coordinated frameworks to implement innovative Earth observation (EO) and geospatial solutions and services. It will focus to make observation for mountain-specific situations, aligning with regional priorities and GEO's societal benefits areas. [5]

Furthermore, Hindu Kush Region has mountain areas consisting of remote areas with difficulties in accessing mainly due to difficult terrain. So, it is very challenging tasks to collect data and information and disseminate the results to the communities living in those areas. However, with the availability of earth observation system, it has become easier to collect the data which can be integrated with the emerging geographic information and communication technologies for decision making in different aspects of fields related to sustainable development of mountain people [6]. Since ICIMOD is a participating organization in GEO and the Hindu Kush Himalayan, therefore, ICIMOD intends to facilitate the regional implementation of **Himalayan GEOSS** with active involvement from its member countries in the region. It is believed that the initiatives of Himalayan GEOSS will ultimately contribute to the development of spatial data infrastructure (SDI) in the region through the promotion of policy, standards, and practices for open access to data, information, and services. [2]

3. TYPES OF REMOTELY SENSED DATA

In remote sensing technology, two basic components: platform and sensor play a role to collect remotely sensed data. The platform is the vehicle used to board the sensor for the collection of related data. The platform could be either a space borne system in which artificial satellites orbiting the earth in its orbit are used or airborne system in which an aircraft is flown over the interested area. The sensor deployed in the vehicle will have a field of view covering a certain area, termed as a scene. Therefore, numbers of scenes are necessary to cover the area of interest. The size of the scene depends upon the altitude of the vehicle and opening of the field of view. The sensor may be of different types depending upon the type of data needed such as thermal imagery, hyperspectral data, multi-spectral data, *et cetera*. Besides that, the data can also be obtained from the technology related to RADAR, LIDAR, Unmanned Aerial System (UAS), *et cetera*.

Hence, in general, data of the interested area are captured either from the artificial satellites that are orbiting the earth continuously throughout the year or by flying the aircraft above the area. The data thus obtained are used for the applications in the related fields using remote sensing technology.

In fact, majority of the persons who use internet in computers and mobiles, are very much familiar with the Google Earth and they use it to find and locate their house or some location to display in their screen or to navigate the route to reach to their destination. This can be considered as special applications which are easily available free of cost and understandable to an individual who have no knowledge about remote sensing technology. However, the professionals use particular data from different sources which are suitable for their purposes, such as GEOEYE, IKONOS, Landsat, QuickBird, SPOT, *et cetera*.

4. PIXEL TO PICTURE

A picture is composed of small squares termed as pixels and the number of elements that compose the image is termed as definition of

a picture. For example, in figure 1, an arrow is formed from 26 pixels in one row and 16 pixels in one column. So the definition of the image of the arrow is considered to be 26 x 16.

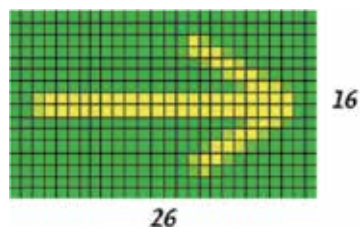


Figure 1

If more pixels are used to form an image its definition will be higher. The size of a square may varies according to the size and resolution of the monitor in which it has to be displayed. Resolution of the monitor is referred to in terms of dots per inch (dpi). If the size of the pixel is small, it will produce sharp picture but it needs more memory for storing the colour and intensity of each pixel. For example, in figure 2, the definition of left picture of a house is 300 x 220 made with 66000 pixels and the definition of right picture of the same house is 30 x 20 is made with 660 pixels. This signifies that left picture has a higher definition than right picture. From these two figures, it is clear that, if there are more pixels the image resembles with the original object.



Figure 2: Image of a house with different no. of pixels

Pixel is referred to a Digital Number (DN) which is related to the energy level reflected by the object and it is also refer to a grey value. The grey value ranges from 0-255. If two-bit memory pixels are used it can display only eight colors whereas eight-bit pixels can display 256

colors.

Remotely sensed data are related to a word “resolution” and there are four types of resolutions namely spatial, spectral, radiometric and temporal resolution [4]. Spatial resolution is ability of a sensor to identify the smallest size detail of a pattern in an image. In other words, spatial resolution refers to the number of pixels utilized in construction of a digital image. If an image is composed with greater number of pixels it refers to an image with higher spatial resolution.

Spatial resolution is expressed in terms of a value which provides the size of the pixel. For example, if an image is 15m resolution, this refer to each pixel of the image is 15m x 15m on ground. Higher resolution data mean that more pixels are used to create sharp and clean image. Consequently, such images can produce high accurate results.



Figure 3: Satellite Image of an area with different resolutions (Source: Finnish Meteorological Institute)

In figure 3, there are four pictures of part of San Francisco city with different resolutions. The resolutions of the pictures clockwise from top left are 10 m, 30 m, 60 m and 100 m respectively. It can easily be recognized that higher the resolution better is the definition of the picture. For higher definition of picture, it takes more time to display and processing will be slower as well in compare to the picture with lower definition. Obviously, features in the higher resolution picture are more clearly recognizable than that in the lower resolution picture. Therefore, appropriate resolution of the picture should be chosen to meet the objective

of the mission.

Radiometric resolution is mainly to discriminate very slight difference in energy of the objects. The finer radiometric resolution of a sensor enables to detect even smaller differences in reflected or emitted energy from the objects. Spectral resolution is ability of a sensor to record the information on a particular spectral wavelength range. It plays very important role for designing the sensor as different objects have different spectral signature. Temporal resolution is to capture the images by revisiting the satellite over the same area at same interval of time. This will facilitates to monitor the area of interest.

5. PICTURE TO PERSON

The products for the application of the technology will be prepared by the persons through the pictures formed from the pixels as shown in the figure 4.

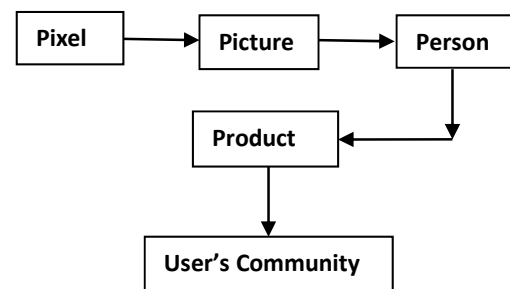


Figure 4: Flow Diagram for Pixel to Users Community

As soon as a picture is formed from the pixels, the picture will be observed by the person either on the screen of the computer or in a printed form. By observing the picture, the person will identify, interpret and recognize the features in the picture to extract information using appropriate remote sensing technology. The information thus extracted from the picture is the product to be used to fulfill their mission and then share the results with the persons from the user's community, see figure 4. .

The person who interprets data needs some knowledge on remote sensing and an experienced person can interpret better. The factors such as

shape, size, shadow, pattern, tone and texture of the features as well as associated features in the picture guide to identify the features. However, it is necessary to make sample field verification or ground truth for confirming the results otherwise it could mislead sometimes.

6. USE OF PICTURE IN REMOTE SENSING

Remote sensing technology is applied in many sectors of our community, and it is still in the process of growing further in the sectors which are beyond the imagination of a layman. In other words, it can be mentioned that the sky is the limit for the application of remote sensing technology. To mention a few sectors where the technology is applied are as follows [3]:

- **Mapping:** Mapping organization used satellite data for producing different types of maps such as topographical maps, land resources maps, geological maps, trekking maps, mapping of ocean floor, *et cetera*. The data can also be used to update the existing maps. Consequently, the corresponding maps can be used for the development activities of the country, for teaching and learning process in the domain of geoinformatics, for hiking, trekking and mountaineering, *et cetera*.
- **Weather forecasting:** Analyzing the trend of the weather from the temporal data and recent satellite image, weather can be forecasted such information is used by the persons from several sectors such as pilots, mountaineers, farmers, *et cetera* for planning their corresponding activities. Even a layman can take advantage from such information whether she/he to wear a thick clothes or to take an umbrella for going out from their house.
- **Monitoring:** Remote Sensing technology is used to monitor corresponding activities of different sectors such as status of agricultural crops, health of trees in the forest, movement of whales for protecting their life to avoid stranding in the beach of the ocean, control smuggling across the border between two countries, *et cetera*.
- **Detecting changes:** It is used to detect

changes such as to observe growth in urban areas, deforestation, study wild animal migration, assessment of damages from natural hazards, loss of forest area from forest fire, amount of melting of icebergs, record rising of sea water level, and so on.

- **Searching and rescuing:** The technology is used to search and rescue operation after occurrence of a disaster such as floods, earthquakes, landslides, avalanche, tsunami, *et cetera*.
- **Observing biodiversity:** Biodiversity sector is one of the most important aspects of the present concerns. In order to understand this field, remote sensing technology is used to make hyperspectral structure and 3D vegetation structures.

Furthermore, there are many more sectors where remote sensing technology can be applied using different types of remotely sensed data. The results will be used for improving social status of the people.

7. WAY FORWARD

As mentioned above, an international organization, Group on Earth Observation (GEO) has established Global Earth Observation System of Systems (GEOSS). The system has identified *agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water and weather are the Social Benefit Areas*. One of the objectives of GEOSS is to link Earth observation resources world-wide and to make available these resources for better decision making in the areas mentioned above [5]. Based on this principle, the workshop has realized to create **Himalayan GEOSS**. The group proposed to make use of the concept, *pixel to picture and picture to person* of Earth observation system for some of the sectors related to social benefit areas of GEOSS. The sectors are as follows:

- **Agriculture and food security:** Monitoring agriculture crop area and yield, develop climate services for agriculture management
- **Water resources:** Assessment of present and future availability of water in the region. Application of EO data for monitoring surface and ground water, snow and glacier, precipitation, water bodies.
- **Disaster risk reduction:** Assessment

of disaster risk from flood, land slide, earthquake, river erosion, forest fire etc. Monitoring of disaster events and damage assessment.

- **Land use, land cover change:** Land cover mapping and change monitoring at national and regional level
- **Ecosystem services:** Application of EO for ecosystem monitoring. Assessment of ecosystem services and vulnerability

These priority themes will build on the existing programs and initiatives and will synergize with different activities in the regional member countries. Other themes will be included as needed and prioritized by the regional member countries through regional consultations [2].

Therefore, the communities related with these sectors should make best use the system for improvement in these sectors which will benefits the people of the country to uplift their social status.

8. CONCLUSION

Remotely sensed data are used more and more in different sectors whether it is a space borne or airborne system. These systems are termed as the earth observation system. Recognizing its potential for betterment of the people of the member countries of ICIMOD and supportive nature of GEO to address some of the related

social benefit areas of GEOSS, the regional workshop organized in Nepal proposed to initiate **Himalayan GEOSS**. The group also prioritized the sectors namely: *Agriculture and food security, Water resources, Disaster risk reduction, Land use and land cover change, and Ecosystem services* which are to be addressed to improve its present status. The slogan of Earth observation system **“Pixel to picture and picture to person”** will be a powerful tool to solve the issues related with the social benefit areas identified during the workshop organized jointly by ICIMOD and GEO. Therefore, **Himalayan GEOSS** initiative could be one of the milestones for the member countries to uplift the status of the people belonging to Hindu Kush Region.

REFERENCES

- Document of Himalayan GEOSS initiative*, 2017, ICIMOD, Nepal
<http://grindgis.com/remote-sensing/remote-sensing-applications>
- Lecture note on satellite platforms and sensors for M. Sc. course on Geographical Information Science and System*, 2013, Kathmandu Forestry College, Kathmandu,
- Sharma R. K., 2012, *Mapping my Professional Journey*, Nepal
www.earthobservations.org
www.icimod.org



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Geoid Determination and Gravity Works in Nepal

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KEYWORDS

Gravity, Geoid, Geopotential Model, Gravity Anomalies

ABSTRACT

Gravimetric geoid plays the important role in the process of local/regional geoidal undulation determination. This approach uses the residual gravity anomalies determined by the surface gravity measurement using the gravimeter together with best fit geopotential model, with the geoid undulations over the oceans determined from the method of satellite altimetry. Mass distribution, position and elevation are prominent factors affecting the surface gravity. These information in combination with geopotential model helps in satellite orbit determination, oil, mineral and gas exploration supporting in the national economy. The preliminary geoid thus computed using airborne gravity and other surface gravity observation and the accuracy of computed geoid was likely at the 10-20cm in the interior of Nepal but higher near the border due to lack of data in China and India. The geoid thus defined is significantly improved relative to EGM -08 geoid.

1. INTRODUCTION:

Survey Department introduced global positioning system (GPS) survey to establish geodetic controls since 1991. This technology has become much more efficient and accurate with reference to World Geodetic System 1984 (WGS 84). It has been widely used in the positioning of the higher order controls and its densification in the country such as First, Second and third order geodetic controls. In the contrary it has also created a challenge of the conversion of position and heights in Everest Spheroid 1830, based on Nepal Datum. This is the national datum of the country on which all the mapping activities are referred.

In the positioning technique of GPS which is now replaced by Global Navigation Satellite System (GNSS) -more satellite constellation used in positioning in its relative carrier-phase mode provides three- dimensional coordinates of latitude, longitude and ellipsoidal height relative to known fixed point in the WGS84. For the transformation of horizontal coordinates (latitude, longitude or easting and northing) Survey Department has been using National Transformation Parameter developed by Mr. Manandhar (Manandhar N, (2072) A Review of Geodetic Datums of Nepal and Transformation Parameters for Wgs84 to Geodetic Datum of Nepal, Nepalese Journal of Geoinformatics, Vol 14)

The ellipsoidal height component must also have to be transformed to an orthometric height using information of geoid- WGS84-ellipsoid separation at each GPS point. Survey Department, Geodetic Survey Division has been using only the horizontal component (latitude and longitude) of the GPS output although the vertical component (height) is one of the vital informational product of the survey however this requirement is fulfilled by conventional method of spirit leveling till today. In order to overcome the use of spirit leveling which is one of the very costly and time consuming technique in height determination process, the gravimetric geoid plays the major role in the process orthometric height determination from ellipsoidal height. (Manandhar N, (2067) Surface Gravity Information of Nepal and its Role in Gravimetric Geoid Determination and Refinement, Nepalese Journal of Geoinformatics, Vol 9).

2. GRAVITY:

A body rotating with the earth experiences the gravitational force of the masses of the earth as well as the centrifugal force due to the Earth's rotation. The resultant force of is called of gravity, simply called gravity. [Torge, Geodesy]

Gravity = Gravitational attraction + Centrifugal Acceleration.

Gravity has the dimension of an acceleration with the corresponding SI units of m/s². The units of gravity most commonly used in geodesy/ gravimetry/ geophysics/geology is the "gal", which is named after Galileo Galilei.

We need to deal with very small differences in gravity between points on the earth surface and with high accuracy up to 9 significant digits- the most commonly used unit is rather the "mgal".

$$1 \text{ gal} = 10^{-2} \text{ m/s}^2 = 1 \text{ cm/s}^2$$

$$1 \text{ mgal} = 1/1000 \text{ gal} = 10^{-3} \text{ gal}$$

$$1 \text{ mgal} = 1/1000 \text{ mgal} = 10^{-3} \text{ mgal} = 10^{-6} \text{ gal}$$

The approximate vale of gany where on the surface of the earth is 981 gal=981x1000mgal=981000mgal.

3. GEOPOTENTIAL MODELS/ GRAVITY MODEL

Geopotential models are gravitational model of the earth gravity field. Earth gravitational potential (V) is represented by a spherical harmonic expansion where the potential coefficient in the expansion have been determined by various techniques. The gravity field information obtained from these geopotential model has applications in different areas such as precise satellites orbital determination, oil mineral and gas deposition exploration, geophysical and geological perspective and in surveying and mapping community.

In the field of surveying and mapping community, the geopotential models are used to derive the geoid undulation. The geoid undulations thus derived from geopotential model are used to translate GPS determined ellipsoidal heights into orthometric height referred the MSL. The chronological development of the geopotential models are as follows OSU91A, JGM-3, EGM96, EGM08, EGM 2020.

3.1 OSU91A:

This is the first earth geopotential model developed by the Ohio State University in 1970, spherical harmonic representations up to degree 180 were estimated. In 1980, expansion up to degree 360 is obtained. In 1991, Rapp, Wang and Palvis (1991) reported a degree 360 model that was based on:

- Satellite developed model GEM-T2 [Goddard Earth model]
- Sea surface height from GEOSAT-altimeter data
- Gravity anomalies from satellite altimeter data
- Surface gravity data
- Topographic information

And they release model called OSU91A.

The major limitation of OSU91A was lack of presice surface gravity over large continental regions-for instance most of the Asia.

3.2 JGM- 3 (Joint Gravity Model)

Since 1991, improvements have been continued on the development of 'low degree' (to 70) combination models. Examples are JGM-1 and JGM-2. These geopotential models were developed to aid the orbit of the TOPEX/POSEIDON (T/P) Satellites.

Finally, JGM-3 Model developed which is improved model over JGM-1 and JGM-2

- Using Laser tracking data
- DORIS data
- GPS tracking of T/P satellites for the first time.

JGM-3 geoid provides more realistic ocean topography. It was developed by NASA GFSC and CSR (Texas University).

3.3 EGM96

This is a spherical harmonic model of the earth's gravitational potential complete to degree and order of 360. This is the composite model - low degree up to degree 70 and high degree from 71 to 360. EGM96 is superior to JGM-3 model. Data sources to develop this model are:

- Improved surface gravity data
- Altimeter derived anomalies from ERS-1 and GEOSAT geodetic mission.
- Extensive satellite tracking data
- GPS data
- NASA's tracking and TDRSS (Tracking and Data Relay Satellite System)
- The French DORLS System.
- USNAVY TRANET Doppler Tracking System
- Direct altimeter ranges from Topex/Poseidon, ERS-1, and GEOSAT.

The resolution of EGM96 is 30'x30', geoid undulation accuracy is better than 1m, and WGS84 as true three-dimensional reference system is used. Other by-products from EGM96 solutions are:

- Estimates of dynamic tide parameters,
- DOT- Dynamic Ocean Topography solutions
- 5'x5' global topographical models.

3.4 EGM08

Earth's gravitational model 2008 is developed by National Geospatial Intelligence Academy (NGA) USA with degree and order 2160. This model used 5'x5' gravity anomaly database, GRACE -derived satellite solutions. This model used latest modelling for the both land and marine area worldwide. Geoid undulation accuracy is of this model $\pm 5\text{cm}$ to $\pm 10\text{cm}$. This model used of 30"x30" topographic model. Data sources are satellite only gravitational model, terrestrial gravity data, and satellite altimetry. In comparison to EGM96 the EGM 2008 represents improvement in quality by six times in resolution and three times to six times in accuracy.

3.5 EGM 2020

The preliminary work on next Earth Gravitational Model has been started jointly with National Geospatial-Intelligence Agency [NGA] together with international partners to replace EGM 2008. It will be an ellipsoidal harmonic model up to degree and order 2160. New data sources and procedures are adapted, updated gravity information from GRACE and GOCE will be used. Mathematically well treated satellite altimetry data, better gravity marine data along with full covariance adjustment technique will make this model robust resulting quality gravimetry database. This model will provide improved global average and resolution over lands.

4. CHARACTER OF GRAVITY:

The gravity is not constant throughout the Earth surface though average value of "g" is 981 gal. The variation of gravity is the function of following factors (Heiskanen, W. A. H. Moritz Physical Geodesy, Freeman San Francisco 1967)

- Mass distribution of earth,
- Latitude of a point and
- Elevation of a point.

4.1 Variation of gravity due to mass-distribution of the Earth:

Uneven mass distribution around on or below the surface of the earth, in other words the non-

uniform density of earth topography causes the variation in gravity. Topography is composed of mountains, plain land, oceans, deserts, minerals, metals, deposited region etc. of which density is different. Mountains are mass surpluses region where as oceans are mass deficient area which causes gravity to vary.

4.2 Variation of gravity due to position (latitude) of a point:

The variation in the gravity is also experienced due to position (Latitude) of a point or region. The value of gravity (magnitude) varies as the latitude of points changes. The value of gravity calculated at a point situated at certain latitude is termed as the normal gravity. The gravity value is higher in polar region in comparison to gravity value in equatorial region.

The mathematical formula to derive of gravity adopted by IUGG in 1967 is given by

$$\gamma_0 = 978.031(1 + 0.0053024 \sin^2 \Phi - 0.0000059 \sin^2 2\Phi) \text{ gal}$$

γ_0 = gravity at any point on the surface of the Earth

Φ = Latitude of the point

At equator $\Phi = 0^\circ \gamma_a = 978.031 \text{ gal}$

At pole $\Phi = 90^\circ \gamma_b = 978.031 + 5.186 = 83.217 \text{ gal}$

4.3 Variation of gravity due to elevation of a point:

The variation in the gravity is also affected by elevation of the point. Variation of gravity due to elevation of a point can be estimated as follows. The value of gravity varies with height i.e. the distance of a point from the center of the Earth. The vertical gradient of gravity $\delta g / \delta h$ is approximated by

$$\frac{\delta g}{\delta h} = \frac{2\gamma}{R} = \frac{2GM}{R^3}$$

γ = mean gravity,

R = Mean radius of the Earth

$\delta g / \delta h = -0.3086$ where h is in meter and g is in mgal.

5. GRAVITY WORKS IN NEPAL

Gravity base was established in the country during 1981-84 British Military Survey.

The gravity reference system: ISGN 1971

Instruments used: LaCoste Romberg Model G gravimeter

Number of Stations observed: 21 out of 36 (MODUK)

Fundamental gravity base at Tribhuvan International Airport (TIA), Kathmandu was established designated as KATHMANDU J. IN 1981 gravity transfer from ISGN71 station BANGKOK to Kathmandu was made. At this time 45 gravity stations were surveyed at 35 different locations, mostly at the airports and accessible places around the country.

KATHMANDU J = 978661.22 ± 0.047 mgal

Total 375 gravity detail stations were established till now which includes both gravity survey from WNTMP and ENTMP.

5.1 First order gravity network of Nepal:

Number of first order gravity points: 36 points, 25 points in airport and airstrips and remaining 11 in government buildings, army barracks, and police stations.

5.2 Absolute gravity observation:

The Fundamental Absolute Gravity Stations (FAGS) was established in 1991 March/April at Nagarkot in assistance with above three organizations.

Purpose of establishing Absolute gravity station were

- To establish a reference datum for the local gravity network in Nepal.
- To establish points that may be remeasured to reveal changes of elevation in future years.

The absolute gravity value measured at Nagarkot

(FAGS -1). The corrected value of the FAGS -1 indoor point at ground level is 978494834.7 +/-6.7microgal.

The gravity gradient at floor level (0 to 0.43m) was 4.4194microgal/cm.

Relative ties were made to three GPS points: Nagarkot, Kathmandu airport, and Simara airport. The relative differences from FAGS-1 to these points are as follows:

Nagarkot FAGS-1	978494834.7 +/- 6.7 mgal
Nagarkot GPS	-0.691 +/- 0.002 mgal
KATHMANDU J	+166.469 +/- 0.005 mgal
SIMARA J	+368.599 +/- 0.017 mgal
SIMARA GPS	+368.706 +/- 0.013 mgal

The ties were undertaken using a pair of Model D LaCoste Romberg gravimeters. For Nagarkot GPS point which is less than 10m from the brick building where GPS measurements were made.

The absolute accuracy of the 1991 measurements is +/- 6 microgals or approximately +/- 1.5cm in elevation.

5.3 Eastern and Western Nepal Topographic Mapping Project (ENTMP & WNTMP) - Phase I

Gravity survey was done during WNTMP (Western Nepal Topographic Mapping Project) and ENTMP (Eastern Nepal Topographic Mapping Project).

During WNTMP, gravity observations were done in GPS points. Gravity values were observed in 56 stations and gravity value of 43 stations which are specified as old British and other points exists.

During ENTMP, gravity observations were done in GPS points. Gravity values were observed in 43 stations and gravity value of 95 stations which are specified as other gravity stations and 10 stations specified as other gravity stations exist.

The numbering of stations, latitude, longitude,

ellipsoidal height, orthometric height, and gravity values can be found in WNTMP and ENTMP reports.

5.4 Airborne Gravimetry in Nepal

An airborne gravity survey of Nepal was carried out December 2010 in cooperation between DTU-Space, Survey Department of Nepal, and National Intelligence Agency- NGA USA.

Primary goals:

- To provide data for a new national geoid model, which will in turn support GPS surveying and national geodetic infrastructure.
- To provide gravity information for future global gravity field EGM 2020.

Secondary goals:

- To provide training of physical geodesy to Nepalese geodesists.
- To make an improved estimate of the geoid at Sagarmatha allowing an independent height determination by GPS.
- To collect airborne data which will provide an independent validation of GOCE and EGM08 in most mountainous part of the Earth.

5.5 Airborne gravity survey details:

Beech King Air aircraft by Danish Company COWI was used. 57 flightlines @ spacing of 6 nautical miles for 13 flight days during Dec 4-17, 2010 made.

Coverage of border regions of the country towards India and China was not possible. The survey operations were a major challenges due to excessive jet streams at altitude as well as occasional excessive mountains waves. Even a reflight attempts did not provide useful data due to persistent wind effects of Annapurna and Mustang valley regions. Surface gravimetry data of those regions should be used. The reported results appeared accurate to few mgal – despite the large 400 mgal above range of gravity anomaly changes from Indian plains to Tibetan plateau.

Instrument installed on aircraft: Lacoste Romberg S –type gravimeter which was controlled by Ultrasys Control System with a number of GPS receivers onboard the aircraft and on ground providing the necessary kinematic positioning.

Checkan –AM gravimeter alongside LCR gravimeter with the special goal to augment the LCR gravity data in expected turbulent conditions.

The airborne gravity reference point at Kathmandu airport tied to NOAA absolute gravity measurement at Survey Department and at Geodetic Observatory Nagarkot. The actual gravity values at altitude differ by 1000’s of mgals from reference values due to the height changes and Eotvos corrections.

The overall accuracy of airborne gravity data collected was 3.3 mgal.

The preliminary geoid was computed and the accuracy of computed geoid was likely at the 10-20cm in the interior of Nepal but higher near the border due to lack of data in China and India. This preliminary geoid was compared to eight reasonable GPS-levelling precise data in the Kathmandu valley. It is seen that a significant geoid improvement has been obtained relative to the EGM-08 geoid.

The computed height of Sagarmatha which confirms the official Survey Department height 8848 m within range of +- 1m, based on an ellipsoid height of the snow summit of 8821.40 +- 0.03m.

6. GEOID DETERMINATION:

Following are the methods of geoid determination

- Astro-geodetic Method
- Gravimetric Method
- Geopotential model
- Satellite altimetry
- GPS or Doppler with levelling
- Analysis of low orbitals satellite
- Collocations (least square collocation)

Gravimetric method of geoid determination is of main importance and explained below.

6.1 Gravimetric method of geoid determination:

Gravity anomalies of uniformly distributed points over the terrain based on both distance and height of the topography of the earth can be used to determine the geoid of that area. Gravity observation is carried out on those well distributed points using gravimeter which is called surface gravity. Surface observed gravity values are needed to be reduced to the level of geoid (MSL Level) by applying:

- Free air correction
- Bouger Plate reduction
- Refined (Complete) Bouger Reduction/ Terrain correction

Then the reduced gravity value is now equivalent to gravity value at geoid. The gravity anomaly can then be calculated as follows:

$$\Delta g = g - \gamma_0$$

$$\Delta g = \text{gravity anomaly}$$

g (reduced) = reduced gravity value at the level of the geoid from the observed gravity

γ_0 = Normal gravity/ theoretical value of gravity at that latitude of point.

The gravity anomaly thus obtained is then used to determine geoidal separation (N) by Stoke’s integral:

$$N = \frac{R}{4\pi\gamma} \iint \Delta g S(\Psi) d\sigma$$

R = Mean radius of the earth

γ = Mean normal gravity

$d\sigma$ = Surface element

$S(\Psi)$ is a called Stoke’s formula and given by

$$S(\Psi) = 1 + \text{COSEC}(\Psi/2) - 6\text{SIN}(\Psi/2) - 5\text{COS}(\Psi) - \text{COS}(\Psi) \ln[\text{SIN}(\Psi/2) + \text{SIN}^2(\Psi/2)]$$

7. CONCLUSION:

The geoid from geopotential model is of global level geoid which could not be directly used for local level geoidal undulations determination. Thus we need to refine this global level geoid through airborne gravimetry and surface gravimetry observation of our terrain resulting reliable local level geoid. Gravimetric method of geoid determination uses the gravity anomalies from airborne and surface gravimetry both and provides geoidal undulation using Stoke's integral. There has been planning for the purpose of refinement of geoid around Sagarmatha regions for the computation of orthometric elevation of Sagarmatha from GPS heightening and geoidal undulations utilizing this approach. To refine the geoid around Sagarmatha, we need dense/extra surface gravimetry data which will improve the past geoid computed from 2010 airborne gravity geoid. The surface gravimetry observations were planned to take on 5km*5km grids, around that region.

REFERENCES

Final Reports of Ground Control Surveys Vol. III Definition of Gravimetric Geoid.

Featherstone W.E., 1995 *On the use of Australian Geodetic Datums in the gravity field determination. Geomatics Research Australasia, 61*

Heiskanen, W. A. H. Moritz *Physical Geodesy*, Freeman San Francisco 1967

Moritz, H (1980a) *Geodetic Reference System 1980 (GRS80) Bulletin Geodesique Vol 54 pp. 395-405*

Manandhar, N: *Geoid Studies of Nepal*, Thesis submitted for Master of Engineering, School of Geomatic Engineering, University of New South Wales, Sydney.

Manandhar N, Shrestha K.G, and Forsberg R (2014) *Geoid of Nepal from Airborne Gravity Survey*

Manandhar, N.: *Report on Topographic Map Preparation of Geodetic Observatory Nagarkot.*

Reports and Results of Gravity Survey in Nepal, 1981-1984

Report and Results of Nagarkot Geodetic Observatory –Observations, Corrections, and Results

The Defense Mapping Agency (1987). *DMA Technical Report (Supplement to Department of Defence World Geodetic System 1984 Technical Report) Part 1: Methods, Techniques, and Data Used in WGS84 Development*, DMA TR, 8350. 2 -A, Washington DC. 1Dec. 1987.

Torge, W. (1991) *Geodesy. 2nd Edition*. Walter de Gruyter: Berlin, 1991.



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Price of Maps

S.No.	Description	Scale	Coverage	No. of sheets	Price per sheet (NRs)
1.	Topo Maps	1:25 000	Terai and mid mountain region of Nepal	590	150
2.	Topo Maps	1:50 000	Hlgh Mountain and Himalayan region of Nepal	116	150
3.	Land Utilization maps	1:50 000	Whole Nepal	266	40
4.	Land Capibility maps	1:50 000	Whole Nepal	266	40
5.	Land System maps	1:50 000	Whole Nepal	266	40
6.	Geological maps	1:125 000	Whole Nepal	82	40
7.	Districts maps Nepali	1:125 000	Whole Nepal	76	50
8.	Zonal maps (Nepali)	1:250 000	Whole Nepal	15	50
9.	Region maps (Nepali)	1:500 000	Whole Nepal	5	50
10.	Nepal (English)	1:500 000	Whole Nepal	3	50
11.	Nepal Map (Nepali)	1:1000 000	Nepal	1	50
12.	Nepal Map (Nepali)	1:2000 000	Nepal	1	15
13.	Nepal Map (English)	1:1000 000	Nepal	1	50
14.	Nepal Map (English)	1:2000 000	Nepal	1	15
15.	Physiographic Map	1:2000 000	Nepal	1	15
16.	Photo Map			1	150
17.	Wall Map (loosesheet)		Nepal	1 set	50
18.	VDC/Municipality Maps (Colour)		Whole Nepal	4181	50
19.	VDC/Municipality Maps A4 Size		Whole Nepal	4181	5
20.	VDC/Municipality Maps A3 Size		Whole Nepal	4181	10
21.	Orthophoto Map		Urban Area (1:5000) and Semi Urban Area (1:10000)	-	1 000
22.	Outlined Administrative Map A4 size		Nepal	1	5

Price of co-ordinates of Control Points

Type	Control Points	Price per point
Trig.Point	First Order	Rs 3 000.00
Trig. Point	Second Order	Rs 2 500.00
Trig. Point	Third Order	Rs 1 500.00
Trig. Point	Fourth Order	Rs 250.00
Bench Mark	First & Second Order	Rs 1 000.00
Bench Mark	Third Order	Rs 250.00
Gravity Point	-	Rs 1 000.00

Price of Aerial Photograph and Map Transparency

Product	Price per sheet
a) Contact Print (25cmx25cm)	Rs 300.00
b) Dia-Positive Print (25cmx25cm)	Rs 1000.00
c) Enlargements (2x)	Rs 1000.00
d) Enlargements (3x)	Rs 2000.00
e) Enlargements (4x)	Rs 3000.00
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 80.00
Photo copy	Rs50.00
Photo lab facilities	US\$ 200/day

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

Price of Digital Topographic Data Layers

LAYER	Rs/Sheet
Administrative	100.00
Transportation	200.00
Building	60.00
Landcover	300.00
Hydrographic	240.00
Contour	240.00
Utility	20.00
Designated Area	20.00
Full Sheet	1000.00

S.N	Data	Price
1	Seamless Data whole Country	Rs. 300000.00
2	Seamless Data (Layerwise- whole country)	
2.1	Administrative Boundary	Free
2.2	Building	Rs. 15000.00
2.3	Contour	Rs. 65000.00
2.4	Transportation	Rs. 60000.00
2.5	Hydrographic	Rs. 70000.00
2.6	Landcover	Rs. 87000.00
2.7	Utility	Rs. 2000.00
2.8	Designated Area	Rs. 1000.00
3	1:1000000 Digital Data	Free
4	Rural Municipality (Gaunpalika) unitwise- all layers	Rs. 1000.00

Image Data:

Digital orthophoto image data of sub urban and core urban areas maintained in tiles conforming to map layout at scales 1:10000 and 1:5000, produced using aerial photography of 1:50000 and 1:15000 scales respectively are also available. Each orthophotoimage data at scale 1:5000 (covering 6.25Km² of core urban areas) costs Rs. 3,125.00. Similarly, each orthophotoimage data at scale 1:10000 (covering 25 Km² of sub urban areas) costs Rs 5,000.00.

Price of SOTER Data	Whole Nepal	NRs : 2000.00.
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Positional Accuracy of Online Geocoding Services: Case Study of Bhaktapur District

Er. Amrit Karmacharya

KEYWORDS

Geocoding, Nominatim, Accuracy, Positioning, Location Based Service

ABSTRACT

Data is food for Information Systems and location data is basis for GIS services. Geocoding services provide this data by converting Street Addresses like NCIT, Balkumari to corresponding geographic coordinates. These coordinates are then used in data processing to deliver services. Many services (especially location based), FourSquare, Uber, depend on these services for operation. Nepalese market is also increasingly using these services like Tootle, sarathi cab. Till now nobody knows how accurate the result of such services are. There exist multiple places with same name. Some names are not actual but referential. Accuracy of the services depend on the underlying database, the method used, the actual geographic location and also the actual query. Different methods yield different results. The assessment of accuracy and suitability of the geocoding services has not been conducted, yet they are being used extensively. The objective of this study is to compare the positional difference between two Geocoding methods, OpenStreetMap (OSM) Nominatim Service and Google Geocoding Services and compare them with standard government datasets to measure their discrepancy. For reference, settlement data from NGIID was used. Addresses were first geocoded to street level and positional difference in the results were calculated using havensire formula. The discrepancies were categorized into intervals of 100m. Out of 267 location points, 118 result were found in Nominatim, whereas only 86 were found in Google. Average discrepancy for Nominatim result was 175m and for Google it was 1810m. Comparisons show minimal difference in median and minimum values, while there were larger differences in the maximum value. Nominatim delivered comparatively accurate results and found more addresses than google. Google on the other hand gave huge mismatches for some cases. The study found out that the databases are missing in both cases as shown by the no of "not found" cases and that the results from Nominatim are more reliable than that of Google because of its hierarchical matching system and user friendly interface.

1. INTRODUCTION

Geocoding is the processing of matching a description of a location to geographic coordinates. With the advances in web technologies and location based mapping, the traditional Geocoding tools provided in desktop GIS software are being increasingly replaced by online geocoding services. The Web geocoding services from various providers offer users an easier way to geocode place names to location coordinates in multiple text formats like extensive Markup Language (XML), JavaScript Object Notation (JSON), or Comma Separated Values(CSV).

Geocoding gives result in form of coordinate pair, usually latitude and longitudes pair. It may also give out extra information as to the shape and size of the features if the features were linear or areal. But mostly the result is in form of a point. The accuracy of a geocoding depends on the database used to perform the search and its hierarchical model.

Result of geocoding depends on the data used, Nepal government has published an Index of Geographical Names for the whole country. Google maps provides geocoding services but the sources of its data are unknown. OpenStreetMap mobilizes volunteers and local community to collect data directly on the field and provides free service for geocoding. In the current situation, the data from Nepal Government is not dense enough to locate places. The data from Google seem to be accurate but have not been verified. Also Google deliberately uses Easter Eggs (false information mixed with original data to identify if data is being stolen) which compromises its accuracy. Google is the most popularly used geocoding service in Nepal. OpenStreetMap data is unevenly distributed over the data, areas with active volunteers are better mapped whereas areas without volunteers are empty.

The assessment of accuracy and suitability of the geocoding services has not been conducted yet they are being used extensively.

1.1. Objective of the study

The objective of the study are as follows:

- To compare the positional difference in results provided by different services.

1.3 Limitations of the Study

Limitation of the study is as follows

- Address in rural areas do not have precisely defined boundaries, so the assessment of accuracy is based on human interpretation.
- Because of unavailability of accurate field data for reference, the results are comparative analysis only.
- The study is limited to settlements only. Geocoding application in other sectors like house numbering, street level geocoding, point of interest matching, have not been conducted.

2. METHODOLOGY

2.1 Source of Data

The address data was collected from the Topographical Base Map Data. National Geographic Information Infrastructure Project (NGIID) distributes the data. The data collected was of the Bhaktapur. The other data of google and open street map are accessed from the web.

2.2. Data Preparation

The data from various sources are in various projection system. The data from NGIID was from UTM system and the data from other geocoding services are in WGS 84 system. So, all of the data from NGIID was converted to WGS 84 for uniformity.

All postal addresses were preprocessed before geocoding to improve standardization and quality. We reviewed the data for misspelled address information and remedied any incorrect home addresses (e.g. incorrect names). In addition, we removed all extraneous characteristics and standardized the spelling. We removed address which were inside the sheet but outside the study area.

2.3. Preparation of comparison table

Comparison table (shown below) was prepared to compare the discrepancies between the different systems. The table consists of location. Its coordinates as given by the 3 different providers. the distance range between the derived coordinates computed using havensire formula.

		NGIID		OpenStreetMap				Google maps			
Sn	Name	Lon	Lat	Lon	Lat	discrepancy (km)	Remarks	Lon	Lat	discrepancy(km)	Remarks

2.4. Data Filing

For comparing the location information from three sources the location data from 3 sources are excelled. For this work, different sources have different system of acquiring the data.

Firstly, from NGIID the data is available in GIS format which can be converted to different format and as we required, the latitude and longitude can be generated and exported to excel file.

For the Nominatim (free geocoding services which uses geographic data from free and open OpenStreetMap project), we can enter the name of location in search box, then it will provide with the number of matches. There may be more matches, so for exact match we can input the location name with the higher level address as well. It will then provide with the area and lat, long of the centroid.

For the Google Geocoding service, there is a web application which can help us to input

and output data from google easily. The app is available here <http://googlemaps.github.io/js-v2-samples/geocoder/singlegeocode.html>. The process is similar as in Nominatim except that the application only shows single result which is usually the first result returned by Google service. In such a case it is important to manually judge whether the location is the desired one or not.

3. DATA ANALYSIS

A total of Two hundred sixty-seven (267) address were searched and matched using the above mentioned procedure. The distance between the location provide by the two different services were compared using the havensire formula. Havensire formula gives distance between two set of coordinates which are in latitude longitude format and gives output in metric system. It takes into account for the distortion due to the curvature of earth and different scale factor at different latitude values. The values given by NGIID were used as a standard data and discrepancy were calculated from other two sources. The discrepancy was then categorized into interval of 100m. There is no standard fixed value to specify how large an area is related to a location. it is big in village areas while small in crowded areas.

4. RESULT

Of the 267 addresses matched, OpenStreetMap found 118 results, whereas Google found 86 results. There is huge variation seen in between these matches. OpenStreetMap matched addressed in the range 100 m to 17 km. Google did the same with range of 70 m to 1034km. This huge difference is because google does not provide user interaction in searches. The high difference is obviously error but they cannot be identified correctly. The average discrepancy in OpenStreetMap is 175 m and the average discrepancy in Google is 1810 m.

Discrepancy Between	0 - 100 m	100 - 200 m	200 - 300 m	300 - 400	400 - over	Total	Not Found
NGIID - OSM	0	15	36	11	56	118	149
NGIID - Google	1	8	8	4	65	86	181
OSM - Google	2	8	4	4	34	52	215

Table 1: Table of Discrepancy

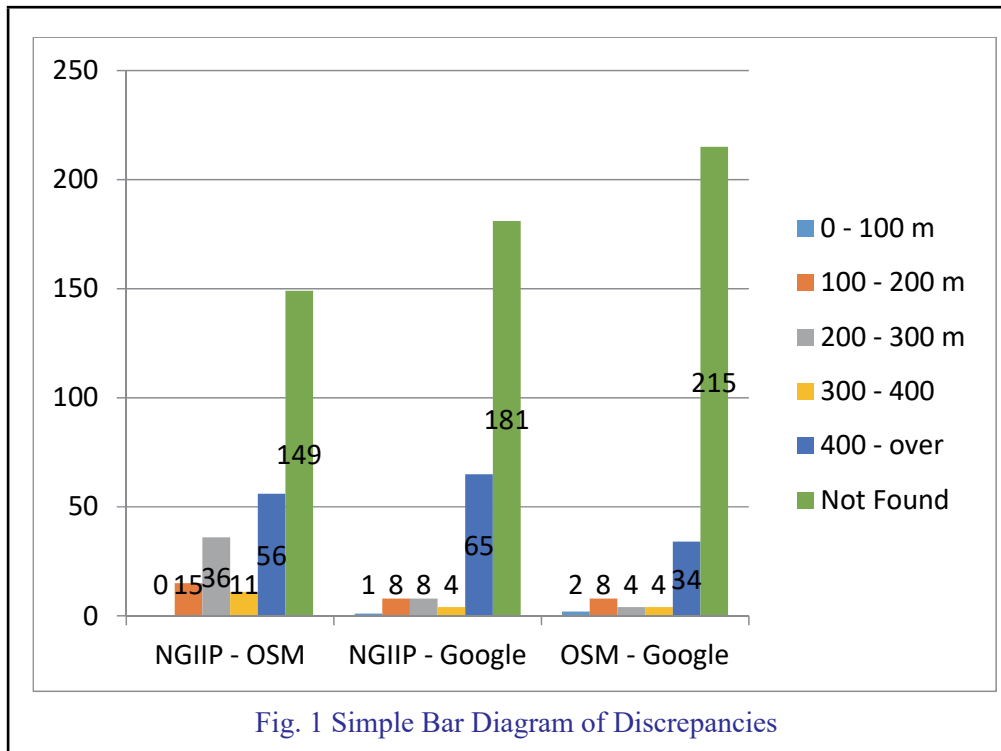


Fig. 1 Simple Bar Diagram of Discrepancies

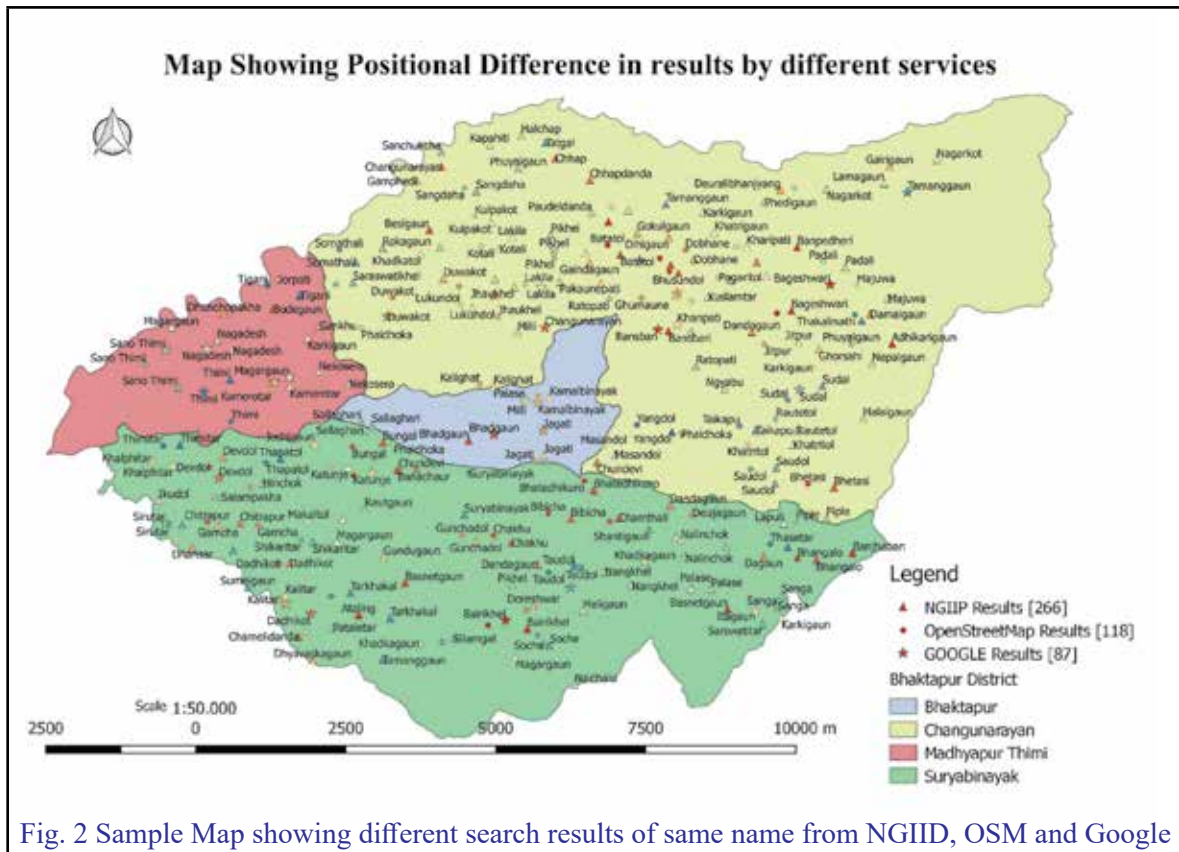


Fig. 2 Sample Map showing different search results of same name from NGIID, OSM and Google

Among the Results found in both OSM and Google, the discrepancy chart below shows there is very not a good match in the results given by both services. Maximum error by OSM is below 20 km whereas Maximum error by Google is around 1000 km. This is because, OSM results are hierarchical, i.e. it will give only results which match the hierarchy while google provides best match from all over the world. This means it will give results that will tend to match the search at least one of the word in the searched location.

5. CONCLUSION

There are many Geocoding services available but they all have one or more of the following limitations: (i) allows only geocoding one address at a time; (ii) requires the creation of a user account; or (iii) includes multi-page navigation before arriving at the geocoding interface. Nominatim is extremely user friendly and does not have these restrictions. Importantly, while a number of studies have evaluated the geocodes produced by Google, much less research has evaluated the geocodes produced by several of these alternative software packages. Since the accuracy of geocodes in part depends on the quality of the street reference maps used to generate the coordinates. The “true” geographic location of each address can be determined through aerial imagery or with global positioning systems (GPS) receiver data. Though these are gold standards, this was not practical nor a central focus of the study. In addition, Bing and Yahoo (the two companies that can be used to produce geocodes) maintain extensive geographic databases, which are frequently updated, ensuring strong address-matching capabilities and a sufficiently high positional accuracy. The street base map data used by the different geocoding services plays a large part in determining accurate address matches. The mapping companies Tele Atlas and NAVTEQ map and sell these base map data to companies like ESRI, Google and Yahoo, which then include them in their geocoding services. We do not know of any such professional companies in Nepal, but Both Google and Open street MapOSM use crowdsourcing to

collect data. Open Street Map is a volunteered powered organization and Google map maker also collects data from crowd. Therefore, the base map data used by the different geocoding services at any given point may vary in quality and completeness. The quality and completeness may also vary by geographic region. Thus, it is important to also document (if possible) what base map data the geocoding service used. However, even if two geocoding services use the exact same base map data, different address-matching sensitivity settings built into the geocoder may produce different positional placements. Further, while error might be introduced due to incorrect geocodes (with correctly recorded addresses), error can also arise due to the quality of the collected addresses. For this reason, we manually cleaned the addresses for this study prior to geocoding. Although we geocoded the same addresses that had been cleaned, it is likely that the editing of the addresses impacted the geocoding findings. Additionally, we used interactive geocoding to investigate ties in order to yield the highest possible match rate and increase the positional accuracy. Our use of interactive matching is likely to have affected the geocodes included in this study. It is also important to note that, in addition to the settings used, different programs, or even different versions of the same geocoding software, might produce different results. Since each of the elements discussed can influence the results, we suggest that future projects take these aspects into consideration when geocoding and examining differences between geocoding methods. In conclusion, although this study indicates that positional differences between the two geocoding methods examined exist, the medians of the differences found with Google and Nominatim were minimal and most addresses were placed only a short distance apart. Although future research should compare the positional difference of Nominatim to criterion measures of longitude/latitude (e.g. with GPS measurement), we feel that Nominatim is a free and powerful alternative when geocoding addresses.

REFERENCES:

- Bakshi, R., Knoblock, C. A., & Thakkar, S. (2004). *Exploiting online sources to accurately geocode addresses*. In D. Pfoser, I. F. Cruz, and M. Ronthaler, eds., ACM-GIS '04: Proceedings of the 12th ACM International Symposium on Advances in Geographic Information Systems, Washington D.C., November 2004, 194-203.
- Bonner Han D., Nie, J., Rogerson, P., Vena, J.E., & Freudenheim, J.L. (2003). *Positional accuracy of geocoded addresses in epidemiologic research*. *Epidemiology* 2003, 14(4), 408-412.
- Boscoe, F. P., Kiehl, C. L., Schymura, M. J., Bolani, T. M. (2002). *Assessing and improving census track completeness*. *Journal of Registry Management*, 29(4), 117-20.
- Davis Jr., C.A., & Alencar, R.O. (2011). *Evaluation of the quality of an online Geocoding resource in the context of a large Brazilian city*. *Transactions in GIS*, 15(6): 851-868.
- Dearwent, S.M., Jacobs, R.R., & Halbert, J.B. (2001). *Locational uncertainty in georeferencing public health data sets*. *J Expo Anal Environ Epidemiol*, 11(4):329-334.
- Gatrell, A.C. (1989). *On the spatial representation and accuracy of address-based data in the United Kingdom*. *Int. Journal of Geographical Information Systems*, 3(4): 335-48.
- Hay, G., Kypri, K., Whigham, P., & Langley, J., (2009). *Potential biases due to geocoding error in spatial analyses of official data*. *Health Place*, 15, 562-567.
- Henley, A.C., & Heiss, G. (2006). *Accuracy of commercial geocoding: assessment and implications*. *Epidemiol Perspect Innov*, 3, 8.
- Lixin, Y. (1996). *Development and evaluation of a framework for assessing the efficiency and accuracy of street address geocoding strategies*. Ph.D. thesis, University at Albany, State University of New York, Rockefeller College of Public Affairs and Policy, 1996.
- Ward, M H., Nuckols, J.R., Giglierano, J., Bonner, M.R., Wolter, C., Airola, M. Mix, W, Colt, J.S., & Hartge, P. (2005). *Positional accuracy of two methods of geocoding*. *Epidemiology*, 16(4): 542-7.
- Zhan, F.B., Brender, J.D., De Lima, I., Suarez, L., & Langlois, P.H. (2006). *Match rate and positional accuracy of two geocoding methods for epidemiologic research*. *Ann Epidemiol*, 16, 842-849.



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Status of Land Tenure Security in Nepal

Harisharan Nepal & Anil Marasini

KEYWORDS

Land, Land Tenure System, Land Tenure Security, SWOT analysis

ABSTRACT

Land is a fundamental natural resource for living, an economic asset for production, legal entity with multiple rights over it and above all, a societal factor for self-actualization. So, ownership of land has multi-faceted understanding around the world. For the developing country like Nepal having diverse societal arrangements, land tenure system plays important role in economic, social and political structure. As Nepal is in the process of implementing federalization, assessment of land tenure security shall be one of the instruments for developing new land related policies and assessing the effect of new policies afterward. The objective of this paper is to perform SWOT analysis on the status of land tenure security in Nepal by reviewing the history of the tenure system and current tenure system, studying country reports and research papers and analyzing policies and institutions. The study shows that despite some initiatives by government, NGOs, bilateral agencies and media to improve land tenure security, land tenure insecurity prevails in all areas of the country even in registered lands. It is found that stable organization, registration of most of the built-up and cultivated land, advocacy to protect the right of landless has strengthened the land tenure security. However, the tenure rights of socially and economically disadvantaged people and displaced people from disasters have not been properly addressed and those people are at high risk of eviction from the place they are living. The study recommends that land tenure insecurity arising from political, legislative and organizational behavior should be managed by appropriate interventions and policy reforms. As most of the analyses of land tenure security in Nepal have been performed in a descriptive way, this study explicitly investigates the issue through SWOT analysis.

1. INTRODUCTION

1.1 Country Introduction

Nepal is a landlocked country in south Asia situated in between two giant economies; China and India. Nepal covers an area of 147,181 sq km possessing diverse topography ranging from 65 m from sea level to the highest peak of the World 8,848-meter-high Mount Everest. With a population of 28.51 million, it is the 45th largest country in the world by population (GoN & UNDP 2014). Nepal is a developing country with per capita income of \$ 712 per year ranking 145th position in the world by Human Development Index (WB 2015). As of 2015, it has GDP of \$21.19 billion with GDP growth rate 2.7% and inflation rate 7.9% (ibid). Enactment of the new constitution on September 20, 2015, replacing the interim constitution of 2007, Nepal has been restructured into the federal democratic republic of Nepal.

1.2 Land Use, Land Ownership and Land Tenure System

Out of total area of Nepal, 28.7 % is agricultural land, 25.4 % is covered by forest and 18.6 % is urban area (FAO 2010). Agriculture is the largest employment sector for over three-quarters of the populations but generating just one-third of GDP (ibid.). Nepal is one of the least urbanized countries in South Asia but one of the fastest urbanizing with a national urbanization rate of 2%. Due to the high rate of urbanization, Nepal is facing the great challenge of managing shelter and housing for increasing population in urban centers.

In Nepal, the average size of agricultural land per household is decreasing from 0.8 ha in 2001 to 0.6 ha in 2008 (FAO 2010). According to National Planning Commission of Nepal 1998, over 70% of farmers own less than one hectare of arable land (GoN & UNDP 2014). The number of landless is more than 1.5 million and the problem of informal settlement is increasing (FAO 2010). In 2008, total number of surveyed land parcels was around 25 million and the number has been increasing in high rate due to haphazard and uncontrolled fragmentation of

land plots (Acharya 2008).

The land tenure system in Nepal has a long history and is based upon Hindu culture (Acharya 2008). Major change in land tenure system happened after 1950 when autocratic *Rana* regime ended and democracy was declared. Government land, public lands, Private (*Raikar*) lands, Trust (*Guthi*) lands and Informal land are the current land tenure types in Nepal. Informal land tenure is increasing due to increase in the occupancy of government land, public land, forest areas and private barren land by landless, bonded labors, conflict victims and disaster victims (CSRC et al. 2009)

2. LITERATURE REVIEW

Land is a fundamental natural resource for living, an economic asset for production, legal entity with multiple rights over it and above all a societal factor for self-actualization. So, ownership of land has multi-faceted understanding around the world. Accordingly, land tenure is multidimensional and complex issue constituting of overriding, overlapping and complementary interests between man and land (FAO 2002). UNHABITAT (2008) defines land tenure as “The way land is held or owned by individuals and groups, or the set of relationships legally or customarily defined amongst people with respect to land. In other words, tenure reflects the relationship between people and the land directly, and between individuals and group of people in their dealings in land”. Land tenure defines the mode of holding over land and the set of relationship between people and land.

Meanwhile, land tenure security is the level of confidence held by people against the eviction of the rights enjoyed to land. For the same type of land tenure system, perception of tenure security can be different in different country, society of the country and among people living in the society. UNHABITAT (2008) defines land tenure security as

- “The degree of confidence that land users will not be arbitrarily deprived of the rights they enjoy over land and the economic benefit that flows from it

- The certainty that an individual's rights to land will be recognized by others and protected in case of specific challenges or
- The right of all individuals and group to effective government protection against forced eviction.”

For the developing countries like Nepal having diverse societal arrangements, security of land tenure plays important role in economic, social and political structure. “Tenure system, in particular, tenure security reflect a lot about the nature society, the development and performance of its informal and formal situations and the way of dealing with change under globalization and factor market liberalization“ (UNHABITAT 2014). Proper governance of land tenure through strong tenure security is the crucial factor for sustainable use of the environment and ultimately for the eradication of hunger and poverty (Munro-Faure & Palmer 2012).

Since security of tenure is the perception of individual people, it can't be measured directly and to a large extent (FAO 2002). Provision of freehold tenure right can be one of the criteria to measure tenure security as it provides stronger tenure security to landowners and thereby stimulating investment and efficient use of land (Holden & Ghebru 2016). In addition to formal titles, security can be achieved through long-term rental contracts or formal recognition of customary rights and informal settlements (UNHABITAT 2014)

3. METHODS

“Land tenure analysis should be performed at an early stage of the design of development projects which will help to ensure and analyze whether the existing rights are made more secure and the conflicts are reduced or not” (FAO 2002). Indicators are commonly used to assess land tenure security, land administration, economic development, environment and even health sector, however, development and operationalization of indicators can be problematic, biased and criticized (D. Simbizi et al. 2014). Experts' opinion, stakeholders view, and rigorous research are prerequisite

to develop indicators so assessing through indicators from desk study can be biased with limited scope. Logical Framework Analysis also assesses indicators and tends to assume a linear progression of effects regardless of contextual conditions (ibid.). Due to the difficulty in deriving indicators, LFA is not used to assess land tenure security in this research.

To analyze the land tenure system in limited time frame through desk research, SWOT analysis could be an appropriate method. In this research, SWOT analysis has been performed to assess the status of land tenure security in Nepal. SWOT refers to Strength, Weakness, Opportunity and Threats and is a comprehensive technique to analyze and compare external and internal characteristics of an organization, of an organizing system or project. (de Vries 2016). The advantage of SWOT analysis is that it is easily understood and the matrix of four quadrants can be quickly derived and ultimately it can be used for strategic planning (ibid). In this research, issues of internal environment and effect of the external environment over land tenure system and security are described in the form of SWOT.

4. DISCUSSION

4.1 History of Land Tenure System

4.1.1 Before 1950 AD (2007 BS):

Before the announcement of democracy in 1950 and promulgation of the new constitution, *Rana* dynasty ruled the then-kingdom of Nepal. *Rana* dynasty was autocratic and characterized by tyranny and isolationism. In that era crown was the supreme owner of land with intermediary customary ownership under various arrangements like *Raikar*, *guthi*, *birta*, *kipat* amongst others (Acharya 2008). Before 1950, land tenure system was characterized by extreme heterogeneity (Chalise n.d.). A brief description of those tenure is described below.

Raikar

The term *Raikar* is derived from Sanskrit words *Rajya* (state) and *kara* (tax). The lands

on which taxes are vested and were on official record of the then government is called *Raikar* land (Acharya 2008). After enactment of land (Survey and Measurement) Act 1963, all those lands were surveyed and registered to respective landholders. This land tenure is similar to freehold tenure.

Birta

The term *Birta* is derived from Sanskrit word *britti* meaning livelihood (Acharya 2008). Birta is the granted land by the state to the individuals for their bravery or loyalty usually on a tax-free and either heritable or in heritable basis (CSRC et al. 2009). Birta was the symbol of high social and economic status and more than one-third of Nepal's farmland was under this tenure before the 1950s (ibid.). Birta Land Abolition Act was promulgated on 1957 and all such lands were converted to *raikar* and *guthi* tenure.

Guthi

Guthi term is derived from Sanskrit word *gosthi* meaning council. It is the type of land which is allocated for managing the expenses for certain religious, charitable and social functions. These are similar to customary lands registered to religious and cultural institutions (Acharya 2008). Currently, 2% farmland belongs to this type of tenure and administered by a different government institution, *Guthi* Corporation under Ministry of Agriculture, Land Management and Cooperative (CSRC et al. 2009). Basically, *guthi* land has two types; *raj guthi* referring to the type of *guthi* land of public nature and *nijiguthi* referring to the type of *guthi* land with transaction and inheritance right to the individual.

Jagir

Jagir means a job and it is the land authorized to civil servants to collect and use the land tax in terms of cash or crops for a certain period in lieu of salary (CSRC et al. 2009). Most of the *Jagir* lands belonged to the relatives and near ones of *Rana* so it was abolished after the end of *Rana* dynasty in 1950 (ibid.).

Rakam

Rakam literally means money. These are the lands provided to carpenters, bricklayers, musicians and similar professionals for their work (CSRC et al. 2009). This type of land was prevalent mainly in Kathmandu Valley.

Kipat

This is the typical example of customary land tenure system in Nepal. This is the land collectively owned and cultivated by *Limbu* community of eastern hill of Nepal (CSRC et al. 2009). Such lands could be sold and inherited within the same community and were converted into *raikar* tenure in 1961.

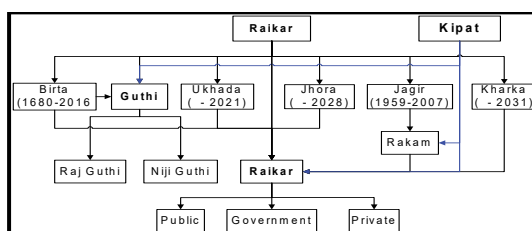


Figure 1: History of land tenure system in Nepal. Source: CSRC et al. (2009)

4.1.2 After 1950 AD (2007 BS)

The political movement of 1950 against *Rana* dynasty resulted in democracy and ultimately political awakening, social and economic development. This political change had a very affirmative impact on land administration sector to abolish a different complex form of landlord favoring tenure system to tenants favored system. Most of the customary form of land tenure was abolished after 1950 change and many issues were resolved after the systematic cadastral survey and registration initiated from 1963 (Acharya 2008). Different forms of land tenure in the past and its conversion time into other type is shown in figure 1.

4.2 Current Land Tenure System

Nepal follows deed registration system with some improvements over it. The current Land tenure system is not as complex as in the past. Figure 2 shows the current land tenure system.

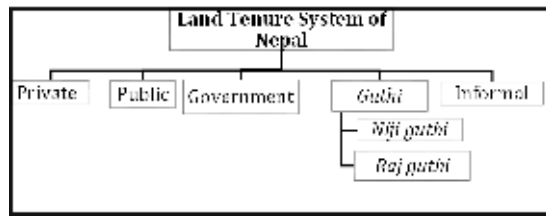


Figure 2: Current land tenure system of Nepal.
Source: Acharya (2008); CSRC et al. (2009)

After the systematic cadastral survey and registration, most of the previous forms of land were converted to private, public or government tenure except for *Guthi* land. Private land is similar to freehold tenure having absolute ownership. The owners of private land have right to use, lease, mortgage, transfer and built upon his/her land. his land According to Land (Survey & Measurement) Act 1963, public land means and includes roads, wells, water conduits, shores, ponds and banks thereof, exits for chattels, pasture lands, graveyards, burial sites, inns, *Pauwas*, *Dewals*, religious meditation sites, memorials, temples, shrines, *Chowk*, *Dawali*, sewerage, *Chautaro*, lands where fairs, markets and public entertainment or sports sites are located, which been used publicly but nor personally since ancient times, and such other lands as prescribed to be the public land by the Government of Nepal, by a notification in the Nepal Gazette. Similarly, government land is the land where there exit roads, railway, government building or office and this expression also includes forest, shrubs, jungle, river, streams, *Nadi Ukas*, lake, pond and ridge thereof, main canal (*Nahar*), water course (*Kulo*), Barron *Ailani*, *Parti* and other types of land, *Bhir*, *Pahara*, *Dagar*, shore (*Bagar*) which is under the control of Government and such other lands as a Government land as prescribed by Government of Nepal by a Notification in the Nepal Gazette. *Raj guthi* are the form of land tenure where concerned *guthi* has the ownership over that land whereas in case of *Niji guthi*, individuals have ownership to the land and pay tax to the *guthi* corporation.

An informal form of tenure is increasing in urban and semi-urban areas. Some of these areas are surveyed and brought into register by different

commissions formed by the government at different times. But most of the informal areas are not in the record of government institutions.

4.3 Implications of Land Tenure System

Many complex forms of land tenure in the past has been resolved by different acts and land reform initiatives. However, it is more challenging to manage the issues of tenants, internally displaced people, bonded labor, landless and *guthi* land. Land Related Act 1964 was formulated to guide the land reform program but the fourth amendment of that Act 1997 terminated the rights of unregistered tenants in the given time frame which has said to be affected 0.45 million unregistered tenants (FAO 2010).

The number of internally displaced people has been increased after the internal civil war of 12 years starting from 1995. Nepal is in the vulnerable zone for naturaldisasters like earthquake, flooding, and landslide so land tenure of people living in disaster-prone area is insecure. The most vulnerable households for disasters are also the people with insecure land tenure like sharecroppers, farm laborers and informal settlers (Mitchell 2010). Besides the loss of lives and buildings, man-made and natural disaster both causes loss of access to land and real estate property (de Vries 2016). April 2015 earthquake of 7.8 MW caused many people to be homeless and internal displacement towards urban and semi-urban area was increased. The tenure rights of displaced people from above-mentioned reasons have not been properly addressed and those people are at high risk of eviction from the place they are living. After the Earthquake of 2015, Nepal is in the process of reconstruction and rehabilitation and facing several problems arising from land tenure practices. NRA provides support for the earthquake affected people for house reconstruction however it is mandatory to have land ownership certificate to get it. Many poor people living in Public lands without land title again become the victim. There are many issues related to land tenure security in Nepal which need to be resolved applying proper tools.

Different land reform and informal settlement management commissions formed by the government in different time with limited timeframe have not been able to solve the issue in long term rather than producing reports. Provision of ending dual ownership is complex and rights of unregistered tenants are not guaranteed in the legislations.

4.4 SWOT Analysis on the status of land tenure security

SWOT analysis has been performed to assess the status of land tenure security in Nepal. Strength, Weakness, Opportunity and Threat has been described below.

4.4.1 Strength

According to the data of UNHABITAT (2014), less than 30% of developing countries are currently covered by some form of land registration however in Nepalese context; more than 90% of the cultivated lands are registered. According to Land Revenue Act 1978, land revenue office should register all type of land that means all parcels in Nepal are subjected to be registered (Acharya 2008). Deed of the transaction, cadastral map and initial register prepared during cadastral survey secure the right held over land. Nepal has well established organizations for registry and cadastre in district level. District level survey office has the authority for cadastral surveying and first registration and district land revenue office has the authority for registration. They are accountable for hearing complaints and solving the issues on land disputes, encroachment and grabbing in the local level.

Article 25 of the constitution of Nepal has secured the right to property and article 37 has secured the right to shelter. These rights protect the poor people from forced eviction. Land Related Act 1964 has fixed the ceiling in the area of land holding that is the great initiative for controlling skewed land distribution. Since 2012 land use policy has been formulated for land use planning and zoning.

Government of Nepal has initiated different programs to promote access and secure the

tenure of marginalized communities to land like exemption of 25% registration fee if the land is registered in the name woman, implementation of leasehold forestry to increase access of poor and marginalized people in the land resources, buffer zone program in national park to improve access to land for indigenous peoples living nearby the park, community forestry, land to freed *kamaiya* (bonded labor), rehabilitation of freed *haliya*(FAO 2010).

Professionals in cadastral organizations are trained in technical disciplines and also educated about right of tenant, poor and marginalized people. There is digitalized data of cadaster and register which is the basis for proper land administration and development of land information system that will minimize the chance of fraud in maps and register and enable landowners to access their information easily.

4.4.2 Weakness

Despite the initiative in the new constitution of Nepal addressing the issues of right of shelter and right to hold property, land tenure insecurity prevails in reality. Most of the cultivated lands are subjected to be registered but the rights of people living and cultivating outside of the surveyed area are not secured. Maps and register created from the first cadastral survey are inaccurate and in poor condition, so boundary and records of land parcels can't be unambiguously identified. Administration and management of *guthi* land is complex and ambiguous. Tenure security of the people living in *guthi* land is also vulnerable. Areas outside of cultivated and built-up areas are not surveyed and brought into maps and register. So, there is a lack of actual data and recordation about the people outside surveyed area and that population is out of formal records.

There is no permanent government institution to settle the issue of informal settlement and unmanaged housing. The government occasionally forms the commission to solve the issue but this is not effective since it is political nomination consisting of members with limited knowledge of the issue.

Nepal follows deed registration system so it is difficult to claim the compensation in fraud

cases of land registration and transaction. There is a lack of coordination among land related organizations and landless and poor people suffer more from this. Human resources in land revenue and land reform organizations are general administrators who are more concerned with accountability and proof in the legal documents with limited awareness of the rights of landless and poor (CSRC et al. 2009). According to the study by transparency international Nepal in 2016, Land revenue office is the most corrupt organization in Nepal that implies that it is very difficult for the poor people with insecure land rights to approach such offices and put forward their issues. There is an insufficient financial and technical resource to improve the tenure security.

4.4.3 Opportunity

After many political and social movements, people are aware of their rights and raise their voice against illegal deeds and forced evictions. Almost all parties' manifesto contains the issue of land reform and are willing to address the issue of informal settlements and landless people. Bilateral agencies are supporting the issues of pro-poor land management, agricultural development through innovative programs like Fit for Purpose Land Administration, GLTN, VGGT amongst others to secure the rights of landless and poor and to improve tenure security.

There are many civil organizations working in the sector of protecting the rights of slums and their tenure security. After the April 2015, 7.8 Mw earthquake people are aware of public space preservation and land use management. The government of Nepal declared it to be the federal republic of Nepal and is in the process of implementing decentralization in every sector so poor people might get access to the service agencies more easily in coming days. Over sighting agencies like Commission for Investigating the Abuse of Authority and National Vigilance Centre are active against the illegal deeds that indirectly helps to improve the tenure security.

4.4.4 Threats

The number of informal settlement and internally displaced people has increased tremendously

after natural disaster and civil war. Nepal is one of the fastest urbanizing country so pressure on land is increasing in urban area. That may increase the chance of adversely possessing the public land and may inhibit the ongoing initiative to improve the security of existing informal settlement. The land market is under the limited control of government body. Increasing commoditization and commercialization of land are the threats to land tenure arrangements. Political interference in the case of adverse possession are also causing threat to land tenure security.

5. Conclusion

This paper analyzed the land tenure system, its history and its implication and finally examined the status of tenure security in Nepal. From the SWOT analysis, it is shown that stable organization, registration of most of the cultivated and built-up area, new policy and projects to protect the right of landless has improved the land tenure security. With existing strength and taking support from the strong civil organization, media, and aware citizen, tenure insecurity induced by the behavior of citizen can be minimized.

Land tenure insecurity arising from political, legislative and organizational behavior should be managed by appropriate reform and interventions. To improve tenure security, all of the lands should be surveyed and brought into registration. Land administration system should be restructured with integrated land laws and educated land professionals. High-level land authority should be established to protect the right of poor living on the bank of the river, squatter and informal settlement. Landless and poor should be educated and organized to raise their issues. The appropriate scientific methodology for land valuation should be developed. Integrated land use zoning has to be developed and rural renewable projects should be implemented to minimize the pressure in the urban area. Cadastral resurvey should be done on demand basis with proper methodology and guidelines for re-registration. Political parties should take this agenda seriously and have to provide sufficient financial and technical resource to improve the tenure security.

REFERENCES

- Acharya, Baburam (Ed.) (2008): *Land Tenure and Land Registration in Nepal. Integrating Generations*, FIG Working week. Stockholm, Sweden, 14-19 June 2008.
- CBS (2013): *National Agricultural Sample Census 2012*. Central Bureau of Statistics, Government of Nepal.
- Chalise n.d., Nava Raj: *Land Tenure Reform in Nepal*.
- CSRC; Land Watch Asia; ANGOC (2009): *Land and Land Tenure Security in Nepal. Case Study: Nepal*. Community Self Reliance Centre Nepal. 2009.
- de Vries, Walter Timo de (Ed.) (2016): *Post Disaster Consolidation of Land, Memory and Identity*. FIG Working Week 2016: Recovery from Disaster. Christchurch, New Zealand, May 2-6, 2016.
- D. Simbizi, Marie Christine; Zevenbergen, Jaap; Bennett, Rohan (Eds.) (2014): *Measuring the Land Tenure Security of Sub-Saharan Africa's Rural Poor*. FIG Congress 2014: *Engaging the Challenges-Enhancing the Relevance*. Kuala Lumpur, Malaysia, June 16-21, 2014.
- FAO (2002): *Land Tenure and rural development. Land Tenure Studies*. United Nations Food and Agriculture Organization, FAO. Rome.
- FAO (2010): *Land Use Policy and Planning*. Food and Agriculture Organization of the United Nations. UN Complex, Pulchowk, Nepal.
- GoN; UNDP (2014): *Nepal Human Development Report 2014. Beyond Geography: Unlocking Human Potential*. Government of Nepal; UNDP. Nepal.
- Holden, Stein T.; Ghebru, Hosaena (2016): *Land tenure reforms, tenure security and food security in poor agrarian economies. Causal linkages and research gaps*. In *Global Food Security* 10, pp. 21–28.
- Mitchell, David (2010): *Land Tenure and Disaster Risk Management*. In *Land Tenure Journal, FAO* 1.
- Munro-Faure, Paul; Palmer, David (2012): *An Overview of The Voluntary Guidelines on the Governance of Tenure*. In *Land Tenure Journal, FAO* 1.
- UNHABITAT (2008): *Secure land rights for all. United Nations Human Settlements Programme; Global Land Tool Network*. Nairobi, Kenya.
- UNHABITAT (2014): *Land tenure Security in Selected Countries*. Synthesis report. Edited by Michael Kirk (2).
- WB (2015): *Data of Nepal. World Bank. Available online at data.worldbank.org/country/nepal*, checked on 3/19/2018.
- Zevenbergen, Jaap.; Kerle, Norman; Tuladhar, Arbind Man (2014): *Spatial Information for Addressing and Assessing Land Issues in Disaster Risk Management*. In *Land Tenure Journal, FAO* 1.



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THE IMPORTANCE OF RRR IN CADASTRAL SYSTEM

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Pradeep Sapkota Upadhyaya-PhD, Tanka Prasad Dahal

KEYWORDS

RRR, Cadastral System, LADM

ABSTRACT

Cadastral System is the base platform to abstracting land rights; maintain its records and registration. It normally makes agreements with dispersed right interests as tenure security, continuum of land rights, registration system, adjudication process and de-facto, local and central government policy aspects within land administration party. As, RRR-Rights, Restrictions and Responsibilities are related to spatial unit and its owner, normally right contains ownership and tenure aspect whereas restrictions is related to control use and different activities on land. Responsibilities relate more to a social, environmental, communal, ethical obligation or defiance to environmental sustainability. Most cadastral system of developing countries are still absence in identifying and assigning clear RRR in certain spatial unit i.e. buffered on Highways, banks of Rivers and Streams and special cases of shade of High-tension-transmission lines etc. This paper aims to provide an overall understanding of such RRR cases with the concept of cadastral system. This paper aims to show AS-IS situation cadastral system with comparing TO-BE condition with gap analysis based on LADM conception of some related cases. This paper concludes that cadastral system will be good when there is clearly defined RRR. So, better identification and assignment of RRR between spatial unit and land administration party can support better cadastral system which supports to better land administration of country.

1 INTRODUCTION

1.1 Background

Land is the vital source, without it life on earth cannot be persistent. Good management of the land is important for present and future generations(UNECE, 1996) .Land tenure security supports transferability of land, greater investment incentive, more sustainable management of land resources (Ghimire, 2011).

A cadastral system can be suitably defined as a parcel-based and up-to-date land information system containing a record of interests in land e.g. RRRs(Williamson, Enemark, Wallace, & Rajabifard, 2010). Interests in relation to land can be characterized as identifying things that you can do (rights), things that you can't do (restrictions), and things that you have to do (responsibilities) (Grant, 2014). These three

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(rights, restrictions and responsibilities) can be abbreviated as ‘RRR’. A property rights system will define what, who, when and (through the cadastral system) where as land parcel object with relation of person. These components can be described as follows: What the RRR is in law? Who (or which organization) holds the RRR or is subject to it? When the RRR came into effect? Or when it ceased to apply? where the land or real property is that it applies to, including its extent(Gogolou, 2013) Cadastre at the core of land administration systems traditionally documented the land ownership rights. With the increasing pressure on land and land use, there is a trend that public authorities impose more and more restrictions and responsibilities. There is an international style that these restrictions and responsibilities are being combined into the cadastre as well, as landowners and other land market participants want and need to know about all factors affecting their land property.

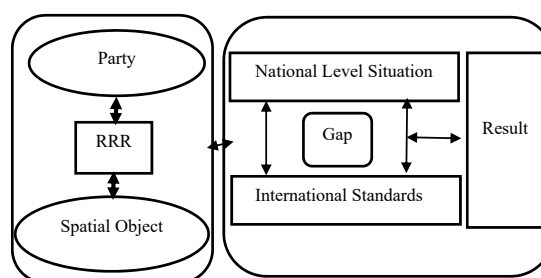
According to Ingram and Hong (2009) the five rights have been defined as Access—a right to enter a defined physical property, Withdrawal—a right to harvest the products of a resource such as timber, water, and food for pastoral animals, Management—a right to regulate the use patterns of other cutters and to transform a resource system by building improvements, Exclusion—a right to determine who will have the right of access to a resource and whether that right can be transferred and Alienation—a right to sell or lease any of the above rights.

The class Right or Restriction allows for the introduction of ‘shares of rights’ in case where a group of Persons holds a total part of a ‘complete’ right; this has to be included: a share in a Right is possible in Version A, but should be openly included as an attribute. Rights, Restrictions and Responsibilities should be specializations of the RRR class; this allows for the introduction of separate aspects in subclasses(Lemmen, 2012). Recent developments in land property- such as the evolution of governmental land-use planning controls- suggest that the previous theories of property as an unrestricted set of rights are now insufficient. Restrictions and responsibilities are now inseparably linked to our theories of property rights and ownership. Sustainable land

management demands that these similar concepts be dealt with in a complete manner(Žróbek, 2008).

1.2 Conceptual Framework

The conceptual framework for the paper is set out in terms of RRR with owner and spatial object. The existing practices and innovative actions will be important to perform Gap analysis to formulating strategy. This paper investigates the national country context of RRR situation



of (AS-IS) situation of cadastral system. The modern system and experience related to RRR in West Africa, Australia and Netherlands are reviewed as international standards (TO-BE) to gap analysis with national level situation, which conceptual framework is shown on Figure 1-1.

1.2.1 RRR -Right, Restriction and Responsibility

Land rights, records and registration normally do agreement with enumerations for tenure security, continuum of land rights, deeds or titles, socially appropriate adjudication, statutory and customary, co-management approaches, land record management for transact ability and family and group rights(Manandhar, 2015). Out of right upon land, restriction and responsibility on land are also important issue and interest in land administration.

The number of restrictions and responsibilities that control land use and development has rapidly increased over the last fifty years(R. Bennett, Wallace, & Williamson, 2005). The new Land Management Pattern demands that land and resources be managed holistically: a new model for the management of property rights, restrictions and responsibilities is required.

This paper aims to describe the major findings of ongoing research into the problematic management of property restrictions and responsibilities. The aim is to change the issue as one of land management, rather than one of information organization. Also discussed are a number of institutional, regulatory and policy issues that relate to restrictions and responsibilities. To date, these issues have received nominal attention: achieving sustainable land management will require that these issues be addressed (Bennett, 2007).

1.2.2 Cadastral System

The development or improvement of land registration and cadastral systems requires a broad view of system concepts if it is to ensure that these systems operate efficiently for many purposes besides the basic tasks of providing legal security by titles or deeds and data for property taxation.

The broad view of such system concepts concerns the integrated management perspective of tenure security, economic development and environmental control (Tuladhar, 2004).

A successful land information system should provide the essential information to provide efficient and effective land administration services and are guided by the government policy. LIS can integrate different tasks in traditional cadastres and land registration system into one thus increasing the efficiency in land administration services (Dangol, 2012).

2 Material and Methods

This paper is based on case study and literature review. It uses cadastral map and rule/ standards of local government or municipal regulation and national standards as secondary data.

2.1 Case study area

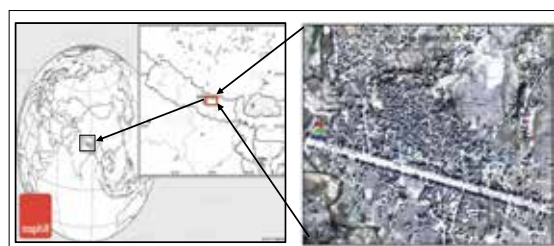


Figure 2-1 Case study site (Banepa, Kavre, Nepal)

Araniko Highway, Punyamata River, Chandeshwori Stream and High-tension (power line), which belong to cadastral map sheet of 157-1324, located in Banepa Municipality, Kavre District in Nepal is taken as case study area which is shown in Figure 2-1 .

2.2 Case study issues

The case study issues are selected in Banepa Municipality, Kavrepalanchok district in Nepal. It is suitable for the study because there are different types of ongoing debate of Right of Way-ROW in Araniko highway, Punyamata River, Chandeshwori Stream and High-tension (power line) at Banepa, which is directly linked with different land right, restriction and responsibility issues.

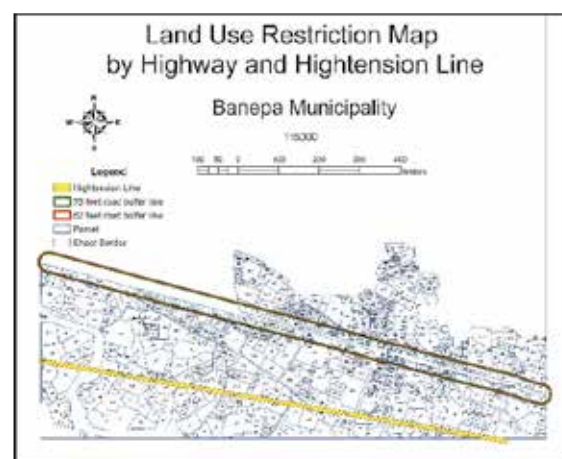


Figure 2-2: Land use restriction map by Highway and high-tension

The major controversial issue of case study area is ROW of Araniko Highway at Banepa Bazaar, because of dual conflicting provision of 75ft provisioned by local government or municipal regulation where 82ft standard is restricted by national highway standards from the center line of the Highway ROW (right of way). Figure 2-2 shows the ROW of Araniko highway with 75 feet and 82 feet from center line of highway and same as 30 feet land area occupied by High-tension (Power line). In figure Araniko highway with buffering zone is shown in upside of figure and the high-tension buffer zone is shown in down side. In case of Punyamata River and Chandeshori stream of Banepa region, the municipal rule is regulated as 15 meters

restriction for river and 7 m for stream from both banks. Lands which are located both at the bank of Punyamata river, are restricted by 15m to freely hold and 7m on Chandeshori stream is shown in Figure 2-3. Governing law for land restrictions in case of highway, rivers, stream and high-tension areas are shown in Table 2-1, which shows the comparatively municipal regulation and national standards of different cases.

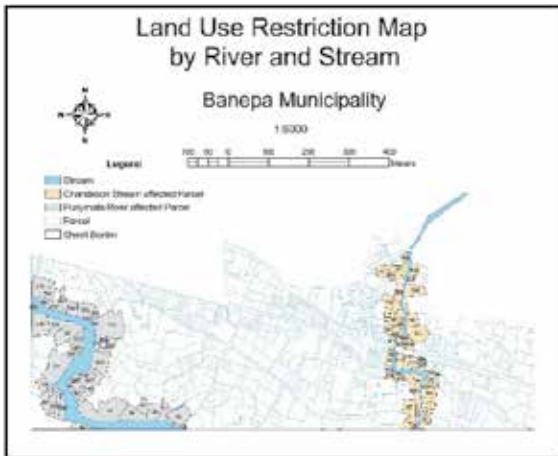


Figure 2-3: Land use restriction map by River and Stream.

There are several laws related to land administration. The rules have gaps and overlaps among the land acquisition techniques. Even, in the Land Acquisition Act of Nepal, the clear statement "When acquisition of land from public, government cannot get land without providing compensation". In the case of land acquisition history of Government of Nepal enforced to get land without compensation. If the right is clear in land administration system, such problems would be solved.

S.N.	Case Issues	Governing law/ Norms/ Rule / Standard		Remarks
		Local Government	National Standard	
1	Araniko Highway	22.86 Meters/ 75 feet	25 Meters / 82 feet	From center of highway
2	Punyamata River	15 Meters	-	From Bank of River

3	Chandeshori Stream	7 Meters	-	From Bank of Stream
4	High-tension (Power line) 64 kv.	-	9 Meters/ 30 feet	From Centre of power line

Table 2-1: Case issues and governing law/ norms/ rule/ standards.

3 RESULTS

It is very important part of the study that shows the problems of RRR in land parcels located near and touched within highway, river, stream and high-tension lines. With consideration of literature review, different levels interview, house hold survey, review of international experiences and case map analysis, we can foster RRR issues as problem in parcel objects.

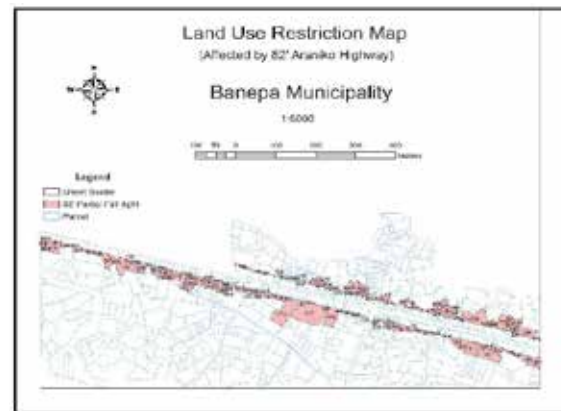


Figure 3-2: Land use Restriction map affected by 82 feet Araniko highway

The related parcel owners of affected case area are holding full right of parcel with their parcel certificate. They own full authorized certificate and map documents. But actually the certificate and parcel map may differ or wrong with actual situation in case of RRR. The provisions offered by land certificate of these areas surely meet low area and value. This creates land disputes, controversy and confusion in land administration. It directly affects in land value, land use, land ownership, land taxation and even in land development process. That variation on certificate and ground situation badly governs to right, restriction and responsibility issues.

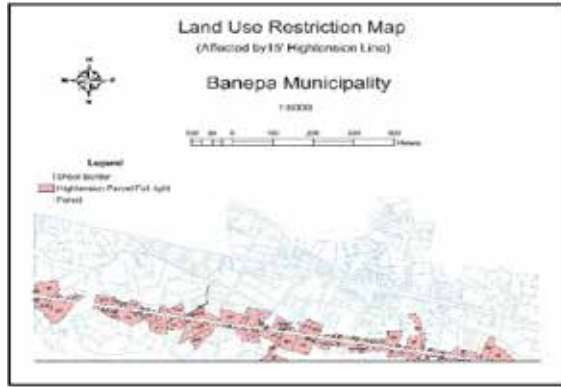


Figure 3-1: Land use Restriction map affected by 30 feet high- tension line.

We can see the parcel variation in shape and area in Figure 3-2, which shows the actual shape and remaining area of parcel after deducting restricted 82 feet ROW of Araniko Highway. Same as in Figure 3-1, we can see the affected parcel by cause of high-tension line. There are serious issues and problems in river bank and sides of stream. The land extended on bank side of river and stream is only for use, but the owner can not enjoy right on these land with law and rule of municipal regulations. But lack of notification of these restrictions on land certificate, owner usually using these illegal rights and overwhelm ignorant by their responsibilities.

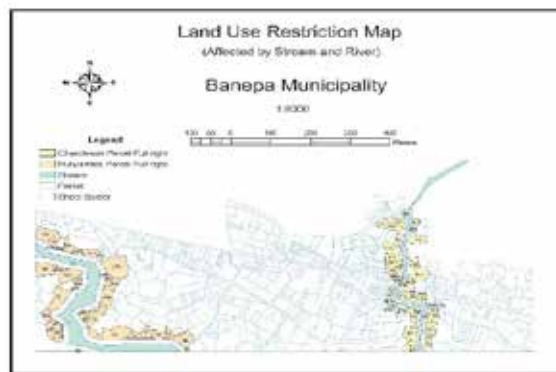


Figure 3-4: Land use Restriction map affected by Stream and River.

Figure 3-4 shows the remained parcel area and shape on the bank of Punyamata River. Same as Figure 3-3 aims to clear parcel visual with the area which deducts in highway and actual remaining parcel along Araniko highway.

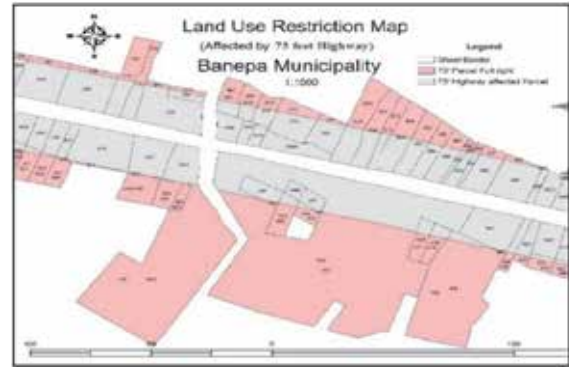


Figure 3-3: Parcel division with allocated to highway and actual remaining.

These figure shows clear visual of land extent problem with differentiation on land certificate and ground nature. Local government or municipal regulation and standards are only listed in official archive but not spark and annotates in land certificate. This issue is not only directly or indirectly increasing land related disputes and controversies day by day but also increasing in loss of land revenues, obstacle in urban development and land development.

4. DISCUSSION

The core components of RRR with respect to cadastral system will be better when we can separate different interest on land. In the context of Nepal, RRR is not clearly mentioned in cadastral system. It will be better to study the gap between country context RRR and Standard form to define RRR, that method will suggest for its solution to maintain good cadastral system in country context.

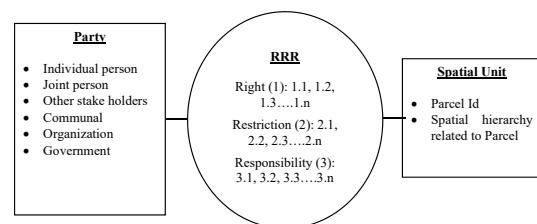


Figure 4-1: The abstract concept adapted by LADM

4.1 ISO standard LADM

Land Administration Domain Model-LADM is the emerging concept in aspect of sustainable land administration system and related to object

to subject base cadastre and land administration system, showing the relationship between party and parcel. This is the ‘Object –Right – Subject’ model. It is generally recognized that a land recording system should be parcel based, not people based, with the parcel being uniquely described in some form of map supported by a land survey system(Lemmen, 2012). There are three categories with different theoretical connections between object and subject, a direct connection between object and subject, a connection through right and obligation and a connection through ownership.

The traditional concept of being relation of human kind to parcel only focuses limited RRR aspect. But LADM concept aims to define

descriptive relation of land parcel as spatial unit with respect to Party as different individual person, Joint person, other stake holders and communal aspect. So, in case of this study, this model is adapted by LADM by requirement of RRR relation with Party and Spatial Unit, which is shown in Figure 4-1.

Considering LADM as ISO standard of land administration, the exploration of figure of LADM having three essential components is shown in Figure 4-1. This concept mainly focuses on element based right, restriction and responsibility with respect to different party and spatial unit. This conception links party to spatial object with RRR. It debates on divers important of RRR to connecting party to spatial unit.

4.2 RRR Elements

Person	RRR			Spatial Unit
	Right	Restriction	Responsibilities	
<ul style="list-style-type: none"> • Individual person • Joint person • Other stake holders • Communal • Organization • Government 	R1.1 Occupy R1.2 Use R1.3 Sell R1.4 Transfer R1.5 Mortgage R1.6 Compensation R1.7 Easement R1.8 Derive income R1.9 Purchase R1.10 Grant R1.11 Inherit R1.12 Develop R1.n.....	R2.1 Exclude R2.2 Land use type R2.3 ROW R2.4 Rule of NEA R2.5 Local act R2.6 Land use zone R2.7 Subdivision regulations R2.8 Minimum parcel size R2.n.....	R3.1 Environmental requisition R3.2 Pollution control R3.3 Disturbance R3.4 Structures for access R3.5 Construction R3.6 Setbacks R3.n.....	<ul style="list-style-type: none"> • Parcel ID • Area • Value • Use • Spatial hierarchy related to parcel

Table 4-1: RRR elements

Cadastral system is backbone of land administration system. A cadastral system can not sustain without recordance of information of parcel and its owner. It is now clear that without clear identification of RRR component with relation of party or owner and spatial unit, recordance of cadastral system can not sustain. Proper issues identification about right, restriction and responsibility in policy, management and operational level is very crucial. It is emergence step to identify and allocate of RRR elements during cadastral survey and generating land certificate. The allocation and assigning RRR element(s) on individual parcel

will be better road mark for getting successful land administration destination. With respect to review of developed cadastral systems and case study the following RRR elements are identified, which are listed in Table 4-1.

In this RRR element table, certain codes are defined such as: R1.1 stands for ‘occupy’, R1.2 for ‘use’, R2.1 for ‘exclude’, R2.2 for ‘land use type’, R3.1 for ‘environmental requisition’, R3.2 for ‘pollution control’ etc. For better management of RRR system, these codes should be included in ‘Land ownership certificate’. Because of it, land administrators and land owners can clearly know about it, which will help in effective land

management system. It will, hence, solve the problems and miss-understandings from the local people to land administrators.

5. CONCLUSION

Cadastral system is the foundation of the land administration system of every country, which directly relates with important sectors i.e. development activities i.e. urban planning, town development, transportation and highway, hydropower and power supply construction project, financial sector, agriculture, and socio-cultural sector. So, the clear identification, allocation and assignation of RRR from process of cadastral system to generating land certificate can reduce conflict and rise positive aspect in cadastral system. Being LADM as ISO standard system model, this paper explores the idea of fitting LADM concept for the clear identification of RRR in cadastral system and assigning these elements in land certificate will support to better relation with party/owner to parcel (spatial object). It will be the base for sustainable land administration system of any country.

REFERENCES

- Bennett. (2007). *Property rights, restrictions and responsibilities: their nature, design and management*. (Doctor of Philosophy), The University of Melbourne, Melbourne.
- Bennett, R., Wallace, J., & Williamson, P. I. (2005). *Achieving Sustainable Development Objective through better Right, Restriction and Responsibilities*.
- Dangol, S. (2012). *E-government based land information system architecture: A case study of Nepal*. ITC the Netherlands
- Ghimire, S. (2011). *Assessing the role of land tenure in hydropower development for social and environmental effects*.
- Gogolou, E. D. a. C. (2013). LADM as a Basis for the Hellenic Archaeological Cadastre. *Research paper*.
- Grant, D. (2014). *Cadastral 2034. A 10-20 Year Strategy for developing the cadastral system: Knowing the 'where' of land-related rights*.
- Ingram, G. K., & Hong, Y.-H. (2009). *Property Rights and Land Policies*. Paper presented at the The 2008 Land Policy Conference.
- Lemmen, C. (2012). *A Domain Model for Land Administration*. *PhD thesis*.
- Manandhar, S. (2015). *State and Public Land Management: Issues of Encroachment and Protection Technique*. *Master's Thesis*.
- Tuladhar, A. M. (2004). *Parcel-based Geo-Information System: Concepts and Guidelines*. Enschede: ITC Printing Department.
- UNECE. (1996). *Land Administration Guidelines: United Nations Economic Commission for Europe*
- Williamson, Enemark, Wallace, & Rajabifard. (2010). *Land Administration for Sustainable Development*.
- Žróbek, S. (2008). *The Influence of Local Real Estate Management Policy on Community Budgets*. Paper presented at the FIG/FAO/CNG International Seminar on State and Public Sector Land Management.



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SPATIAL DISTRIBUTION AND TEMPORAL CHANGE OF EXTREME PRECIPITATION EVENTS ON THE KOSHI BASIN OF NEPAL

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KEYWORDS

Koshi Basin, Extreme precipitation events, Climate change, Inverse distance weighting, Kriging interpolation

ABSTRACT

Climate change, particularly at South Asia region is having a huge impact on precipitation patterns, its intensity and extremeness. Mountainous area is much sensitive to these extreme events, hence having adverse effect on environment as well as people in term of fluctuation in water supply as well as frequent extreme weather events such as flood, landslide etc. So, prediction of extreme precipitation is imperative for proper management. The objective of this study was to assess the spatial distribution and temporal change of extreme precipitation events on Koshi basin of Nepal during 1980-2010. Five indicators (R1day, R5day, $R > 25.4$ mm, SDII and CDD) were chosen for 41 meteorological stations to test the extreme events. Inverse distance weighting and kriging interpolation technique was used to interpolate the spatial patterns. Result showed that most extreme precipitation events increased up to mountain regions from low river valley; and then it decreased subsequently up to Himalayan regions (south to north direction). However, there is high value of indices for lowland Terai valley also. Most of the indices have hotspot with higher value at north western and southern part of the study area. For temporal change, most of the extreme precipitation indices showed increasing trend within 30 years' period. The spatial distribution of temporal change in indices suggests that there is increasing trend in lowland area and decreasing trend in mountainous and Himalayan area. So, adaptive measure should be adopted through proper land use planning, especially at those hotspot areas and their tributaries; to reduce adverse effect of extreme precipitation events.

1. INTRODUCTION

South Asia region is particularly vulnerable to climate change (IPCC, 2014). Mostly, global warming is having effect on many components of hydrological systems such as precipitation

patterns, its intensity and extreme event (Agarwal, Babel, & Maskey, 2014). This is likely to manifest through increased precipitation and more frequent extreme weather event, such as floods, particularly in vulnerable areas like coasts and river basins. There is a raising

concern on issues such as drought and erosive rainfall that causes risk of land degradation and desertification(Costa, Durão, Soares, & Pereira, 2008).

Mountainous area is more sensitive to these environmental change, hence affect the important environmental services it offers such as drinking water supply, irrigation etc (Agarwal et al., 2014). In addition, they are characterized by steep slopes and small drainage basins, so heavy rainfall can trigger rapid and unexpected flash flood events, landslides, debris flow and soil erosions, especially at non forested area (Pereira, Oliva, & Baltreinaite, 2010). As extreme rainfall events have important impact on mountain area, it is particularly important to understand the spatial and temporal distribution of extreme rainfall to have knowledge of and to predict impact of these events and identify higher vulnerable areas. (Pereira et al., 2010; Pereira, Oliva, & Misiune, 2016). But, distribution of rain gauge stations in mountainous area is generally sparse. Additionally, there is quick change in precipitation pattern within small distance. So better prediction with higher value of extreme precipitation is necessary for better land use planning and minimizing the effect of flood, landslides and soil erosion(Pereira et al., 2010).

The objectives of this study were i) to identify spatial patterns of the extreme precipitation indicators; and ii) to analyse the temporal change and their spatial distribution of each extreme precipitation indicators.

2. STUDY AREA

This study was conducted in the Koshi river basin, in Nepal. This is the largest river basin, covering 18 districts (administrative units in Nepal) and nearly 30,000 km² of land from Himalayas to the lowland of terai region. This basin consists of seven major sub-basins, namely Sun Koshi, Indrawati, Dudh Koshi, Tama Koshi, Likhu, Arun and Tamor. The basin area lies within 26°51' N and 29°79' N latitudes and

85°24' E and 88°57' E longitudes, with elevation ranging from 65 mamsl (meters above mean sea level) in low valley (terai region) to over 8000 mamsl in high Himalayas. The majority of area in Koshi basin falls under the mountains, followed by hills, himalayas, high mountains, terai plane and low river valleys (Agarwal et al., 2014).

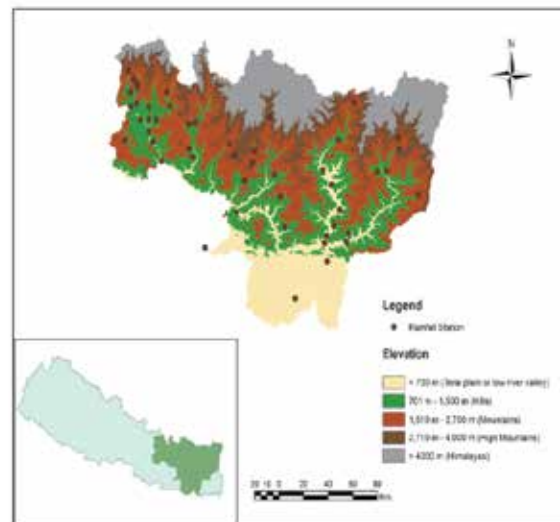


Figure 1: Study area with elevation range and precipitation station

3. DATA AND METHODS

3.1 Data

Time series data of daily precipitation, which were used to calculate precipitation extreme, recorded at 48 meteorological stations on the Koshi basin were collected for this study from 1980 and 2010. This data was provided by Department of Hydrology and Meteorology, Nepal.

Basic assumption was made (Pereira et al., 2016), where meteorological station with more than 10% of missing values were not considered.

Indicator of Extreme Climate Events

Five indicators on extreme precipitation index [from over 50 in the list defined by CCI/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI)] were

used. Of the five extreme precipitation indices, four of them related to “wetness” (R1day, R5day, R25.4, SDII) while one of them related to “dryness” [consecutive dry days (CDD)], described in table 1.

Only 42 stations were used for calculating the extreme precipitation index, after filtering out the station for basic assumption made. For each indicator, two value were extracted, one for duration of 1980-1982 and another for duration of 2008-2010. This was done by averaging each value for that duration.

Indicators	Definition	Unit
R1d	Intense precipitation event: Maximum 1 day precipitation	mm
R5d	Intense precipitation event: Maximum 5-day precipitation total	mm
R > 25.4	Heavy precipitation days: Number of days with precipitation $\geq 25.4 \text{ mm day}^{-1}$ (1 inch)	Days
SDII	Simple daily intensity index: Annual total precipitation/number of Rday $\geq 1 \text{ mm day}^{-1}$	mm
CDD	Consecutive dry days: Maximum number of CDD (Rday < 1mm)	days

Table 1: Extreme precipitation indicators

3.2 Methodology

3.2.1 Exploratory Data Analysis: Descriptive and Bivariate Analysis

Some descriptive statistics of all variables were performed, mean (m), median (md), standard deviation(SD), coefficient of variation (CV%), minimum (min), maximum (max), quartile (Q1), 3rd Quartile (Q3), skewness (Sk) and kurtosis (kur). Also, Pearson’s correlation between each variable with longitude, latitude and elevation was also performed to test the

relation of each variable with geographic and terrain characteristics so that decision can be made for kriging interpolation.

3.2.2 Exploratory Spatial Data Analysis

Various ESDA tools such as data posting, regional histogram, voronoi maps, local and global moron’s I statistics, contour lines and moving window statistics were applied to every indicator to know about its spatial behavior in study area. This is an essential step prior to interpolation.

3.2.3 Interpolation

Establishment of spatial representation of precipitation is based upon the principle of ordinary kriging and inverse distance weighting (Borges, Franke, Anunciação, Weiss, & Bernhofer, 2015). Current studies (Borges et al., 2015; Griffiths & Bradley, 2007) make use of terrain characteristics such as elevation, geographic position to describe spatial representation of precipitation using co-kriging techniques.

Inverse distance weighting is a deterministic method whose estimation is based on the weighted average which is proportional to the inverse of distance between point to be interpolated and measured points (Borges et al., 2015). IDW is performed with power value as 2 to create an interpolated surface as it is mostly used in interpolating precipitation value.

Geostatistical method, kriging interpolation takes consideration of both the distance as well as degree of variation between the measured points(Pereira et al., 2010). The main advantage of kriging is that it gives statistically unbiased estimates of surface value from a set of observations at sampled location. This is done by fitting mathematical semi variogram model (inverse function of spatial and temporal covariance) on experimental variogram, representing variability of spatial and temporal pattern of physical phenomena (Costa et al., 2008). Several types of models are available

such as ordinary, simple, and universal kriging. The parameter of variogram model such as sill, range and nugget are used to assign weight for spatial prediction.

Here, we used omnidirectional variogram as there is no sign of anisotropy in all variables. Here, we used exponential model which captures spatial characteristics of each sample in study area subjectively to model experimental semi-variogram considering the physical knowledge of the area and phenomenon (Costa et al., 2008).

It is being said that spatial heterogeneity of precipitation distribution varies with topography as well as spatial position where co-kriging can act (Pereira et al., 2016). But, as there is poor linear relationships (assessed through Pearson's correlation coefficients) between five indices and topographical variable as elevation and spatial position (longitude and latitude), we preferred ordinary kriging over co-kriging.

Experimental space time semi-variograms were calculated for the two-time period, between 1980-1982 and 2008-2010, for each extreme precipitation indices. For those indices, whose semi variogram could not be modelled; interpolation surface resulted from inverse distance weighting is considered for spatial analysis. For rest, comparison between IDW and kriging is done to assess the appropriate interpolation technique and surface is generated which has high accuracy.

3.2.4 Assessment Criteria for Interpolation Techniques

Interpolation techniques such as inverse distance weighting and ordinary kriging were tested for determining most appropriate interpolation technique for every indicator. Every assessment criteria are based on error produced by each model i.e. observed value – predicted value. Leave one out cross validation method was used to assess the error associated with each model, which based on the principle that is achieved by taking each sampled point and estimating it from the other remaining values. The error produced

for each model allowed us to calculate mean error (ME) and root mean square error (RMSE), as per following formula and is used extensively to assess the accuracy of interpolation methods.

$$ME = \frac{1}{N} \sum_{i=1}^n \{z(xi) - \hat{z}(xi)\} \quad (1)$$

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^n \{z(xi) - \widehat{z(xi)}\}^2} \quad (2)$$

Where (xi) is sampled observed value and z(xi) is predicted and N is number of data points. The best model is the method with lower value of ME and RMSE.

4. RESULT AND DISCUSSION

4.1 Descriptive and Bivariate Analysis

The table 2 shows the basic statistics of five extreme precipitation indices and elevation of meteorological station. On average, the meteorological stations were located at 1370 m and ranged from 85m to 2625 m, with standard deviation of 715.1. In koshi basin, there are on average 90.8 mm of maximum precipitation in one day per year; 174.2 mm of maximum precipitation in consecutive 5 days per year, 21 days per year with R >= 25.4mm, 15.1 mm of average value of wet days and 54.5 consecutive dry days per year, with standard deviation of 27.1, 69.3, 12.6, 15.1 and 54.4 respectively. We can see that for all indices, mean is somehow greater in amount. So, we can say that distribution of all variables is positively skewed. This may be due to the presence of extreme values, possibly an outlier.

	R1 Day (mm)	R5 day (mm)	R25.4 mm (days)	SDII (mm)	CDD (days)	Elevation (m)
Mean	90.8	174.2	21.0	15.1	54.4	1370.2
Standard Error	4.2	10.7	1.9	0.6	1.2	110.3
Median	85.1	159.6	19.0	14.2	52.0	1507

Standard Deviation	27.1	69.3	12.6	4.0	7.4	715.1
Sample Variance	735.1	4797.8	158.7	16.3	55.1	511295.7
Kurtosis	4.1	0.6	2.2	1.1	-1.4	-0.6
Skewness	1.6	0.7	1.4	1.2	0.4	-0.2
Range	138.3	318.9	59.0	17.7	20.0	2540
Minimum	56.5	43.0	3.0	9.4	45.0	85
Maximum	194.8	361.9	62.0	27.1	65.0	2625
Sum	3812.7	7315.1	883.0	618.3	2231	57550
Count	41	41	41	41	41	41

Table 2: Descriptive statistics for extreme precipitation indicator and elevation of respective stations

The result from Pearson's correlation suggests that almost all precipitation indices shows low correlation with elevation and geographic position (longitude and latitude). However, there is somehow positive correlation between $R > 25.4$ mm index and elevation with latitude.

4.2 Exploratory Spatial Data Analysis

Regional histogram of all five indices reveals that there is two possible suspect of spatial/data outliers/spatial regime, one at the north-western part and one at the northern part of the study area. But the points at the north-western parts spread throughout the histogram, thus there is no suspect of spatial regime at this area. But, one point at northern part is still highly different (large value) from neighbouring points. As there is no local characteristic of that point to favour that extremity, we considered it as data outlier and remove before preceding other exploratory spatial data analysis.

Data posting of precipitation index in relation with elevation shows that there is increase in precipitation index (R1day, R5day, $R > 25.4$ and SDII) with elevation up to mountain regions; and then it decreased subsequently, analogous with conclusion drawn from (Ichiyonagi, Yamanaka,

Muraji, & Vaidya, 2007). But for indices like R1day, R5day and SDII, there is also a high value in lowland valley. This may be due to the reason that, most of heavy rainfall in Nepal is due to humid wind from Bay of Bengal, which enters through south east part of Nepal (Lal & Shrestha, 2012).

Several exploratory spatial data analysis of five extreme precipitation indices reveals that there is oversampled area at north western part or near eastern part of the study area, whereas under sampled area lies at high land (mountains and upper mountain). There is no sample point located at Himalaya region. No spatial outliers, global trend or anisotropic pattern were seen for all indices. Proportional effect is seen in some indices, but as it is so less in area, we can interpolate whole study area at once. Global Moran I index for all indices shows that spatial distribution of high values and low values in the dataset is more spatially clustered than would be expected if underlying spatial processes were random.

4.3 Interpolation

Index	Period	Nugget	Major Range	Partial Sill	Lag Size	No of Lags
R1 Day	1980-1982	40	46100	415	20220.4	10
R5 Day	1980-1982	0	41500	4150	3728.6	10
SDII	1980-1982	0	32675	17	3559.5	10
CDD	1980-1982	0	41000	65.57	3925.8	10

Table 3: Parameters for semi-variogram model

Experimental space time semi-variograms for the two-time period, between 1980-1982 and 2008-2010 were calculated for each extreme precipitation indices. In some cases, distribution of experimental semi-variogram is random,

so semi-variogram model cannot be modelled well. In addition, in some case, though semi-variogram is well distributed to model but major range for this is so less that it cannot contain sufficient measured data due to sparse sample data. As an output, interpolated surface is not smooth.

Taking this into consideration, for only four indices, namely R1day for 1980-1982, R5day for 1980-1982 and SDII for 2008-2010, CDD for 2008-2010, exponential semi-variogram models is fitted keeping in mind that the spatial component is isotropic as suggested by exploratory spatial data analysis. Parameters for selected indices are shown in table 3.

4.4 Interpolation Method Accuracy

Index	Period	Method	ME	RMSE
R1Day	1980-1982	IDW	-2.654	28.989
		Ordinary Kriging	-0.812	18.794
	2008-2010	IDW	-0.136	31.919
R5Day	1980-1982	IDW	-2.534	51.622
		Ordinary Kriging	1.00	47.733
	2008-2010	IDW	-1.753	60.951
R > 25.4 mm	1980-1982	IDW	-0.168	9.607
	2008-2010	IDW	-1.486	13.551
SDII	1980-1982	IDW	-0.069	3.19
		Ordinary Kriging	-0.028	3.340
	2008-2010	IDW	1.897	25.311
CDD	1980-1982	IDW	0.292	7.765
		Ordinary Kriging	0.142	7.768
	2008-2010	IDW	0.308	5.432

Table 4: Comparison of IDW and Kriging for extreme precipitation index

The ME ad RMSE calculated from the residuals obtained from each model are presented in table 4. For all tested model, Ordinary kriging is the most accurate method to interpolate surface.

4.5 Spatial Distribution

4.5.1 Spatial Pattern of Extreme Precipitation Indicators

R \geq 25.4 mm (number of days with precipitation \geq 25.4 mm day⁻¹) (figure 2E and 2F) shows clear increasing trend of index low land valley up to Himalayas ranging from 5 days to 69 days. R5day (maximum 5-day precipitation) index (figure 2C and 2D) showed similar spatial distribution except it has high value at lowland valley too. It has maximum value as 334.5 mm at north west corner and southern part of study area and minimum value as 46 mm at middle part of study area but maximum study area is covered by high values.

The hotspot area for R1day index (ranges from 57.32 mm to 142.95 mm) (figure 2A and 2B) and SDII Index (ranges from 144.48 mm to 144.48 mm) (Figure 3G and 3H) is same as that of R5day index with the highest values in north western part and southern part of the study area, but overall trend is not similar with previous index. Other parts is characterized by less value of these index.

CDD index (figure 2I and 2J) ranged from 45.3 to 65 days with the smallest values in the northern and eastern part and greatest value in the south and south western part. This implies, the low land and hills are more severely affected by drought than other regions, with more intense value of CDD falls under this reason.

Maximum intense precipitation index has high value at northwestern and southern part (lowland) part of study area; basin of tributaries lying in this part should be taken into greater priority to avoid flood, landslide, and soil erosion events.

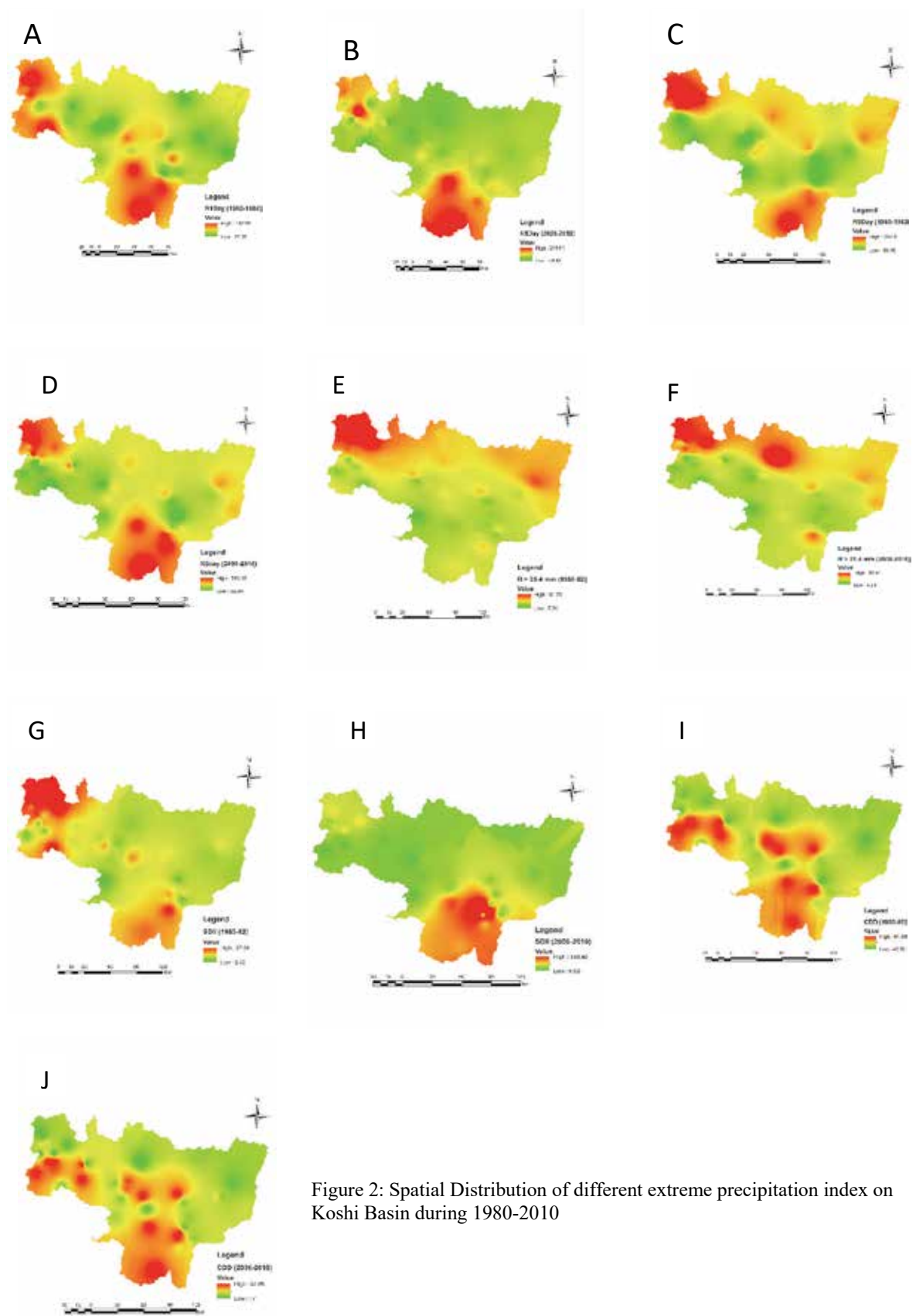


Figure 2: Spatial Distribution of different extreme precipitation index on Koshi Basin during 1980-2010

4.5.2 Spatial Pattern of Temporal Change of Extreme Precipitation Indicators

Table 5 shows the maximum and minimum value of change of each extreme precipitation indices with mean overall change in the period of 30 years. R5day, R > 25.4 mm and SDII indices shows overall increasing trend, while R1day shows overall decreasing trend and CDD is somehow constant. For R1day index, though there is overall decrease in trend, there is increasing trend in area where intensity of this index is high (i.e. north western and southern part of study area). This symbolizes the situation is getting worse in that area with increasing maximum precipitation per year. For R5day index, there is increasing trend in hill and lowland area and decreasing trend in mountains, high mountains and himalayas. For SDII index, lowland area faced increasing trend and there is decreasing trend in hill, mountains and high mountains. Since CDD is somehow constant over thirty years, there is no serious increasing threat on drought over the study area.

Overall, almost all extreme precipitation indices are in increasing trend in lowland area, whereas there is decreasing trend in mountain, high mountain and himalayan area. Hilly area showed random pattern.

Index	Period	Positive Extreme of change	Negative Extreme of change	Mean Increase	Mean Decrease
R1 Day	1980-2010	114.49 mm	-83.47 mm		7.614
R5 day	1980-2010	128.79 mm	-67.9 mm	2.387	
R > 25.4 mm	1980-2010	47.992 day	-13.39 day	4.173	
SDII	1980-2010	123.12 mm	-6.5 mm	5.124	
CDD	1980-2010	3.8 day	-5.4 day		0.08

Table 5: Temporal change of precipitation indices showing maximum positive, maximum negative and mean change.

5. LIMITATIONS

In this study, interpolation for some of the indicator is not performed; as mathematical semi variogram model (inverse function of spatial and temporal covariance) couldn't be fitted on experimental variogram. This is because there is very sparse network of meteorological stations, especially at high elevated regions. So, we can't model semi-variogram to represent variability of spatial and temporal pattern of physical phenomena. The situation may got worsen due to orographic effect in mountainous area. Also, due to sparse network, major range cannot accommodate sufficient data point; as a result resultant surface is very poor. So, we only used IDW (though not very good) for that indicator where semi-variogram model cannot be fitted.

6. CONCLUSION AND RECOMMENDATION

Daily precipitations at 41 meteorological stations on the Koshi basin during 1980-2010 were used to analyze the spatial distribution and temporal change of extreme precipitation indicators. The spatial distribution of most of precipitation index shows that there is increase in extreme precipitation index with elevation up to mountain regions; and then it decreased subsequently for Himalayan regions. However, there is high value of indices for lowland terai valley. For most of the indices, there is a hotspot with higher value at north western and southern part of the study area. Most of the extreme precipitation indices showed increasing trend within 30 years' time period. The spatial distribution of temporal change in indices suggests that there is increasing trend in lowland area and decreasing trend in mountain and himalayan area.

The abovementioned spatial distribution and temporal change of extreme precipitation indices suggest that there is increasing possibility of soil loss, landslides and flood. Special care should be given to the hotspot area and its tributaries and proper land use planning should be adopted.

REFERENCES

- Agarwal, A., Babel, M. S., & Maskey, S. (2014). Analysis of future precipitation in the Koshi river basin, Nepal. *Journal of Hydrology*, 513, 422–434. <http://doi.org/10.1016/j.jhydrol.2014.03.047>
- Borges, P. de A., Franke, J., Anunciação, Y. M. T., Weiss, H., & Bernhofer, C. (2015). Comparison of spatial interpolation methods for the estimation of precipitation distribution in Distrito Federal, Brazil. *Theoretical and Applied Climatology*, 123(1), 335–348. <http://doi.org/10.1007/s00704-014-1359-9>
- Costa, A. C., Durão, R., Soares, A., & Pereira, M. J. (2008). A geostatistical exploratory analysis of precipitation extremes in southern Portugal. *RevStat: Statistical Journal*, 6(1), 21–32. Retrieved from <https://www.ine.pt/revstat/pdf/rs080102.pdf>
- Griffiths, M. L., & Bradley, R. S. (2007). Variations of twentieth-century temperature and precipitation extreme indicators in the northeast United States. *Journal of Climate*, 20(21), 5401–5417. <http://doi.org/10.1175/2007JCLI1594.1>
- Ichiyanagi, K., Yamanaka, M. D., Muraji, Y., & Vaidya, B. K. (2007). Precipitation in Nepal between 1987 and 1996. *International Journal of Climatology*, 27(13), 1753–1762. <http://doi.org/10.1002/joc.1492>
- IPCC. (2014). Climate Change 2014 Synthesis Report Summary Chapter for Policymakers. *Ipcc*, 31. <http://doi.org/10.1017/CBO9781107415324>
- Lal, J., & Shrestha, N. (2012). Climates of Nepal and Their Implications ...
- Pereira, P., Oliva, M., & Baltreinaite, E. (2010). Modelling extreme precipitation in hazardous mountainous areas. Contribution to landscape planning and environmental management. *Journal of Environmental Engineering and Landscape Management*, 18(4), 329–342. <http://doi.org/10.3846/jeelm.2010.38>
- Pereira, P., Oliva, M., & Misiune, I. (2016). Spatial interpolation of precipitation indexes in Sierra Nevada (Spain): comparing the performance of some interpolation methods. *Theoretical and Applied Climatology*, 126(3–4), 683–698. <http://doi.org/10.1007/s00704-015-1606-8>



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Participation in the International Events by the Officials of Survey Department

- **Mr. Ganesh Prasad Bhatta**
Director General , Survey Department
7th Partners Meeting of Global Land Tool Network (GLTN),
24-26 April
Nairobi, Kenya
- **Mr. Ganesh Prasad Bhatta**
Director General , Survey Department
UN-GGIM International Workshop
on Legal and Policy Frameworks for
Geospatial Information Management;
Licensing of Geospatial Information,
7-9 November 2017
Tianjin, China
- **Mr. Ganesh Prasad Bhatta**
Director General , Survey Department
Seventh Session of the United Nations
Committee of Experts on Geospatial
Information Management(UNGGIM)
2-4, August 2017,
United Nations
New York,USA
- **Mr. Shankar Bahadur Thapa**
Joint Secretary, MoLRAM
Mr. Ganesh Prasad Bhatta
Director General, Survey Department
Mr. Tikaram Ghimire
Director General, Department of Land
Reform and Management
Study Visit to learn the practices of
Cadaster and land Registration of
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Switzerland and Netherlands
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Obituary



*All the officials of Survey Department pray to
the almighty for eternal peace to the
departed soul of the following
officials of the department and this
department will always remember the
contribution they have made during
their service period in this department.*

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Office Helper
Survey Office Dhanusa
2074/9/10

Cip Narayan Tharu

Surveyor
Survey Office Kapilbastu
2074/10/7

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Cadastre 2014: Performance of Nepal

Susheel Dangol & Ganesh Prasad Bhatta

KEYWORDS

FIG, Cadastre 2014, Nepal

ABSTRACT

International Federation of Surveyors (FIG) is the federation of different nation's member associations representing the interests of surveyors in the professional fields of global surveying, geomatics, geodesy and geo-information. Technical work of FIG is led by ten different commissions with individual themes. Among these commissions, 7th commission with the theme "Cadastre and Land Management" decided to make a vision for cadastre in 20th FIG congress in 1994 and in line with this decision, "Cadastre 2014 - A Vision for A Cadastral System in the Future" was published in 1998. This vision addresses about the future development of cadastre and consists of views for ensuring the cadastre to be globally integrative and shaping the future of surveying occupation. This paper discusses on the vision of Cadastre 2014, its implementation status in Nepal to evaluate Nepal's "Cadastre 2014" performance.

1. INTRODUCTION

The International Federation of Surveyors (FIG) is the international organization working for the advancement in the field of surveying and mapping representing the interests of surveyors all over the world. It is a federation of the national member associations from different countries with technical activities in the professional fields of surveying, mapping, geomatics, geodesy and geo-information. It also provides an international forum for discussion to promote different surveying and mapping related development from the world. Technical task of FIG is led by ten different commissions. Commission 1-Professional standards and practice, Commission 2-Professional education, Commission 3- Spatial information management,

Commission 4-Hydrography, Commission 5-Positioning and measurement, Commission 6- Engineering surveys, Commission 7-Cadastre and land management, Commission 8-Spatial planning and development, Commission 9-Valuation and the management of real estate and Commission 10-Construction economics and management. Among these ten different commissions, 7th commission: Cadastre and land management decided to develop a vision on future cadastre in 20th ordinary congress in 1994. Accordingly, the work group was formed to develop the vision according to this decision which published a report named "Cadastre 2014 - A Vision for A Cadastral System in the Future" in 1998 (Polat *et. al.*, 2015). This report has underlined the view on how cadastre will be develop and how it will look like in the following twenty years (Polat *et. al.*, 2015). The report

contained six statements which deals with the public rights and restrictions, integration of services, the digital format and data model, Public-Private Partnership in surveying and the economic sustainability (Stuedler, 2006).

2. THE VISION OF CADASTRE 2014

Main aim of Cadastre 2014 is to recognize all rights and restrictions on the land legally to ensure the legal security of rights (Kaufmann and Stuedler, 1998). Besides this, combination of cadastral maps and records, the modeling of cadastral system, the usage of informational technology in the cadastre, cooperation of public and private sector in the cadastral field and conducting the cadastral applications and survey as cost-recovery system were stated in the Cadastre 2014 (Kaufmann and Stuedler, 1998).

2.1. Vision I: "The Cadastre 2014 will show the complete legal situation of land including public rights and restriction".

The concept of this vision is that, by 2014 all the detail information regarding land should be visualized by the cadastre (Figure 1). The world population and the consumption of land is increasing and hence to ensure the security for having lands, all facts related to land should be clearly realized by the cadastral systems (Kaufmann and Stuedler, 1998). The cadastral system should provide the detail information about the legal situation of the land in order to provide the required land tenure security (Paudyal, 2007).

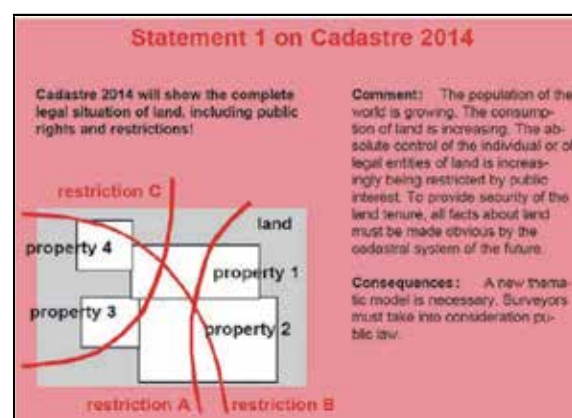


Figure 1: Vision 1 of Cadastre 2014. (Source: Stuedler, 1998)

2.2. Vision II: "The separation between maps and records would be abolished"

Many countries have a land registration system with both the land registries and cadastre components together in the same system. However, there are some countries still having land records and cadastral data separate like in Nepal. So, there exist two different organization involved in single land administration service as a result of this job distinction. The concept of this vision is that parcel based land administration system should be developed and there should not be disintegration of cadastral data and land records (Figure 2). Historically it was necessary because of the technologies adopted at that time where papers and pencils were used (Paudyal, 2007). But now, more advancement in the technology have come. Hence, entities of single service need not to disintegrated today. This also support in efficiency of land administration services in accordance with land governance.

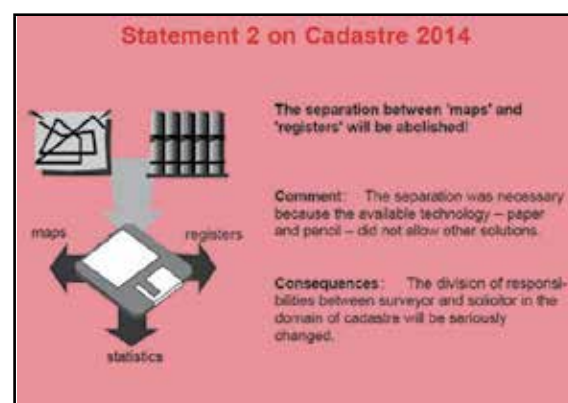


Figure 2: Vision 2 of Cadastre 2014. (Source: Stuedler, 1998)

2.3. Vision III: "The cadastral mapping will be dead! Long live modeling!"

Maps are the models that depicts the land surface. The adopted technology in the past doesn't support dynamism in mapping and hence maps with different scales need to be prepared according to the requirement. The concept of this vision is that, there must be flexibility in the scale during mapping and different scales has to be represented by different data model (Stuedler, 1998). Different scales must be shown by different data models (Figure 3). Advanced

modern technology can create maps of different scales and registers in different forms from the same data so that there would not be any draftsman and cartographers in the cadastral field (Kaufmann and Steudler, 1998).

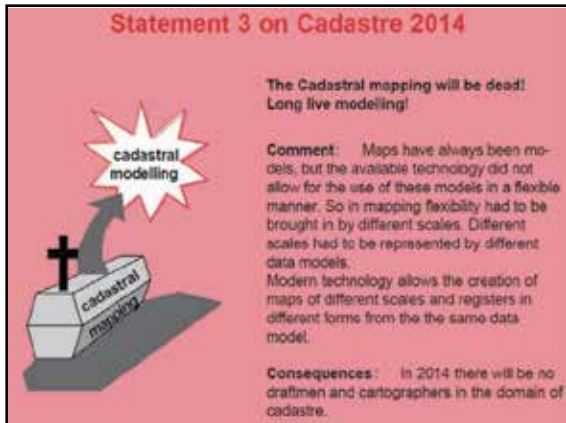


Figure 3: Vision 3 of Cadastre 2014. (Source: Steudler, 1998)

2.4. Vision IV: "Paper and pencil-cadastre will have gone".

In the past, paper and pencils were used to prepare the cadastral data. With due advancement in the technology, it has been replaced by computers and machines. Hence the concept of this vision is, all the cadastral activities will be conducted by computers and there will not be any paper and pencil used in cadastral field. All surveyors across the world should think in the manner of model and should obtain these models by using the modern technology (Figure 4) (Kaufmann and Steudler, 1998).

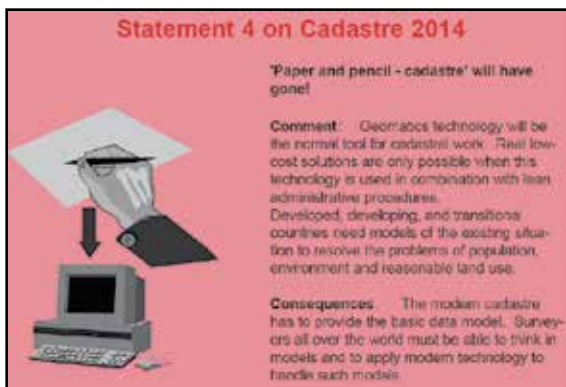


Figure 4: Vision 4 of Cadastre 2014. (Source: Steudler, 1998)

2.5. Vision V: "Cadastre 2014 will be highly privatized! Public and private sector are working together!"

Public sector and systems tend to be less flexible and customer oriented rather than private organizations and private sector can help public sector to improve the efficiency of service delivery (Paudyal, 2007). The concept of this vision is that, there must be Public Private Partnership (PPP) in cadastral system where private sector can conduct the task like preparation of deeds, warrants, registries and the public sector can focus on registration, supervision & monitoring of private sector, control and ensuring security (Figure 5).



Figure 5: Vision 5 of Cadastre 2014. (Source: Steudler, 1998)

2.6. Vision VI: "Cadastre 2014 will be cost-recovering".

There is a need of high investment in cadastral survey and record management (Polat, et al., 2015). There is a huge difference between the total sum of the cost for land tax and land administration service and the cost of cadastral data acquisition. The concept of this vision is that, at least a part of costs necessary for the cadastral data acquisition and processes must be taken back from the customers (Figure 6).

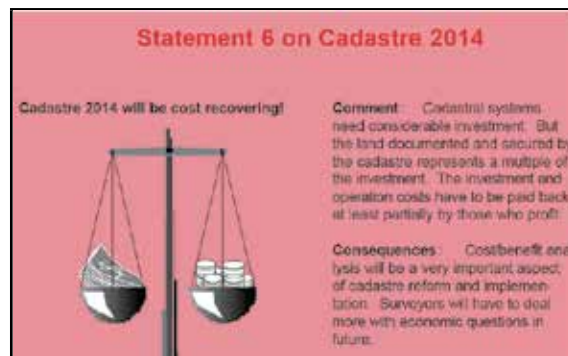


Figure 6: Vision 6 of Cadastre 2014. (Source: Steudler, 1998)

3. PERFORMANCE OF NEPAL ON CADASTRE 2014

Performance measurement is generally a measurement of outcomes and results, which generates reliable data on the effectiveness and efficiency of programs on the basis of set indicators. It can involve studying processes or strategies to see whether output are in line with what was intended or should have been achieved. Several performance measurement systems are in use like, the Balanced Scorecard, performance Prism, action-profit linkage (APL), Cambridge Performance Measurement Process, Total Performance Measurement (TPM) Process, 7-step TPM Process Total Measurement Development Method (TMDM). However, in this study, authors' own experience have been used to list out the performance of Nepal. The performance of Nepal in land administration system and services have been identified and discussed on the base of six vision statements of Cadastre 2014.

In Nepal, under the Ministry of Agricultural, Land Management and Cooperative, there is Survey Department (SD), Department of Land Reform and Management (DoLRM) and Department of Land Information and Archives (DOLIA) working for land administration system and services. SD has District Survey Office (SO) for conducting cadastral survey and parcel data updating. DoLRM has District Land Revenue Office (DLRO) working for land transactions and records management. DOLIA is responsible in developing digital environment for all land

administration services.

3.1 Performance on vision one statement

The first statement is to legally recognize all restrictions and rights on the land and to ensure the legal security of these rights and restrictions. In Nepal, complete documentation of the legal situation of land has been addressed. The surveyor verifies and validates the information about the land object during adjudication and conducting first registration. The land parcels are delineated and all rights and restrictions are recorded and registered to provide the tenure security. The first registration is conducted by district survey office. Approximately 95% of the cadastral survey has been completed where legal rights and restrictions has also been recorded. Remaining 5% includes village blocks. These blocks are also identified and surveyed already but delineation of individual parcel is not conducted because of the small parcels in the blocks that could not be shown in the cadastral survey and map due to technology adopted for surveying and time limits. As new technology is adopted later for cadastral survey now, parcel delineation within this village blocks are under process. After the first registration, the collected land records are transferred to DLRO and cadastral maps are kept in SO itself. Hence, all the land transaction are conducted through DLRO and parcel sub-division if necessary is conducted by SO. During land transaction, in the registration deed, all the information are kept. If any parcel is left for registration during first registration, then there is legal provision to request to DLRO for registration with due submission of formal request letter along with available proofs legally.

3.2 Performance on vision two statement

The second statement is to abolish the separation of maps and registers. In Nepal, this vision has not been achieved. Initially during first registration, both collection of land records and cadastral survey are conducted by SO. But afterwards, land registers are handed over to DLRO and cadastral plans are kept with SO itself. During land transaction, deed registration

is conducted by DLRO and parcel sub-division if necessary are done at SO. Both the offices performs the task on their own separate system and separated business workflow. However, digital cadastral survey, which is being conducted as pilot survey if some municipality of the country is tasking in line with this vision. The system used is the "Parcel Editor" with the provision to record spatial as well as attribute data in same system and database. The system is also capable of generating all legal reports and notice required during registration. But since, legally land register are handled by DLRO, after this survey also land registers are handed over to the DLRO where they use their own separate system (Land Records Information Management System, LRIMS where adopted) which does not support this database and system. Hence, the cadastral data and land registry are separated again technically as well. Besides, Parcel Editor, MoLRM also developed open source based system for land administrations services called "Solution for Open Land Administration" (SOLA). This system is not developed for first registration process as of Parcel Editor but to handle pre-collected data. The system merge land registry from DLRO and parcel data from SO. But due to immaturity in the system and existence of separate organization for land registry and cadastral data, the system could not be continued. Thus it can be said that very few percentage (<5%) of this vision has been covered.

3.3 Performance on vision three statement

The third vision is cadastral modeling than cadastral mapping. All the cadastral survey was completed producing paper maps using plane table survey in Nepal. But now, many of the SO have started conducting digital cadastre adopting Parcel Editor. Since the records are collected digitally, cadastral maps of any scale can be produced according to requirement. Like for urban area, larger scale (1:500) maps can be produced and for rural area reduced scale (1:1250) cadastral maps can be produced as per the requirement. Besides this system, SO are also using Spatial Application Extension (SAEx) system which is used to digitize the

paper maps that were prepared by plane table survey and conduct parcel subdivision during land transaction. Since the paper maps has been digitized it can be modeled for any scale. Almost all the paper maps of 76 districts among 77 districts have been digitized. However, in most of the SOs, parcel sub-division is not being conducted in digital data but only in paper maps which has created the outdated digital cadastral database.

3.4 Performance on vision forth statement

The fourth vision is paper and pencil free cadastre. In Nepal, this vision has not been achieved to full extent. In spite of the availability of the digital cadastral data, since we are not in position of conducting digital transaction fully in all the survey office, we are still using paper maps and pens to update cadastral maps. Parcel Editor is using digital data to produce cadastral maps and record land registries. But the system does not support parcel sub-division. SAEx can conduct parcel sub-division but does not support first registration and record land registry. There is also no connection between systems of DLRO and SO. DLRO also produce paper print of Land Ownership Certificate (LOC).

3.5 Performance on vision fifth statement

The fifth vision is use of private sector in cadastral survey. In Nepal, no private surveyors are involved in cadastral data acquisition. All the process are conducted by government surveyors from SOs. However, if anyone wants to know the status of their land like area then they can request for any private surveyor. But that is only for their personal information and affirmation of their land. This cannot be used for legal purpose. During land transaction, there are legal writers who helps in preparing deeds. This is more or less like private conveyancing. But help and use of legal writer is not compulsory. If any individual is capable of preparing the deeds then they can do it themselves without help of legal writers. Besides, private sectors are fully involved in system development of land information system.

3.6 Performance on vision sixth statement

The sixth vision is cost recovery cadastral survey. But in case of Nepal, the cadastral survey is not cost recovery. There is huge investment of money for cadastral data acquisition. All the budget is from Government of Nepal. The only get back of this investment are the land tax and revenue during land transaction which are very nominal in comparison to total investment of cadastral data acquisition. Hence, cadastral survey in Nepal is not cost recovery.

7. CONCLUSION

Almost all the information regarding rights and restrictions on the land has been recorded in Nepal. Remaining few percentage are to be conducted with priority to complete 100% of recording. Regarding the vision two: abolish of separation between map and registers, it is only possible if the two cadastral and land registry organization are merged institutionally or not, both organization use single system technically. Regarding the vision three and four, digital parcel sub-division should be made compulsory in order to keep the digital data up to date. For this necessary physical infrastructure, training and technical support need to be provided to the Survey Offices. Also, at least there must be single system for first registration and cadastral data updating. Support from private sector may be helpful in conducting land administration services. Private sectors can be used for cadastral

survey and public sector can inspect and monitor their task, conduct adjudication, land registration and LOC distribution. Regarding vision six, the service cost and tax may be revised in order to increase the cost recovery which still may not be 100% recovery. To sum up with the study, it seems that the vision of Cadastre 2014 is more relevant and achievable to the developed country rather than developing country. There still exist big room for development in cadastral sector to increase the efficiency in land administration services.

REFERENCES

- Kaufmann, J. and Steudler, D., (1998). *Cadastre 2014 – A Vision for a Future Cadastral System*, FIG Publication, 44 s.
- Paudyal, D. R., (2014). *Assessment of Digital Cadastre in Nepal from the Cadastre 2014 Vision*. Strategies Integration of Surveying Services, FIG Working Week 2007, Hong Kong SAR China, 13-17 May 2007.
- Polat, Z. A., Ustuner, M. and Alkan, M., (2015). *On the way to vision of cadastre 2034: Cadastre 2014 performance of Turkey*. FIG working week 2015: From the wisdom of the ages to the challenges of the modern world, Sofia, Bulgaria, 17-21 May 2015.
- Steudler, D., (1998). *Cadastre 2014 and Beyond*. FIG Publication, 61.
- Steudler, D., (2006). *Cadastre 2014 – Still a Vision? XXIII FIG Congress Munich, Germany, October 8-13, 2006*



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GNSS PRACTICE IN SURVEY DEPARTMENT

Sushmita Timilisina & Bibek Nepal

KEYWORDS

GNSS, Reference System, PNT, CORS, Transformation Parameters

ABSTRACT

Control Networks for Nepal was originally defined through the use of conventional measurements. Conventional mapping methods have led to a static and inactive networks of control point. This network of control served us very well until the devastating earthquake hit Nepal and disturbed it. Determination of precise ground locations is essential for various tasks such as engineering works, earth observation, location-based technologies, emergency service providers, etc. Global Navigation Satellite System plays a very important role in providing quick and reliable positioning/navigation data. The term 'global navigation satellite system' (GNSS) refers to a constellation of satellites providing signals from space transmitting positioning and timing data. These systems use the principle of trilateration to calculate the location of a user, through the information obtained from a number of satellites. Each satellite transmits coded signals at precise intervals. In principle, three satellites must be available to determine a three-dimensional (x,y,z) position, additional fourth signal is necessary for precise location of a single point. This helps in eliminating the time differences between satellite's atomic clocks and the receiver's clocks. USA in around 1970's started the use of Global Positioning System(GPS). Geodetic Survey Division under Survey Department commenced the use of GPS technology in 1991 A.D as a method for survey technology. Survey Department initiated the use of GPS for carrying out survey of the previously established high order control points. Transformation Parameters (TP) between the National Co-ordinate System and WGS-84 System was derived using the initial Control points co-ordinate and co-ordinate of the same Control points obtained from GNSS survey. GNSS has been used for establishing, updating and rehabilitation of Control Network, measure shift in location produced by earthquake and for various survey task carried out by Survey Department.

1. BACKGROUND

The history of Surveying and mapping in case of Nepal dates back from the period Malla dynasty. Practice of keeping records about land and its type started long ago for collecting taxes. Over the time value of land has increased exponentially and so has emerged the need of accurately mapping boundaries between the land pieces. Mechanism for land measurements started from eye judgments and hand measurements progressed to tape, chains and advanced to Theodolites, EDM's, Total Stations & GNSS. The purpose for measurement of land has shifted from fiscal purpose to legal purpose. In order to provide legal boundaries, the measurement regarding the land must be accurate. This was possible from linking the measurements with the accurate control point network. These control points form a common framework for all mapping activities and act as backbone for all surveying and mapping purposes.

Measuring, recording and registering land is a delicate and critical job and is deeply connected to the public sentiments. This huge responsibility of functioning as the national mapping agency demonstrates the importance of Survey Department in good governance in the nation. Hence, this organization has maintained a very intimate relation with general public for a long period till date.

In 2026 B.S Trigonometrical Survey Branch was established under Survey Department for establishing Control Points Network all over Nepal. Precise horizontal and vertical controls are the prerequisite in carrying out any mapping activity, hence establishment of Trigonometrical control points of different order with no vertical data deemed insufficient to fulfill the geodetic requirements. Hence, Geodetic Survey Branch was established under Survey Department in the year 2032 B.S to work on various geodetic activities like setting up Precise Leveling Network, carrying out Astronomical and Gravity Observations, defining of geoid, etc.

Control Network for Nepal was originally defined through the use of conventional measurements. Conventional mapping methods have led to

static and inactive networks of control point. This network of control served us very well until the devastating earthquake hit Nepal and disturbed it. The extent of disturbance is still to be calculated. Since all measurements on land, air or water are based on national Control Network has become essential to catch up with the rapid advancement in Survey technology and use it to update the national reference system for the country.

There is a need to determine precise ground locations for use in various tasks such as engineering works, earth observation, location-based technologies, emergency service providers, etc. Location information is vital to a large number of applications involving strategic decision making such as disaster management, earth monitoring, environment conservation, management of natural resources and food production. The global navigation satellite systems (GNSS) service is achieved by using a global network of satellites that are deployed on the space and transmits radio signals from thousands of miles above the earth. Accurate position of any point in the form of precise latitude, longitude and altitude can be achieved at any time and at anywhere around the world.

2. INTRODUCTION

In recent years Positioning and Navigation has become an integral part of every engineering and non-engineering field. When it comes to proper positioning/navigation satellite navigation technology plays a very important role in providing quick and reliable data. Satellite-based navigation systems use the principle of trilateration to locate the location of a user, through the information obtained from satellites. Each satellite transmits coded signals at precise intervals. In principle, three satellites must be available to determine a three-dimensional (x,y,z) position. Positioning accuracy is improved with fourth satellite providing data to help eliminate the time differences between satellite's atomic clocks and the receivers' clocks.

The term 'global navigation satellite system' (GNSS) refers to a constellation of satellites providing signals from space transmitting

positioning and timing data. By definition, a GNSS provides global coverage. GNSS receivers determine location by using the timing and positioning data encoded in the signals from space. GNSS basically is a system of satellites that provide autonomous geo-spatial positioning with global coverage. It allows electronic receivers to determine their location (longitude, latitude, and altitude) using signals transmitted by radio waves from satellites. There is a common misconception about GPS and GNSS being same. In fact, GPS is a kind of GNSS. There are several other such GNSS today. Advances in satellite technologies have yielded several navigation systems such as

- NAVSTAR GPS (Navigation System with Time and Ranging–Global Positioning System) developed by USA
- GLONASS developed by Russia
- BeiDou (BDS) developed by China
- Galileo developed by European Union
- Indian Regional Navigation. Satellite System (IRNSS) developed by India
- Quasi-Zenith Satellite System (QZSS) developed by Japan

Generally, the global coverage for each system is achieved by the constellation of 20-30 Medium Earth Orbit Satellites with the orbit inclinations of $>50^\circ$, satellite being at an altitude of about 19000- 20,000 kilometers orbital period of about 12 hours. In case of systems with regional coverage such as in QZSS and IRNSS the satellites are placed in geostationary orbit.

Development of hand-held receivers along with advancement in GNSS integrated system in mobile/smartphones/tablets have led to an enormous growth in application such as vehicular navigation systems, emergency and location-based services, etc. These multiple applications have increased the need for improved accuracy, availability, continuity and integrity in the systems. Differential GNSS (DGNS) is one possible solution for engineering grade user requirements. Correction data emitted from

a known/reference station are obtained in the receiver. It is possible to achieve sub-centimeter level accuracy with high-precision receivers working with carrier phase tracking techniques. Thus, GNSS technology has become principal method for carrying out survey works.

3. GNSS PRACTICE IN NEPAL

USA in around 1970's. started the use of Global Positioning System(GPS) for military purpose. Geodetic Survey Division under Survey Department commenced the use of GPS technology in 1991 A.D for carrying out land survey. Survey Department initiated the use of GPS for survey of previously established high order control points. As the Reference System of the Control points established by Survey Department (in Everest 1830) does not match with the co-ordinate reference system (WGS-84) of the data obtained from GPS hence Transformation Parameters (TP) between the two-system needed to be established. This TP was computed using the initial Control points co-ordinate and co-ordinate of the same Control points obtained from GNSS survey.

4. GNSS PROGRAMS IN SURVEY DEPARTMENT

- Establishment of different (first/second/third) order of controls for strengthening the geodetic network throughout the country is done on regular basis.
- Observation of previously established static control points (of different order) through the use of GNSS is done regularly as yearly development program of the department.
- During this process the description card of the control points are also revised to provide updated access route to the points.
- Survey Department is also responsible for establishing precise control points for different surveying and mapping activities as per demand. The Geodetic Survey Division has established Control Points using GNSS for cadastral survey

in different districts as per the demand of district Survey Offices. Also, it has established control points as per the demand of several other Governmental and Non-Governmental organization.

- The devastating earthquake of 2072 caused a lot of damage to the overall Control Network of the nation. It substantiated the need in modification of the current reference System in the country. GNSS observation data collected over the period by Survey Department are currently being used to develop semi dynamic datum for the country.
- Remote Sensing Branch under Topographical Survey Division uses GNSS for setting up Ground Control Points for image rectification.
- High Precision GNSS instruments are being used in Continuously Observing Reference Station(CORS) setup with the view of periodic update of Control Network and providing continued observation for monitoring changes (deformation, seismic, etc.,). Survey Department has established first of its CORS in Nagarkot observatory.
- GNSS technique will also be adopted in height determination process of the Mt. Everest.

Data collected in the field are processed in the office using suitable parameters for adjustment of network of control points through suitable processing software. Thus, processed data are then archived in the Geodetic Database Management System (GDBMS) which was developed for storing, managing and updating geodetic data of whole country. The information regarding control points established by this department has been made available to other organizations, researchers and to the general public at minimum cost. Yearly hundreds of organizations, researchers visit Survey department for data about control point in order to use them in construction, surveys, verification

of surveying tasks etc.

5. GNSS PROCEDURE

GNSS surveying involves collection of data (precise code and carrier phase measurements) at two or more station using GNSS equipment. Since the real-time GNSS techniques are generally considered suitable for general purpose. Static GNSS survey is carried out for establishing the control point station.

The location and distribution of survey control point station in case of GNSS survey do not depend on factors such as network shape or inter-visibility, but rather depend on sufficient redundancy to achieve the intent of the survey and any required specifications. Site selection and planning of observation sessions should aim to minimize the influence of internal and external effects.

Redundancy in the observations, absence of signal obstructions and longer observation times are well-accepted methods for minimizing the errors due to these effects. The final estimation of survey mark positions is also influenced by effect external to the GNSS measurements themselves, and surveyors should incorporate procedures for minimizing blunders by checking mark identifiers, the centering and orientation of the antenna and the measurement of antenna heights.

5.1 Preliminaries of GNSS Survey

The most important factor for determining GNSS station location is the requirement of project. After considering the requirements of the project the consideration must be given to the following limitations

- Station should be situated in location which are relatively free from horizon obstructions.
- A clear view of sky is required.
- Satellite do not penetrate metal, buildings or tree and are susceptible to signal delay errors when passing through leaves, glass, plastics and other

materials

- Locations near strong radio transmission should be avoided because radio frequency transmitters, including cellular phone equipment, may disturb satellite signal reception.
- Avoid locating stations near large flat surfaces such as buildings, large signs, fences etc. as satellite signals may be reflected off these surfaces causing multipath errors.

Following are the basic field procedure followed to minimize external error factors that affect GNSS measurements

- Place station as far as possible from communication towers including mobile phone towers as they can cause interference.
- Satellite elevation mask set to 10° above horizontal for field sessions
- 10 second observation rate shall be used on observation sessions.
- Every observation must have GDOP ≤ 3 (at least 75% of observation period).
- Ensure correct setting is available on all controllers.
- No observation shall be carried out during electrical storms (thundering/lightening).
- Antenna are to be orientated to within 5° of true north.

5.2 GNSS survey guidelines

The specification for GNSS field survey describe the methods and procedures that are necessary to obtain a desired accuracy to maintain the standard.

5.2.1 GNSS survey Instruments

GNSS survey Instruments	Specification
Technique	Static GNSS Observation

Receiver	Capable of receiving dual frequency code and carrier phase tracking
Antenna	Choke ring antenna/Geodetic Antenna
Tripod and other instruments	High quality stable tripod, tribrach Optical plummet to ensure accurate centering over marks

Following are the basic guidelines for observation to establish Control Stations in connection with pre-existing control Points.

- Baseline of 30-65 km shall be maintained
- Minimum observation session for shall be for 6 hours in at least two sessions.
- Occupations of the same station shall be separated by a minimum of 30 minutes between the end of one session and the start of the subsequent session (unless restarting due to an unplanned event like battery failure, tripod slip etc.)
- At least 3 (two pre-existing Control Points and one Network Control) stations shall be observed simultaneously
- The tripod must be reset with the instrument height varied by a minimum of 0.05 m between two occupations/session.
- Instrument height measurements are to be independently verified at start and end of occupation/sessions.
- Photos shall be taken of all session setups.

Static GNSS survey procedures allow various systematic errors to be resolved when high accuracy positioning is required. Static procedures are used to produce baselines between stationary stations by recording data over an extended period of time during which the satellite geometry changes.

6. PROBLEMS IN GNSS PRACTICE IN NEPAL

Nepal has a rich geographical diversity with landscape ranging from flat lowlands of Terai

through hills to high altitude Himalayas. This difference in landscape implies variation in ground density which indicates significant change in geoid. GNSS based surveys can vary in quality, depending on the type of GNSS receiver, antenna, equipment and observation parameters chosen. These factors are directly or indirectly affected by the geographical structure.

Generally, the higher order control points of Nepal are situated hilltop which on one hand make it safe from daily disturbances but on other make it difficult to reach with the heavy instrument. Most of these control points established are being encroached either by building communication tower or view tower. While establishing controls elsewhere, there lies the chance of getting limited number of satellite coverage and multipath error due to obstruction from hills.

7. RECOMMENDATIONS

The availability of high quality Positioning, Navigation and Timing (PNT) resources is becoming a matter of national security serving for effective operation of the emergency services. The provision of widely available GNSS services is an essential part of every national infrastructure. Thus, it should be cost effective to incorporate in civil GNSS receivers and free to use.

The availability of accurate and reliable information relating to the position is very critical. GNSS surveying involves the collection of precise code and carrier phase measurements recorded simultaneously at two or more survey control point station using high precision GNSS equipment. To apply proper adjustments and produce accurate output there is a need of state-of-art processing software and skilled manpower to process the data collected from field. Along with this Survey Department needs to workout proper course of action to save disturbed Control points situated atop of hills.

8. CONCLUSION

Besides high precision GNSS instruments/ equipment's used for engineering grade applications, integration of GNSS in smartphones, tablets etc. has made positioning and mapping task very easy and GNSS have become an integral part of our life. Nations worldwide are exploring potential growth areas for their national economy through the varied applications of satellite positioning, navigation and timing. With GNSS being more widely used for various purpose such as revenue generation or protection, there lies the possibility of growth in criminal activity aimed at disrupting the system. As for a country like Nepal without independent positioning system the policy makes should review the dependency on GNSS and prepare a strategy for developing country's independent GNSS system.



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CALENDAR OF INTERNATIONAL EVENTS

9th International Conference on Recent Advances in Space Technologies

Date: June 2019

Country: Istanbul, Turkiye

Website: www.rast.org.tr

9th International UBI Summer School 2018

Date: 4-9 June 2018

Country: University of Oulu, Finland

Website: <http://ubicomp.oulu.fi/UBISS>

Workshop on Earth Observation with Chinese Satellite Systems

Date: 11-12 Jun 2018

Country: Vienna, Austria

Website: <http://china-sat-workshop.univie.ac.at>

2018 GeoInformatics Summer School

Date: 1-8 July, 2018

Country: Wuhan, China

Website: <http://www.lmars.whu.edu.cn/geosummerschool>

10th IAPR Workshop on Pattern Recognition in Remote Sensing (PRRS 2018)

Date: 19-20 August 2018,

Country: Beijing, China

Website: <http://www.prrs2018.org>

15th International Circumpolar Remote Sensing Symposium

Date: 10-14 Sep 2018

Country: Potsdam, Germany

Website: <https://alaska.usgs.gov/science/geography/CRSS2018>

EURASIAN GIS CONGRESS 2018

Date: 4-7 September 2018

Country: Baku, Azerbaijan

Website: <http://eurasiangis2018.selcuk.edu.tr/>

1st EARSeL Workshop UAS “UAS for mapping and monitoring”

Date: 05-07 September 2018

Country: Warsaw, Poland

Website: <http://uas.earsel.org/workshop/1st-uas-ws/>

Organiser: University of Warsaw

Co-organiser : Warsaw University of Technology

6th International FIG Workshop on 3D Cadastres

Date: 2-4 October 2018

Country: Delft, Netherlands

Website: <http://www.gdmc.nl/3DCadastres/workshop2018/>

5th International Conference on Geoinformation Science: GeoAdvances 2018

Date: 10-11 October, 2018

Country: Casablanca, Morocco

Website: <http://rhinane.sirecom-maroc.com/>

39th Asian Conference on Remote Sensing

Remote Sensing Enabling Prosperity

Date: 15-19 Oct 2018

Country: Kuala Lumpur, Malaysia

Website: <https://acrs2018.mrsa.gov.my>

Price of some of the publications of Survey Department

- List of Geographical Names, Volume I to V – NRs 600/- per volume.
- The Population and Socio - Economic Atlas of Nepal (HardCopy) NRs.2,500.00 (In Nepal), €200.00 (Outside Nepal)
- The Population and Socio - Economic Atlas of Nepal (CDVersion) NRs.250/-

ARTICLES IN PREVIOUS ISSUES

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1. Concepts towards cm-geoid for Nepal GPS to replace conventional leveling using airborne gravity

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By Rabin K. Sharma

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By Shijan Kumar Dhakal

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1. Applications of open source software in land administration: An initiation with land administration education

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Mr. Nawal Kishor Raya

Mr. Santosh Kumar Jha

Mr. Khim Lal Gautam

Background

Utilizing the opportunity opened for establishing social and professional organizations in the country with the restoration of democracy in Nepal as a result of peoples movement in 1990, Survey professionals working in different sectors decided to launch a common platform named Nepal Surveyors' Association (NESA) in 1991, as the first government registered Surveyors' Organization in Nepal.

Objectives

The foremost objective of the association is to institutionalize itself as a full fledged operational common platform of the survey professionals in Nepal and the rest go as follows

- To make the people and the government aware of handling the survey profession with better care and to protect adverse effects from its mishandling.
- To upgrade the quality of service to the people suggesting the government line agencies to use modern technical tools developed in the field of surveying.
- To upgrade the quality of survey professionals by informing and providing them the opportunity of participation in different trainings, seminars, workshops and interaction with experts in the field of surveying and mapping within and outside the country
- To upgrade the quality of life of survey professionals seeking proper job opportunities and the job security in governmental and nongovernmental organizations
- To work for protecting the professional rights of surveyors in order to give and get equal opportunity to all professionals without discrimination so that one could promote his/her knowledge skill and quality of services.
- To advocate for the betterment of the quality of education and trainings in the field of surveying and mapping via seminars, interactions, workshops etc
- To wipe out the misconceptions and illimage of survey profession and to uplift the professional prestige in society by conducting awareness programs among the professionals and stakeholders
- To persuade the professional practitioners to obey professional ethics and code of conduct and to maintain high moral and integrity
- To advocate for the satification of Survey Council Act and Integrated Land Act for the better regulation of the profession and surveying and mapping activities in the country.

Organizational Structure

The Organization is nationwide expanded and it has the following structure: 14 Zonal Assemblies (ZA), 14 Zonal Executive Committees (ZEC), 5 Regional Assemblies (RA), 5 Regional Executive Committees (RAC), Central General Assembly (CGA) and a Central Executive committee (CEC).

Membership Criteria

Any survey professional obeying professional ethics and code of conduct, with at least one year survey training can be the member of the Association. There are three types of members namely Life Member, General Member and Honorary Member. At present there are 2031 members in total.

Activities

- Nepal Surveyor's Association (NESA) organizes Free Health Camp on 8th Baisakh 2075 at Survey Department, Minbhawan, Kathmandu .



Nepal Remote Sensing and Photogrammetric Society (NRSPS)

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26th Anniversary Celebration of NRSPS

On April 11, 2017, NRSPS observed its 26th Anniversary with varieties of programme. Accordingly, **Mr. Buddhi Narayan Shrestha**, Former President of NRSPS released **Earth Observation: Volume IX**; Annual Newsletter of NRSPS in which four articles: **25 Years of Achievements of NRSPS** by **Rabin K. Sharma**, **A Brief Report on the Visit of ISPRS President in Nepal** by **Durgendra Man Kayastha**, **Activities of ISPRS WG V/7: Innovative Technologies in Training Civil Engineers and Architects** by **Laxmi Thapa** and **NRSPS Training Workshop on Image Analysis and Land Cover Classification using Free Images and Open Source RS/GIS Tools** by **Anish Joshi** were included. A special message from President of Nepal Institution of Chartered Surveyors **Mr. Punya Prasad Oli** was also included.

President of NRSPS Participated the Diamond Jubilee celebration of Survey Department

Survey Department observed its Diamond Jubilee Celebration on May 28, 2017 in which one of the programmes was to felicitate the former Director Generals of the department. Accordingly, **Mr. Rabin K. Sharma**, President, NRSPS is also one of the former Director Generals so he was felicitated with a **Silk Shawl** and also received a **Certificate of Appreciation** for his contributions made during his tenure.

“ ENCOURAGE APPLICATION OF REMOTE SENSING TECHNOLOGY”

President of NRSPS attended the Programme of Kraveli Surveyor's Society, Nepal

On 26th October 2017, **Kavreli Surveyor's Society (KSS)** organized its Annual General Assembly in which **Mr. Ganesh Prasad Bhatta**, Director General, Survey Department was the **Chief Guest**. The society invited President of NRSPS, **Mr. Rabin K. Sharma** as a **special guest of honour**. He received a token of love from the President of the Society, **Mr. Sanjaya Manandhar** and he also addressed the gathering of the assembly. The other **special guest of honour** was **Mr. Buddhi Narayan Shrestha**, Former Director General of Survey Department.



Photo: Mr. Sanjaya Manandhar, President, KSS handing over a memento to Mr. Rabin K. Sharma, President, NRSPS

President attended the Programme of NICS

On January 3, 2018, **Nepal Institution of Chartered Surveyors (NICS)** organized its Annual General Assembly in which the **Chief Guest** was **Mr. Shambhu Koirala**, Secretary, Ministry of Land Reform and Management. **Mr. Rabin K. Sharma**, President, NRSPS was invited to represent the Society and also gave him an opportunity to speak a few words in the event.



Photo From Left: Mr. Neeraj Manandhar, Mr. Punya Prasad Oli, Mr. Nagendra Jha, Mr. Shambhu Koirala, Mr. Buddhi Narayan Shrestha, Mr. Rabin K. Sharma.

Call for papers

The Editorial Board requests for Papers/articles related with Geoinformatics for the publication in the Eighteenth issue of the Nepalese Journal on Geoinformatics.

For more information, please contact

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Instruction And Guidelines For Authors Regarding Manuscript Preparation

- Editorial Board reserves the right to accept, reject or edit the article in order to conform to the journal format.
- The contents and ideas of the article are solely of authors.
- The article must be submitted in soft copy form on CD in microsoft Word or compatible format or by email.
- Editorial Board has no obligation to print chart/ figure/table in multi colour, in JPEG/TIFF format, the figure/picture should be scanned in a high resolution.
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Margin: upper 1", left 0.9", right 0.9", bottom 0.9".

Length of manuscript: The article should be limited upto 6 pages.

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Title: The title should be centrally justified appearing near top of 1st page in cambria, "20" point (Bold).

Authors Name: Authors name should be in Calibri "10" with Upper and lower casing, centrally justified. There should be a gap of two lines between the title and author's name.

Author's Information: The author should provide Name, Academic Qualification, Organization, Current Designation, Work Experience (in years), Published Papers/Article (Number), e-mail ID and scanned copy of author's passport size photo.

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Director General, Mr. Ganesh Prasad Bhatta participating in UN-GGIM International Workshop on Legal and Policy Frameworks for Geospatial Information Management; Licensing of Geospatial Information, 7-9 November 2017, Tianjin, China

Survey Officers Er. Anu Shrestha and Er. Tina Baidar participating in Airborne LIDAR survey organized jointly by Department of Mines and Geology, Nepal and Earth Observatory of Singapore along the Central and Western Nepal Main Frontal Thrust from February 28 - March 30, 2018



The Nepal-India Joint Field Teams conducting joint field works in Nepal-India border area. Among different tasks performed by Field Teams we can see the same boundary pillar before and after repair works.

Chief Survey Officers of Survey Department Mr. Sanjaya Chhatkuli, Mr. Bijaya Mahato and Mr. Magnu Dutt participating in Capacity Building for National Mapping and Geographic Information Institute, Sep 5, 2017, Seoul, Korea.



Making Sense of Geo-spatial data for total solution in National and Local Development Activities

Available Maps and Data

- ❖ Geodetic Control data
- ❖ Aerial Photographs
- ❖ Topographic Base Maps
 - ❖ Terai and middle mountain at the scale of 1:25,000
 - ❖ High hills and Himalayas at the scale of 1:50,000
- ❖ Land Resources Maps
- ❖ Administrative and Physiographic Maps of Nepal
- ❖ Maps of
 - ❖ Village Development Committees/Municipalities/Rural Municipalities
 - ❖ District, Zone and Development Region
- ❖ Digital Topographic Data at scales 1:25,000 & 1:50,000
- ❖ Topographic Digital Data at scales 1:100,000 1:250,000 1:500,000 1:1,000,000
- ❖ Cadastral Plans
- ❖ Orthophoto Maps
- ❖ Orthophoto Digital Data
- ❖ SOTER Data
- ❖ CORS Data

Available Services

- ❖ Establishment of control points for various purposes of Surveying and Mapping
- ❖ Cadastral Surveying
- ❖ Surveying and mapping for development activities
- ❖ Topographic and large scale mapping
- ❖ GIS related services
- ❖ Other services in the field of Surveying and Mapping

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