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Joint Secretary Mr. Kapil Dangol, Director General Mr. Nagendra Jha & Chief Survey Officer Mr. Ganesh Prasad Bhatta visited Japan Aerospace Exploration Agency (JAXA) on 14th June 2013.

Scene of the orientation program on "Technical aspects of Border Management & the role of local administration" in Nepalgung on 7th March 2013.

Participants of the Second Workshop on the use of Multi-GNSS for sustainable Development, Bangkok, Thailand on 5-7 March 2013. Mr. Jagat Raj Poudel, Head Geodetic Survey Branch & Mr. Niraj Manandhar Chief Survey Officer, participated from Survey Department.

Mr. Madhu Sudan Adhikary, Deputy Director General Topographical Survey Branch, Survey Department addressing the orientation program on "Technical aspects of Boarder Management & the role of local administration" at Birganj on 23rd January 2013.

Participants of Workshop on the use of Multi-Global Navigation Satellite System organized by Survey Department on 4th January 2013, Kathmandu, Nepal.

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Features

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Editorial

The publication of journal was started in 2002 A.D. viewing this as one of the appropriate media to disseminate information on the new development in the field of geo-informatics that was rapidly gaining momentum in our country. After a dozen journal published we can say that this publication has been able to achieve in what we aspired. So, this is a proud moment for me and the Survey Department to present the 12th issue of "Nepalese Journal on Geo-informatics", the annual publication of Survey Department. The journal aims to include research and informative articles in the sector of geo-informatics and regular features concerning annual activities of Survey Department. We are continuously making our efforts to improve the quality of the articles to be published since last 11 years of its publication. For the convenience of the readers we have made all the past issues of the journal available online at www.dos.gov.np. From 11th issue, we have also been successful to find a place in Nepali Journal Online (NEPJOL: www.nepjol.info) with the cooperation of Central Library Tribhuwan University.

At last, I would like to express sincere appreciation to Mr. Nagendra Jha, the Director General and the Chairperson of the Advisory Council for his invaluable guidance and kind forewords. Likewise, I would like to express my sincere thanks to all the authors, members of the Advisory Council, members of the Editorial Board and to all who have contributed for the publication of the journal. I do hope to receive similar cooperation in the future too.

June 2013 — Jagat Raj Paudel

Kathmandu — Editor-in-chief

Forewords

It is indeed a matter of immense pleasure for me to reveal the 12th issue of 'Nepalese Journal on Geoinformatics', the annual publication of Survey Department. This is happening on the auspicious occasion of the 56th Year of the establishment of the Department.

In capacity of the National Mapping Organization of the country, the Department has been constantly putting its best effort in the mission of nation building and we believe, the Department has offered significant contribution in the past 56 years of its services. Establishment of the Department was aimed to conduct cadastral surveys but it has widened its scope over the time and wide varieties of geo-information products, apart from cadastral surveys, are being produced in recent years. The journey that began with traditional technology is in the stage of modernization. Furthermore, the Department is also playing the leading role of developing and widening the Surveying and Mapping profession in the country. In the present era of SMART Geospatial technologies and emerging concept of spatially enabled societies, the Department has a greater role to play ahead.

Despite the significant contribution in the nation building and professional development, and important responsibilities ahead, in recent decades, the Department's activities are not in a position to attain national priority. The Department is facing severe lack of resources and capacity. As a result, it is very difficult for the Department to meet the demand of modern geoinformation society. However, the Department is doing its best to bear its responsibility through the best use of resources and capacity. Publication of the journal is one of its efforts in this line.

At this moment, I would express heartiest appreciation to the member of Advisory Council and Editorial Board for their tireless efforts in making this publication successful. Similarly, I would like to extend heartiest thankfulness to the authors of the papers for their professional contribution. I would also like to thank the readers for taking time to go through it.

Finally, I would like to congratulate all the staff of the Department at the completion of 56 years of the department in serving the nation and extend heartiest thankfullness to those who have contributed to bring this department at this stage in a way or another.

Enjoy reading!

Thank you!
Nagendra Jha
Director General
Survey Department
2070 Jestha

Consolidation of Stakeholders' Initiatives to Mitigate Adverse Impacts of Climate Change in Nepalese Context

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Keywords

Green House Gases (GHG), Climate Change, MoLRM, Land Policy, Land Use Policy

Abstract

Although Nepal contributes very low emissions of Greenhouse Gases (GHGs) compared to the developed nations, it is the fourth most vulnerable country in the world due to the effects of climate change. These effects have already lead to more natural disasters, loss of biodiversity, increase in mountain snow melt, uncertainty in precipitation, shortage of food, water and energy etc. resulting in devastating impacts on the life of people living in both mountain and plain areas. Climate change therefore is the vital issue in the country. Understanding the potential impacts of climate change, Government of Nepal since last two decades has taken significant initiatives in response to the effects of climate change including the participations in international conventions, the approval of Climate Change National Policy 2067 (2010), and establishment of a high level Climate Change Council (CCC) under the chairmanship of the Rt. Hon'ble Prime Minister of Nepal. In addition, The Ministry of Environment, Science and Technology (MoEST), being the National Designated Authority (DNA) in Nepal for United Nation Framework Convention on Climate Change (UNFCCC), has executed several programmes and projects related to mitigation and adaptation of climate change effects including Clean Development Mechanism (CDM) projects and National Adaptation Programme of Action (NAPA). International Non-governmental Organizations such as UNFCCC, DANIDA, DFID, UNEP, UNDP, UN-HABITAT, World Bank, Food and Agricultural Organization (FAO), Asian Development Bank (ADB) etc. as well have carried out numerous climate change projects and activities in Nepal in conjunction with various government agencies.

Studies have revealed that the major sources of GHGs are from the burning of fossil fuel (75%), land use changes (20%), and other sources (5%). It has also been postulated that the effects of climate change can be significantly reduced through the implementation of land use policy and activities. Ministry of Land Reform and Management (MoLRM), Government of Nepal (GoN) is the central agency in Nepal dealing with the formulation and implementation of land related policies and activities in the country. MoLRM has commenced to formulate the National Land Policy and has planned to complete it at the end of fiscal year 069/70. This policy will definitely assist in mitigating the effects of climate change in the country. Another essential policy for the mitigation of the impacts of climate change in the country is National Land Use Policy which was prepared by MoLRM and has been approved by GoN in 2012, but it is yet to be implemented. One of the important policies that it has focussed on for the mitigation of climate change effects is to increase the present forest coverage to 40% of the total area of the country while protecting the government land by forestation and plantation programmes on degraded lands.

1. Introduction

Land is the mainstay of human life as it provides food, shelter, clothing and energy required for the people, without the proper management of land, it is not possible to improve the economy of a country. Nepalese economy depends primarily on agriculture, which employs more than 65.7 percent of the total population contributing nearly 32.7 percent of GDP. The population growth rate is about 1.35 percent per annum while the increase in food grain production is merely 2.8 percent (CBS, 2012). During the past few decades, the studies have shown that effects of climate change in Nepal have resulted in loss of agricultural production from the drought, depletion of biodiversity, disruptions of water supply to urban areas, spread of tropical diseases, health damage and even deaths from heat waves, spreads of harmful pests, etc. Moreover, disruptions of weather patterns caused by the climate change will lead to the increase in floods, glacial lake outbursts, hurricanes and other extreme events with the loss of lives and properties.

The atmosphere is largely transparent to incoming short-wave (or ultraviolet) solar radiation, which is absorbed by the Earth's surface. Much of this radiation is then re-emitted as heat energy at long-wave, infrared wavelengths. Some of this energy escapes back into the space and due to the presence of Greenhouse Gases (GHGs - i.e. Carbon Dioxide (Co_2), Methane (NH4), Nitrous Oxides (N_2O), Ozone (O_3), Hydrophloro Carbon (HFC), Perfloro Carbons (PF_6), Sulphur Hexafloride (SF_6) and Chloro-fluoro Carbons) in the earth's atmosphere, heat energy is trapped inside. Earth as well emits terrestrial radiation. There is a delicate balance between solar and terrestrial radiation which keep the earth's environment warm. If there were no GHGs, the temperature of earth would be inhabitable. The presence of natural GHGs is therefore important for maintaining an optimum temperature and has helped in survival on earth. However, due to the increasing concentration of anthropogenic GHGs (mostly Co_2, NH_4, and N_2O) resulted from the human activities on earth, additional heat energy is trapped in the atmosphere. It is estimated that more than 75% of GHGs is generated from the burning of fossil fuel, 20% from land use changes, and 5% from other sources. Effect of this heat trapping due to the increasing presence of GHGs in the atmosphere is known as greenhouse effect. This effect causes global warming and its main consequence is the climate change.

Even though Nepal contributes very low emissions compared to other developed nations, it is the fourth most vulnerable country among the 170 countries in the world (with Bangladesh and India ranking first and second respectively) due to the effects of climate change. These effects lead to more natural disasters, species migration, loss of biodiversity, changes in vegetation cover, increase in mountain snow melt, uncertainty in precipitation, shortage of food, water and energy etc. resulting in devastating impacts on the life of people living in both mountain and plain areas (WFP, 2009). Climate change has therefore become a priority issue in Nepal.

Understanding the potential impacts of climate change, Government of Nepal (GoN) since 1990s has taken important steps in response to the effects of climate change and has participated in international conferences and conventions. In addition, GoN has approved the Climate Change National Policy 2067 (2010) and has established a high level Climate Change Council under the chairmanship of the Rt. Hon'ble Prime Minister of Nepal. Likewise, the Ministry of Environment, Science and Technology (MoEST), being the National Designated Authority in Nepal for UNFCCC, has executed several programmes and projects related to mitigation and adaptation of climate change effects (Clean Energy Nepal, 2002). International non-governmental organizations as well have carried out numerous climate change projects and activities in Nepal in conjunction with various government agencies.

Furthermore, there is a strong relationship between sustainable economic development and climate change. Climate change issues however have not become sufficiently prominent in government development plans. In order to increase the economy with environmental protection, the country must reduce its emissions through the proper implementation of land related policies including climate change policies, National Land Policy, National Land Use Policy etc. These policies as well deal with the issues on land use changes which contribute nearly 20% total GHGs emission.

Ministry of Land Reform and Management (MoLRM), GoN is the central agency in Nepal dealing with the formulation and implementation of land related policies and activities in the country. Moreover, it is the core ministry looking after the land administration and management activities, and is responsible for ensuring efficient and effective administration and sustainable management of available land resources. With the implementation of land related policies and use of land information systems produced by various agencies under MoLRM, the impacts of climate change in Nepal could be reduced with the significant increase in sustainable economic and social development of the country.

2. Sources of GHGs and Climate Changes

Emissions of three principle GHGs, which include carbon dioxide (CO_2), methane (NH_4) and nitrous oxide (N_2O), cause green house effects in the atmosphere. CO_2 is the major component which forms about 75 percent of the total GHGs. CO_2 is mainly produced from burning of fossil fuels (such as oil, coal and gases), energy generation and transport. Annual flow of Global emission of Co_2 is nearly 42 Gegatons in the year 2000. Studies reveal that rapid industrialization coupled with urbanization, excessive consumption of fossil fuels, deforestations, slash & burning of forests, agricultural development etc. in the world over the past two centuries have resulted in significant increase of CO_2 gas in the atmosphere. Before the rapid industrialization, the share of CO_2 gas in the atmosphere was estimated to be 280 ppm (parts per million) which now has increased to 430 ppm. If this trend in rising of CO_2 gas continues, the level of this gas in the atmosphere is predicted to be 800 ppm at the end of this century, which will create serious impacts on the entire earth. Concentrations of other GHG gases such as NH_4 and N_2O as well have significantly increased over the period. Methane which is generated from the energy industries, agricultural sources and wastes to landfills contributes about 17% of the total GHGs in the atmosphere; whereas N2O produced mainly from the agricultural sources accounts for nearly 6% (NCVST, 2009).

Over the last few decades, studies have indicated that temperature of earth surface has been rising and this has caused changes in weather patterns, resulting in rise in sea level, melting of glaciers, floods, draught, loss in agricultural production etc. Meteorological measurement records show that a warming of 0.3-0.6^0 Celsius (C) in global average temperature since 1860. Moreover, the global temperature has increased by 0.76^0 C during the period of 150 years (IPCC, 2007). It is also recorded that 1990s was the warmest decade of the global surface temperature since 1850. The studies further reveal that the global temperature could rise up to 4.5°C (2.4° to 6.4°C) by sometime in the 21st Century (IPCC, 2000). In addition, it has been suggested that warming of more than 2.5°C could reduce global food supplies and contribute to higher food prices (UNEP & UNFCCC, 2002).

Effect of the climate change also causes variability in precipitation patterns leading to increased variability and uncertainty in rainfall. The study also reveals that monsoon delayed in Nepal is caused by the climate change effects. Likewise, speed and direction of wind change due to the climate change effects leading to higher risks of cyclones resulting in devastating phenomena.

3. Scenario of Climate Change Effects in Nepal

Based on the available information, annual Global emission of Co_2 is nearly 42 Gegatons with United Arab Emirates, Kuwait, United States and Canada being ranked highest per capita Co_2 emitters. The annual per capita Co_2 emissions from these countries are 33.4t, 32.7t, 19.9t and 17.9t respectively. Nepal's per capita emission of Co_2 ranks lowest among SAARC nations at 0.1 metric tons per year. Although the contribution of total GHG emission by Nepal to the global community is insignificant (nearly 0.025% of the total global emission) compared to the developed countries, Nepal has already encountered several negative effects due to the global climate change. Studies carried out by the Department of Hydrology and Meteorology, GoN reveal that average temperature in Nepal is increasing at the rate of nearly 0.06°C per year (0.04°C in Terai) between the period of 1977 and 1994. Another temperature analysis from 1976 to 2005 has revealed that the average temperature in Nepal has increased by 0.597°C per year. The projected figures for Nepal further show that average increase in temperatures of 1.2ºC for the year 2030, 1.7ºC for 2050 and 3.0ºC for 2100. The temperature in the Himalayan Region, on the other hand, is increasing at a greater rate with 0.09°C per year, which is having severe effects on the glacial lakes, which are the main source of Nepal's water resources. It is also recorded that more temperature rises in the winter seasons than the summers (Shrestha et al., 2000). Due to the rise of temperature in the Himalayan region, Rika Samba Himalayan Glacier in the Dhaulagiri region, western part of Nepal, for example, is receding at a rate of 10 m per year.

People's lives and livelihoods, especially of poor and marginalized social groups such as farmers, indigenous communities, women and children in the rural areas who are least able to cope with are most at risks and vulnerable to the disasters caused by the climate change.

4. Nepal's Initiatives in Response to the Climate Change

Climate change is a serious issue in global scale with its effects globally in different ways and scale. Least developed countries such as Nepal are the most vulnerable ones to its impacts. Understanding the potential impacts of climate change, Nepal has therefore signed the United Nation Framework Convention on Climate Change (UNFCCC) in Rio De Janerio, Brazil in June 12, 1992 and has ratified it on 2nd May in 1994. Since then, Nepal has been regularly participating in Conference of the Parties (COP) and other subsidiary meetings. It also became party of Kyoto Protocol by submitting its instrument of Accession on September 16, 2005. Nepal is listed as the non-annex 1 party to the Protocol.

In addition to the ratification of UNFCCC, Nepal also has ratified the two other Rio Conventions: the Convention to Combat Desertification (UNCCD) and the Convention on Biodiversity (UNCBD). All conventions oblige their signatories to follow a stipulated reporting system. Nepal's national report to the UNCCD was prepared and presented in the Fourth Conference of the Parties (COP 4) in 2000.

4.1 The Ministry of Environment in Response to Climate Change

The Ministry of Environment, Science and Technology (MoEST) is the focal point for the UNFCCC in Nepal and is the National Designated Authority (DNA) to execute Clean Development Mechanism (CDM) projects. So far two biogas CDM projects have been approved. MoEST also has prepared the first National Communication Report of UNFCCC in 2004, outlining the GHG emission sources, possible impact areas and some adaptation measures. In addition, MoEST in conjunction with UNEP/GEF is preparing Second National Communication Report. Likewise, MoEST in cooperation with DANIDA has developed a project on "Strengthening the Capacity Building on Negotiations and COP 15 Preparation."

In November, 2008, MoEST has signed the contract with UNDP to officially start the National Adaptation Programme of Action (NAPA) formulation process in Nepal, targeting mainly to the marginalized and vulnerable communities in the country. The preparation of the NAPA is the first official initiative to mainstream adaptation into national policies and actions so as to address the adverse impacts of climate change and reduce vulnerability to changing climate and extreme events. NAPA has six basic thematic sectors; namely, Agriculture and Food Security, Forest and Biodiversity, Water and Energy, Climate Induced Disaster Public Health, Urban Development and Infrastructure. Similarly, Local Adaptation Plan of Action (LAPA) supported by DFID donor agency has been implemented in the country.

The Ministry has prepared NAPA document in 2010 with some good progress in terms of initial understanding on vulnerability context and identifies preliminary sectoral issues through the mobilization of thematic working groups. Research and Development on Climate Change unit has been established within this Ministry in Collaboration with universities in 2010.

GoN has enforced a variety of strategies and has to imply different policies owing the long term climatic change affects. Nepal's 9th and 10th Plan has emphasized several alternative energy sources to reduce the domestic use of wood and fossil fuels with more use of hydropower and bio-gas. Interim Government of Nepal has also decided to promote various CDM projects under the UNFCCC and alternative energy system in rural communities. GoN is also promoting clean energy and sustainable development in the country in order to take advantage of the CDM as a source of new investment and technology. Policies have also been implemented to import Euro-1 standard vehicles and ban on the registration of two stroke vehicles to increase the efficiency and reduce pollution from the transport sector.

National Planning Commission has as well initiated Climate Resilience Planning Process Programme with the support from ADB for the running Three Year's Plan (2010-2013). Mitigation Plan on Climate Change became the National Agenda.

4.2 Non-Governmental Organizations in Response to Climate Change

Government agencies along with International Non-governmental Organizations (INGOs) are regularly working for data and information generation on climate change related impacts and for raising awareness among local people. MoEST has set up Climate Change Network comprising of representatives of relevant government bodies, NGOs, civil society and experts for information and knowledge management and policy input.

In addition, Nepal has other policies and programmes for promoting clean energy. Some Non-governmental Organizations (NGO) along with the donor agencies and private organizations as well are actively involved in these programmes. For example, the Alternative Energy Promotion Centre, together with several NGOs and private companies, is promoting clean energy efficiency technologies such as biogas, micro-hydro and solar through subsidies as well as technical assistance. Moreover, Nepal is promoting electric vehicles as a promising alternative for transportation. Kathmandu now has more than 600 zero-emission electric vehicles and there is potential for a lot more, provided that the government policies are favorable.

The World Bank has also established Forest Carbon Partnership Facility (FCPF) to support developing countries in their efforts to build capacity for Reducing Emissions from Deforestation in Developing Countries (REDD) at the country level. The purpose of the facility is to assist developing countries to be ready for REDD by 2012. Nepal, after the approval of its Readiness Plan Idea Note (R-PIN) by the Bank in July 2008, has officially been selected as one of the FCPF countries. The Bank has now pledged to support Nepal for preparing Readiness Preparation Proposal (R-PP) with an aim that the country could be able to implement initially forest carbon pilot projects, and subsequently get ready for implementing larger scale incentive based forestry development and conservation program at the country level.

4.3 Other Initiatives in Response to Climate Change

One of the important initiatives to the climate change that GoN has carried out was the historic cabinet meeting held at Kalapani (5,545 m above the sea level), the base camp of Mount Everest (8,848 m.), on December 4, 2009, which was attended by the former Prime Minister Madhav Kumar Nepal and 23 other ministers in order to draw attention of international communities towards melting of Himalayas due to climate change effects. Addressing the historic meet, the former Prime Minister said that the issues regarding climate change were not restricted only to the mountainous nations but was relevant to the whole world. He sought initiatives from the nations which produce large amounts of carbon emissions to address the issues regarding climate change at the earliest. Likewise, GoN has carried out Regional Climate Change Conference in Kathmandu in August, 2009. Similarly, GoN has included Climate Resilient Programme in the running Three Years Plan (2010 – 2013).

In addition, GoN has constituted a high level coordination council such as the Climate Change Council (CCC) under the chairmanship of the Rt. Hon'ble Prime Minister of Nepal, and other committees including Pilot Programme on Climate Resilience Coordination Committee (PPCR), and Multi-stakeholder Coordination Committee Initiative on Climate Change (MCCICC). Major functions of CCC are as follows:

- Provide guidance and ensure coordination for the formulation and implementation of Climate Change related policies
- Promote Climate Change integration in long-term policies, plans and programmes
- Promote Climate Change as national development agenda
- Process for additional financial and technical support for Climate Change programmes
- Process for benefiting from international negotiations and decisions

Furthermore, the sixth meeting of CCC under leadership of former Prime Minister Madhav Kumar Nepal endorsed a document on Climate Change National Policy 2067 (2010) in the year of 2010. The draft of the Climate Change Policy 2067 has aimed at promoting development of clean energy and making economic evaluation of the impacts and possible advantage and disadvantage of the climate change. Vision of this policy is the pollution free Nepal, increase in productivity through management of resources, environment-friendly infrastructure development, reduced natural disasters, and enhanced livelihood opportunities. Major broader areas included in this policy are institutional strengthening, natural resources management, disaster mitigation and adaptation, GHG emission, pollution control and CDM, awareness capacity building and empowerment etc. This Policy 2067 was approved by the Government of Nepal in January 17, 2011.

There are other national initiatives like the Pilot Programme on Climate Resilience (PPCR) and REDD under the Ministry of Forest and Conservation. PPCR has launched stakeholders meeting in September, 2009. Likewise, with the participation of Department of Hydrology and Meteorology (DHM), the Asian Pacific Network has initiated capacity-building activities in Nepal; Ministry of Agriculture and Cooperative (MOAC) with the assistance from FAO has as well carried out Agriculture and Climate Change Project.

5. Role of Ministry of Land Reform & Management

Ministry of Land Reform and Management (MoLRM) is the central agency in Nepal dealing with the formulation and implementation of land related policies and activities in the country. Initially, this ministry was set up in 1964 (2021B.S.) as a Ministry of Land Reform with 3 major directorates; namely, Land Reform, Cooperatives and Cadastral Survey. Since the inception of its establishment, this ministry has been taking significant responsibilities, especially in the formulation and implementation of land related policies and activities in the country.

Since last few decades effects of climate change have become a priority issue in Nepal. It has been postulated that the effects of climate change can be significantly mitigated with the proper implementation of land related policies. National Land Policy and Land Use Policy are the fundamental land related policies in the country to cope with all kinds of land problems along with the adaptation and mitigation of climate change effects.

5.1 National Land Policy

One of the major tools for the mitigation of climate change effects in Nepal is the implementation of National Land Policy. MoLRM has planned to prepare it at the end of fiscal year 069/70 although it has been addressed effectively in the past. In order to prepare this policy, MoLRM has carried out the first seminar on National Land Policy with the stakeholders in Kathmandu on December 24, 2012.

Land related problems have not been viewed in an integrated way in the past. Planning system of Nepal has remained sectoral. However, in the Tenth Plan (2002–2006) has clearly emphasized the formulation of land policy of the country, but it was not possible. The current Three Year’s Plan (2010-2013) as well has put stress on the formulation of Land Use Policy and National Land Policy. The absence of integrated national land policy and land use programmes has led to unsystematic planning and development of the country with deteriorating environment and land degradation. Increment in agricultural productivity, employment generation and food security are other issues that need to be solved properly. In order to cope with all these problems, GoN has finally perceived the need of developing and implementing National Land Policy for the long term integrated land use planning and management for the sustainable use of limited land resources of the country. Maximum benefit from land resource can only be achieved by classifying land on the basis of utility and appropriateness with the implementation of such policy. This will lead to poverty alleviation, increase in crop productivity, conservation of natural resources, social and economic development of the country. This policy also will help provide opportunities for the investors, and will assist in mitigating the effects of climate change.

5.2 National Land Use Policy

Another essential policy for the mitigation of the impacts of climate change in the country is National Land Use Policy. Unlike the National Land Policy, this policy keeps first priority on the optimal use of land resources with secondary preference given to land ownership and tenures. In the 9th Plan (1997-2002), GoN has clearly specified the land use policy in the country. The need for classification of agricultural land on the basis of land capability has been emphasized. The plan further states the need of zoning land for agriculture, forestry, residence, industrial areas, and non-agricultural purpose in order to maintain environmental balance and sustainable uses of environmental resources. Moreover, implementation of national land use programmes has been included in the 10th Plan. Some of the programmes included in the 10th Plan are updating land use maps, preparation of district level digital land resources GIS database, preparation of district profiles etc.

National Land Use Policy was finally approved by GoN in the year 2012 through the Cabinet Decision (April 16, 2012), it has however not been implemented. Furthermore, GoN has already included the *land use acts and Formulation of Land Use Council* in the modified land acts (2058 B.S.). One of the important policies that it has focused on for the mitigation of climate change effects is to increase the present forest coverage to 40% of the total area of the country while protecting the government land by forestation and plantation programmes on degraded lands. The studies reveal that the overall deforestation rate in Nepal is currently 1.7%, which is well above the Asian average (1%) and the global average (1.3%) (MFSC, 2008). This policy also has discouraged the land fragmentation practices while encouraging the public to land consolidation. It has as well discouraged the present improper land use practices in the country. The policy has addressed to manage the mountains and hills while controlling soil erosion, which causes floods in the downstream, especially in the valleys and the Terai. There are several other essential policies that it has concentrated on, some of them include the protection of biodiversity, sustainable development of the country while mitigating the impacts of climate change, discouraging the development of residential areas under the hazardous prone zones etc. Moreover, it has emphasized to include the land use issues in the educational curriculum in order to increase the awareness in the young generation. For the optimum use of land and its resources, land use zoning policy which is included in the aforementioned policy will be imposed based on the land capability, geological structures, climatic conditions and suitability of the areas.

5.3 Survey Department

One of the important organizations under MoLRM for the mitigation of climate change effects in the country is Survey Department (SD) which is now recognized as a National Mapping Organization. This department established in 1957 conducts the surveying and mapping activities and has a broad multi-disciplinary resource base and produces a wide range of ground surveys, aerial photography, photogrammetry, geo-information and cadastral map products and services in order to support multi-sectoral development activities including the reduction and adaptation programmes of climate change effects.

Moreover, SD has prepared topographic maps of the entire nation in 2001. One of the major components of these maps is the land cover information which is very useful for the estimation of forest biomass for the climate change study. Topographic maps at the scale of 1:25,000 were prepared for the Terai and the Mid Hill Regions of Nepal and are based on aerial photographs taken in 1992 and 1996 with extensive ground truthings. Topographical maps at the scale of 1:50,000 dated 1996-97 on the other hand are available for High Mountain and Himalayan Regions of Nepal. Moreover, digital data of these topographic map series are as well available from this department. These databases were created in 2002 using ARC/INFO GIS software programmes by a project under SD with the financial assistance from the Finish Government. These databases are valuable tools for the preparation of national forest inventory as well as for the estimation of forest biomass using GIS technology.

Likewise in 1986, Land Resources Mapping Project (LRMP, 1986) under SD has prepared Land Utilization maps at 1:50,000 scale of the entire Nepal, using 1978/79 aerial photographs with extensive ground verifications. These data have provided an opportunity to estimate forest biomass and prepare basic forest inventory of the country as well as for the study of climate change effects. LRMP data has also placed specific emphasis on forests, shrublands, agriculture, and grassland resources. Forest units have been further classified into various components including forest cover types, species associations, crown density coverage, and maturity classes. LRMP information as well was used for the preparation for the Master Plan of the Forestry Sector of Nepal in 1989.

6. Conclusions

Climate change is a serious issue in global scale with its effects globally in different ways and scale. Least developed countries such as Nepal are the most vulnerable ones to its effects. People's lives and livelihoods, especially of poor and marginalized social groups such as farmers, indigenous communities, women and children in the rural areas who are least able to cope with are most at risks and vulnerable to the disasters caused by the climate change. Climate change therefore has become a priority issue in Nepal. Following conclusions are drawn to lessen and adapt the adverse effects of the climate change in the Nepalese context.

- Although Government of Nepal along with several stakeholders (including INGOs in conjunction with various government organizations) have taken initiatives in response to the effects of climate change and have carried out plentiful projects and activities in Nepal, there is still a lack of consolidation of stakeholders' initiatives to mitigate and adapt the impacts of climate change.
- Moreover, there is a need of comprehensive research works, capacity building at different levels, inter-departmental coordination and focus on integrated policy on climate change and its impacts.
- Climate change issue is not only concerned to one organization such as MoEST, but to all. All the stakeholders therefore must work together in order to reduce and adapt the effects of climate change.
- There is also a need to raise awareness on climate change and global negotiations.
- Finally, since MoLRM is the central agency responsible for the formulation and implementation of all land related policies and activities in Nepal, this ministry should formulate the National Land Policy on schedule and also should implement the approved National Land Use Policy as soon as possible to mitigate the effects of climate change.

References

CBS, 2012. Statistical year book Nepal. Central Bureau of Statistics, National Planning Commission, Kathmandu, Nepal.

Clean Energy Nepal, 2002. Clean Energy Nepal's Fact Sheet #2. Kathmandu. Nepal.

Dahal, N. 2006. Implications of Climate Change in Nepal: Some Observations and Opportunities. Paper Presented at 23rd Warden Seminar, November 2006 held in Pokhara, Nepal.

DHM, 2007. Climatological & Agrometereological Records of Nepal 2007, Department of Hydrology and Meteorology, Ministry of Environment, Science and Technology, Government of Nepal.

DFRS, 2010. Forest Resource Assessment (FRA) Nepal Project, Department of Forest Research and Survey, Ministry of Soil and Conversation, Government of Nepal.

Li-BIRD, 2009. Climate Change and Agro-biodiversity in Nepal, A Report Prepared for Platform for Agrobiodiversity Research in collaboration with FAO and Bioversity International. Pokhara, Nepal. 17 pp

MFSC, 2008. Forest Carbon Partnership Facility Readiness Plan Idea Note (R-PIN) Nepal.

MoEST and UNDP, 2008. National Adaptation of Programme of Action to climate change project Document. Ministry of Environment Science and Technology and United National Development Program.

NCVST, 2009. Vulnerability Through the Eyes of Vulnerable: Climate Change Induced Uncertainties and Nepal's Development Predicaments. Institute for Social and Environmental Transition-Nepal. Nepal Climate Vulnerability Study Team (NCVST). Kathmandu, Nepal.

Pokhrel, A. P., 2002. Temperature and Precipitation Trend and Its Impact in Nepal, Paper presented on First Preparatory meeting on Eighth Conference of Parties, COP 8, organized by IUCN Nepal.

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

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

UNEP & UNFCCC, 2002. Climate Change Information Kit. Sheet 10. United Nation Environment Programme and United Nation Framework Convention on Climate Change. WFP, 2009.

UNFCCC, 2002. Annotated Guidelines for the Preparation of National Adaptation Programmes of Action. Least Developed Countries Expert Group.

WFP, 2009. The Cost of Coping. A collision of crises and the impact of Sustained Food Security Deterioration in Nepal. United Nations World Food Programme. Nepal Food Security Monitoring System.

Wigley, T.M.L. and S.C.B. Raper. 1993. "Future Changes in Global-Mean Temperature and Sea Level," in Climate and Sea Level Change: Observations, Projections and Implications, R.A. Warrick, E. Barrow, and T.M.L. Wigley (eds.), pp.111-133. Cambridge University Press, Cambridge, 424pp.

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Identification of Locations for Potential Glacial Lakes Formation using Remote Sensing Technology

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Keywords

Glacial Lake, Remote Sensing, COSI-Corr.

Abstract

In past Nepal has encountered a number of glacial lake outburst flood (GLOF) events causing loss of billions of rupees. Still there are a number of glacial lakes forming and there are chances of new glacial lake formation. Hence there is intense need to monitor glaciers and glacial lakes. The development on remote sensing technology has eased the researches on glacier and glacial lakes. Identification of locations of potential glacial lakes through the use of remote sensing technology has been proven and hence is opted for identification of locations of potential glacial lake in Khumbu Valley of Sagarmatha Zone, Nepal. The probable sites for glacial lake formation are at Ngojumpa, Lobuche, Khumbu, Bhotekoshi, Inkhu, Kyasar, Lumsumna, etc. As per study, the biggest glacial lake could form at Ngozumpa glacier. Even in other glaciers potential supra-glacial lakes could merge together to form lakes that occupy significant area.

1. Introduction

In past 40 years, Nepal has encountered more than 13 huge GLOFs with many villages destroyed, many human lives taken away, many infrastructures like hydropower station, mini hydropower plant, and bridges collapsed causing loss of billions of rupees (Ives et al., 2010). The studies report formation of a number of glacial lakes due to speeded glacier retreat (Ives et al., 2010). And there are lot more chances of new glacial lake formation which might eventually lead to natural hazards, justifying the necessity to identify potential glacial lakes.

Remote sensing-based measurements provide the platform to monitor the glacier and glacial lakes and could be used for identification of possible glacial lakes (Frey et al., 2010). The technology not only eases the researchers and academics by making measurements readily available without having to tread those seldom accessible glaciers and glacial lakes but provides possibly complete coverage.

In the article, we use remote sensing technology for the identification of locations for potential glacial lake formation.

1.1 Study Area

The area of study is the glaciers of Khumbu Valley of Solukhumbu District of Sagarmatha Zone, Nepal. Khumbu Valley extends from 27º 38’ 58”N to 28º 6’46”N latitude and 86º 30’ 52”E to 86º 59’09”E longitude and consists of three VDCs namely Khumjung, Namche and Chaurikharka. The total area covered by Khumbu Valley is 1475.4 square kilometers.

Khumbu Valley consists of the highest peak of the world, Mt. Everest and Namche VDC of Khumbu Valley is regarded as the gateway to Mt. Everest. Khumbu Valley also consists of the longest active glacier of Nepal, Ngojumpa glacier. Sacred Gokyo Lake and Sagarmatha National Park are also situated in this Valley.

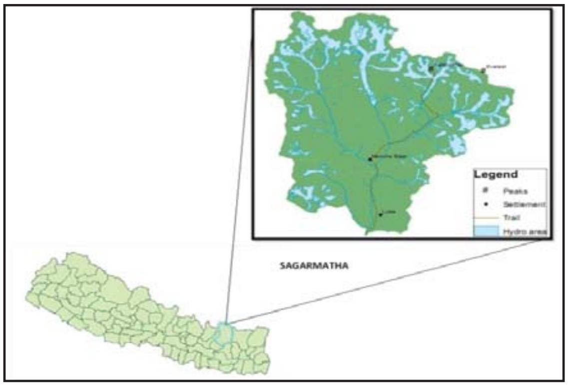

Figure 1: Study Area

The valley shelters more than hundred glaciers among which 31 are identifiable through remote sensing. The glaciers that can be identified through remote sensing are Amadablam, Ambulapcha, Bhotekoshi, Chhule, Chola, Cholotse, Churo, Duwo, Gaunara, Goraksep, Imja, Inkhu, Khangri Nup, Khangri Shar, Khumbu, Kyasar, Landak, Lanmuche, Lhotse, Lhotse Nup, Lhotse Shar, Lobuche, Lumdin, Lumsumna, Melun, Minbo, Nare, Ngojumpa, Nuptse, Thyanbo and Tobuche.

2. Method And Materials

The possible glacial lakes are determined by selecting the area with slope below threshold slope which is also called slope criteria and area with the velocity below threshold velocity. The result can be more refined through manual application geographic association criteria; distinct slope increase, reduction of glacier width, and crevasse-free part followed by heavily crevassed part (Frey et al., 2010). However the geographic association criteria are for detection of overdeepenings on glacier bed.

The glacial lakes, in Himalaya, are found to be developed usually at the tongue of debris covered glaciers due to negative mass balance by down wasting rather than retreating (Richardson, 2010). According to the studies by Reynolds (2000) on Glacial Lakes of Bhutan, the large glacial lakes were found to be developed on the places in glaciers having surface slope less than 2° which was later on supported by Quincey et al. (2007).Quincey et al. (2007), in the research on the possibility of formation of glacial lakes in Himalaya, applied slope below 2° as glacial slope threshold criteria. The research also found that the glacial lakes were found to form at the regions of glaciers with the surface velocity less than 10 m/a. The formation of glacial lakes with the glacier velocity over 10 m/a are not likely as there is high possibility of draining out (Quincey et al., 2007). But the study of European Alps found the surface slope less than 5° as a criteria for glacial lakes forming at the glaciers parts with overdeepened bed that are caused by the previous glaciers. But the research didn't use the velocity as the determinant of glacial lake but geographic association, such as distinct slope increase, reduction of glacier width, and crevasse-free part followed by heavily crevassed part, was used. These geographic association criteria are for detection of overdeepenings on glacier bed and the study reported the high possibility of formation of glacial lakes on these overdeepenings (Frey et al., 2010).

This article will use both the criteria defined by Reynolds (2000), Quincey et al. (2007) and Frey et al. (2010) to find out the possible glacial lakes in Khumbu Valley for comparative analysis. The overall methodology for glacial lake prediction is illustrated in the **Figure 2**.

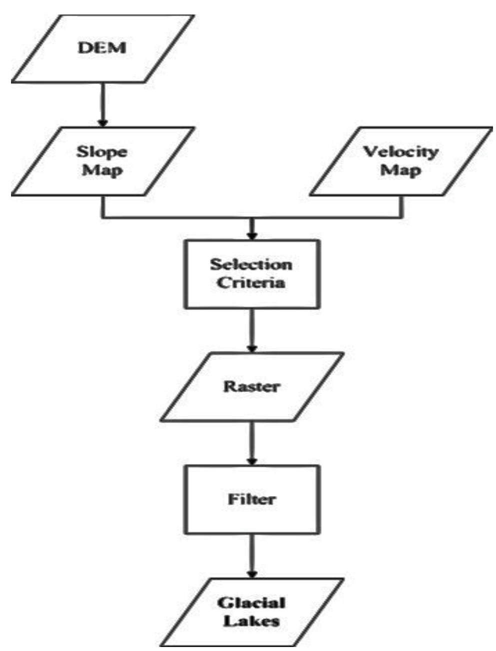

Figure 2: Overall Process for Identification of Locations of Potential Glacial Lakes

2.1 Materials Used

SPOT 5 satellite imageries of Level A for 2010 and 2009 was used was used for the deriving surface velocity of glacier using COSI-Corr (Co-registration of optically sensed image and correlation, Leprince et al. 2007). Digital elevation model (DEM) required for the COSI-Corr technique and preparation of slope map was produced from the contour map of 40m interval produced by Department of Survey, GoN.

2.2 Inventory of glaciers

The inventory of glaciers was prepared by manual digitization of glaciers over the image of 2010. The inventory contains 31 glaciers. The names of the glaciers are derived from the topographic map of Pumori, Namche Bazar and Solukhumbu.

At first, attempts were made to prepare the inventory through classification of the image of 2010. In order to classify glaciers, we also calculated Normalized Difference Snow Index (NDSI) of 2010 image from which we were able to differentiate snow and clouds but as the glaciers as well as the hills were covered with snow, it hindered the classification, both supervised and unsupervised, due to separate classes being spectrally similar. Moreover, the study area contains many debris-covered glaciers so the inventory was prepared through manual digitization.

2.3 Slope and Velocity Map Preparation

The preparation of slope map and velocity map is essential, as this study uses slope and velocity threshold to predict the formation of glacial lakes in the study area.

The slope map was prepared from the DEM (**Figure 3**). This DEM was prepared from the contour map of contour interval 40 m, obtained from the Department of Survey, GoN.

The velocity map (**Figure 4**) was produced from orthorectification, co-registration and correlation (COSI-Corr technology) of satellite images of year 2010 and 2009 of area under study. The satellite image of 2010 was orthorectified with respect

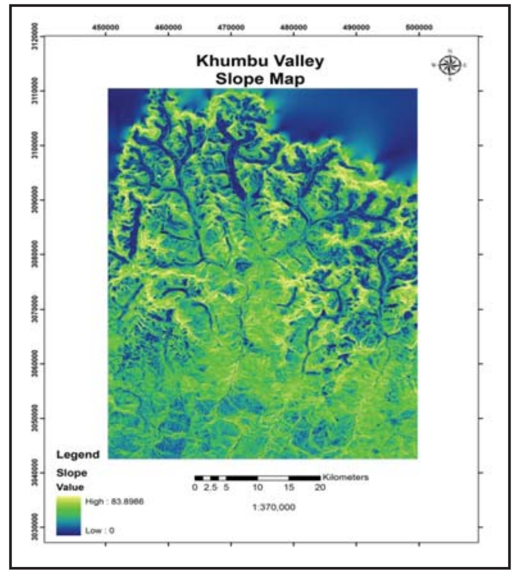

Figure 3: Slope Map of Khumbu Valley (Scale not as mentioned)

to the DEM and that of 2009 was orthorectified with respect to orthorectified image of 2010. Now these orthorectified images were correlated and the displacement maps were produced which after omitting outliers were subjected to the calculation to give velocity map as output. The formula for calculation of the velocity map out of displacement map is,

$$V=D/T \quad (1)$$

Where D=Displacement, T=Time interval between the acquisitions of two images.

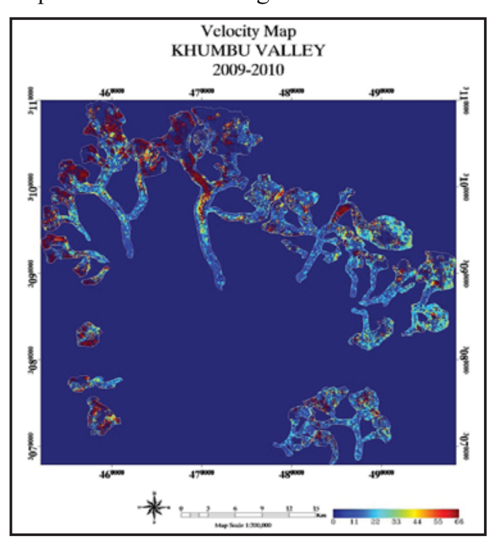

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Figure 4: Velocity Map of Khumbu Valley Glaciers (Scale not as mentioned)

2.4 Model of possible glacial lakes

The conditional raster was prepared by selecting the region whose slope is less than 2ºand velocity less than 10 m/a. Similarly another raster was prepared whose slope was less than 5º and velocity less than 10 m/a. These conditional raster were prepared in reference to the criteria proposed by Reynold (2000), Quincey et al. (2007) and Frey et al. (2010). Reynold (2000) and Quincey et al. (2007) proposed the slope criteria for formation of glacial lake to be below 2º while Frey et al. (2010) proposed it to be below 5º. Quincey et al. (2007) proposed the velocity criteria for the formation of glacial lakes to be below 10 m/a. From the above criteria, the possible sites for the glacial lake formation were derived. The produced output is a rough estimate of the potential sites for glacial lake formation. This output was further processed using various filters such as removing the pixels with less count values and polygonising the remaining pixels to prepare possible glacial lakes formation model.

3. Results And Discussion

The predicted model of glacial lakes formation with slope below 2º and velocity below 10 m/a, and with slope below 5º and velocity below 10 m/a are shown in **Figure 5** and **Figure 6**, respectively.**© CNES (2008), distribution Spot image S. A.**

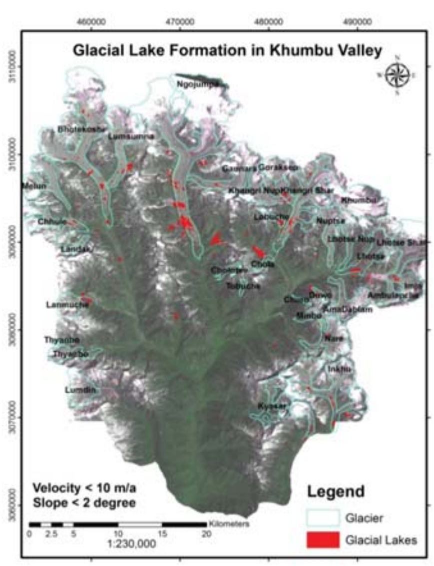

Figure 5: Locations and area covered by potential glacial lakes (Scale not as mentioned) for slope<2 º

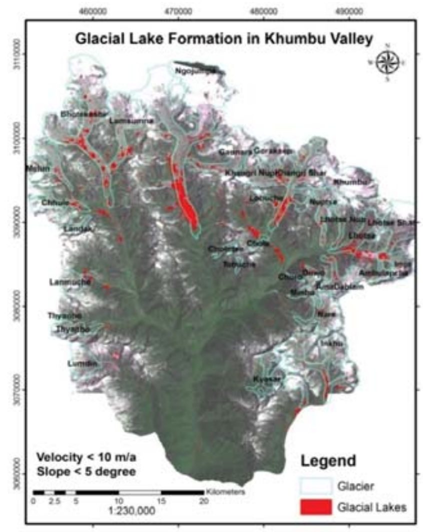

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Figure 6: Locations and area covered by potential glacial lakes (Scale not as mentioned) for slope<2 º

The probable sites for glacial lake formation are at Ngojumpa, Lobuche, Khumbu, Bhotekoshi, Inkhu, Kyasar, Lumsumna, etc. It is seen that the probable sites for glacial lake formation for each glacier are more in the terminus region than in the head region. The reason behind it is that in the head region, both the slope as well as the velocity is higher compared to that of the terminus region. The estimated area (in sq. km.) of the potential glacial lakes in Khumbu Valley with slope less than 2° and velocity less than 10m/a is shown in the **Figure 7.**Similarly the estimated area (in sq. km.) of the potential glacial lakes in Khumbu Valley with slope less than 5° and velocity less than 10m/a is shown in the **Figure 8**.These estimated areas of glacial lakes don't include the area of the existing glacial lakes. The glaciers with the existing glacial lakes are enlisted in **Table 1**.

As per the study, the biggest glacial lakes can form in Ngojumpa glacier. Under the criteria of slope threshold less than 5° and velocity threshold less than 10 m/a, the total area that can be occupied by the lake is around 7.19 Sq. km. The single huge lake will be formed from 1200 meters to 7500 meters from the terminus resulting on the formation of huge glacial lake (**Figure 9**). According to study, there should already have formed glacial lake in Ngojumpa glacier, but in reality it is not so. This suggests that the prediction of glacial lakes cannot be done just by observing slope and velocity.

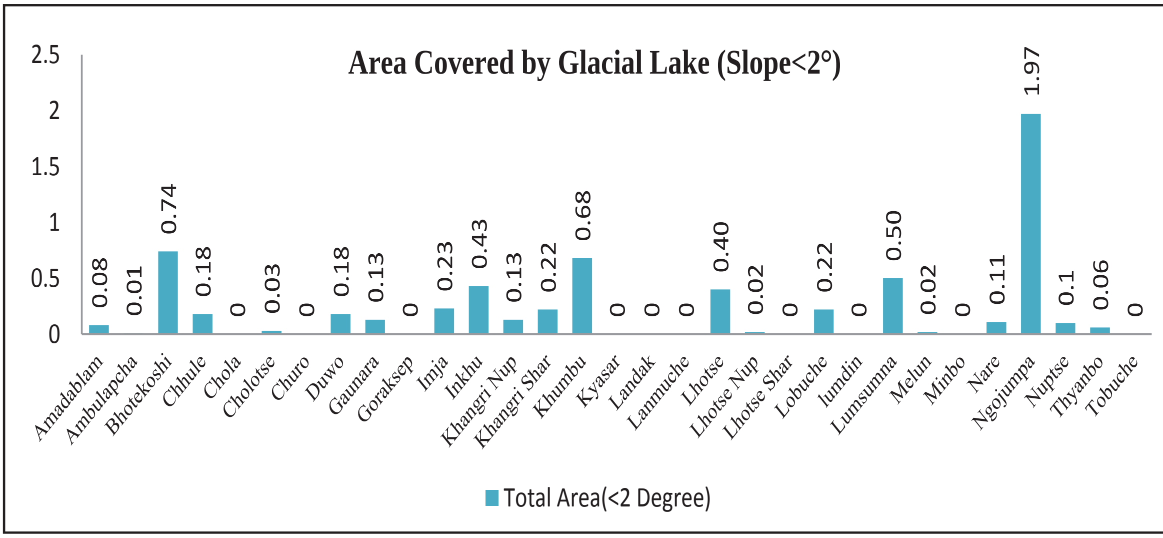

Figure 7: Area covered by glacial lake for slope<2 °

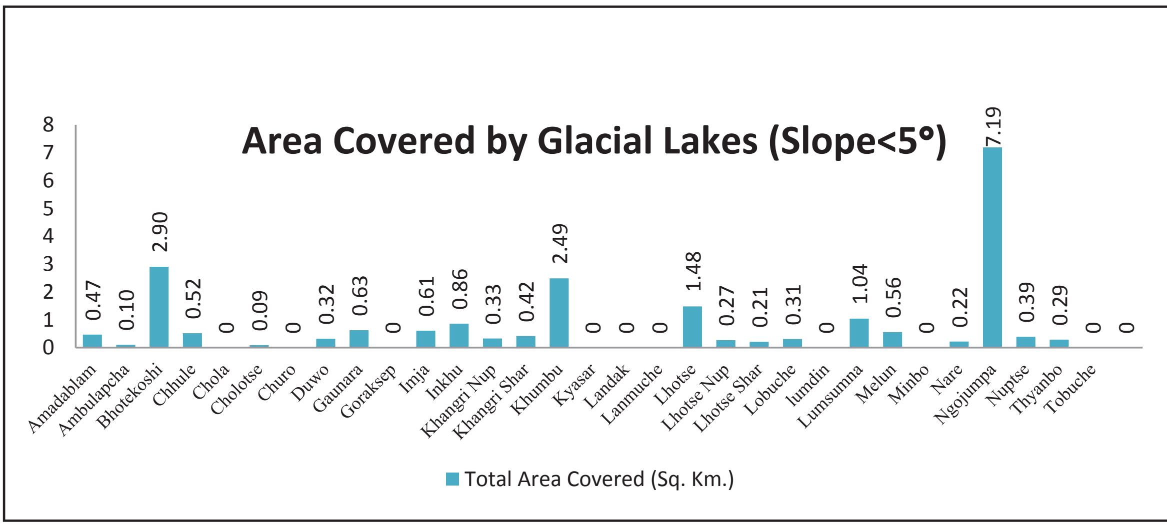

Figure 8: Area covered by glacial lake for slope<5 °

S.N	Glaciers	Glacial Lakes	Type
1.	Chola	Chola Cho	Lateral Moraine
2.	Imja	Imja Cho	End Moraine
3.	Kyasar	Kyasar Cho	End Moraine
4.	Lanmuche	Dig Cho	End Moraine
5.	Lumdin	Lumdin Cho	End Moraine
6.	Ngojumpa	Thonak Cho, DudhPokhari, Toujun Cho	Lateral Moraine

Table 1: Existing glacial lakes and their types

Additional information about glacier characteristics, topography should be included while observing, so as to achieve more realistic results. In case of some glaciers, a number of supra- glacier lakes are predicted to form. Moreover those possible supra-glacier lakes have the possibility of expanding to form a huge glacial lake in future. **Figure 10** illustrates the supra-glacial lakes that can form in the Lhotse. These supra-glacier lakes can combine together to form a single huge lake within the glacier.

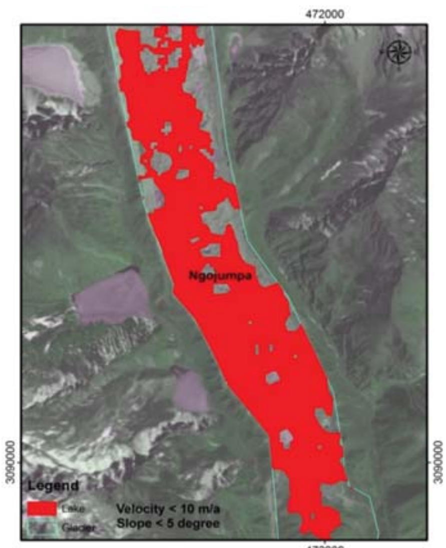

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Figure 9: Potential glacial lake in Ngojumpa Glacier

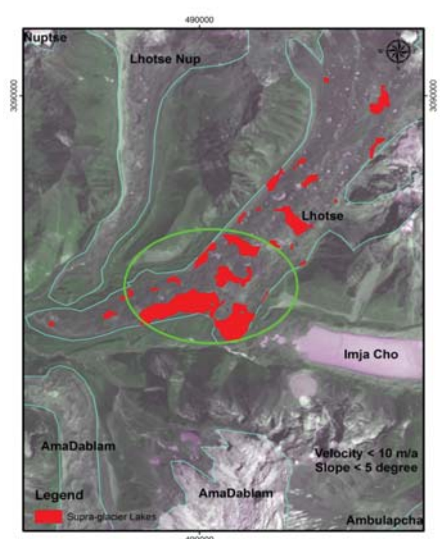

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Figure 10: Potential glacial lake in Lhotse Glacier

The study shows even in the glaciers with existing glacial lakes, there is possibility of formation of supra-glacial lakes increasing the possibility of expansion of the existing ones. Typically this characteristic is seen in the Imja glacier. There is a glacial lake Imja Cho at the terminus of the Imja glacier. Three glaciers Imja, Lhotse Shar and Ambulapcha contribute to this lake. The study shows that there is still a chance of formation of supra-glacier lakes at the junction of these three glaciers just above the Imja Cho (**Figure 11**). These lakes in future can terminate into Imja Cho resulting on its expansion and increased risk of GLOF.

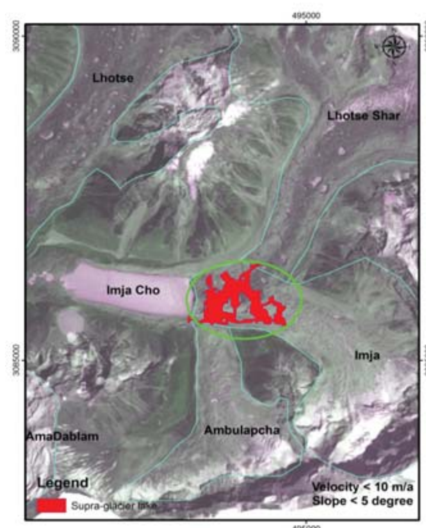

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Figure 11: Potential glacial lake at Imja Glacier

4.0 CONCLUSION

The study shows that there is possibility of formation of glacial lakes at glaciers; Ngojumpa, Lobuche, Khumbu, Bhotekoshi, Inkhu, Kyasar, Lumsumna, etc. Among all the glaciers, the biggest glacial lake could possibly form at Ngojumpa glacier which will cover around 7.19 sq. Km. of area if the threshold criteria proposed by Frey et al. 2010 used or 1.97 sq. Km. of area if the threshold criteria defined by Reynold, 2000 is used. It is seen that in some glaciers there are chances of forming a number of potential supra-glacial which within a single glacier could merge together to form a huge lake. This study also concludes with the potentiality of remote sensing technology for glacial study.

References

1. Frey, H., Haeberli, W., Linsbauer, A., Huggel, C., and Paul, F. (2010). A multi-level strategy for anticipating future glacier lake formation and associated hazard potentials. *Natural Hazards and Earth System Sciences* 10, 339-352.
2. Ives, J.D., Shrestha, R.B., Mool, P.K.(2010). *Formation of Glacial Lakes in the Hindu Kush-Himalaya and GLOF Risk Assessment*, Kathmandu: ICIMOD.
3. Leprince S., Ayoub F., Klinger Y., Avouac J. P. (2007). Co-Registration of Optically Sensed Images and Correlation(COSI-Corr): an Operational Methodology for Ground Deformation Measurements.
4. Quincey, D. J., Richardson, S. D., Luckman, A., Lucas, R. M., Reynolds, J. M., Hambrey, M. J., and Glasser, N. F. (2007). Early recognition of glacial lake hazards in the Himalaya using remote sensing datasets. *Global and Planetary Change,* 56, 137-152.
5. Reynolds, J. M. (2000). On the formation of supraglacial lakes on debris-covered glaciers. *In "Debris-Covered Glaciers."* (M. Nakawo, C. F. Raymond, and A. Fountain, Eds.). IAHS Publication No.264, IntAssoc Hydrological Sciences, Wallingford. 153-161.
6. Richardson S. D. (2010).*Remote sensing approaches for early warning of GLOF hazards in the Hindu Kush-Himalayan region.* UN/ISDR

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Looking back 2012-2013

Change of leadership in Survey Department:
Government of Nepal appointed Mr. Nagendra Jha the then Joint Secretary of Ministry of Land Reform and Management as the Director General of Survey Department. After taking charge of the Director General on12 September 2012 Mr. Jha addressed the staff in the meeting hall of the Department. He stressed on the fact that he will put his best effort for the betterment of the department. Before his address Deputy Director General Mr. Madhu Sudan Adhikary delivered welcome speech. He also wished for the successful tenure of the Director General.

Directives of distribution, use & regulation of digital data
Ministry of Land Reform and Management has inforced the directives of distribution, use & regulation of digital data 2069 (on 21st August 2012). After the implementation of the directive the dissemination of digital data will be easier and the unauthentic use of the data will be controlled. The digital data produced by different Departments, Branches, Projects & Offices within the Ministry will be distributed as per the process mentioned in the directives.

Annual Discussion Programme on Cadastral Survey:
Cadastral Survey Branch organized an annual discussion programme on 22-24 August, 2012 to review the programme of previous fiscal year and to discuss the programme of running fiscal year.

Total Station and Data Processing Training:
Cadastral Survey Branch conducted total station and data processing training on 2-11 October, 2012 at Cadastral Survey Branch .The Surveyors from all the Survey Offices of Kathmandu valley, Survey Office Banepa and from the branch participated in the training.

Distribution of Land Ownership Certificate:
Director General of Survey Department Mr. Nagendra Jha distributed the land ownership certificate of Banepa Municipality ward number 8 and 9 amid a function on 11th November 2012. Survey Officer of Banepa Survey Office Mr. Tanka Prasad Dahal delivered welcome speech and the then Head of Cadastral Survey Branch Mr. Jagat Raj Paudel delivered vote of thank to the guest and participants.

Chief District Officer of Kavre district Mr. Tulashi Prasad Gautam also addressed the function. Like wise land ownership certificate of 30 wards of different 20 municipalities and 9 village development committees were distributed by the concerning survey offices.

Multi-GNSS workshop:

Survey Department jointly organized an international workshop as per the annual program of the Geodetic Survey Branch for the fiscal year 2069/070. The title of the event was "workshop on the use of Multi-GNSS for policy and decision makers".

An organizing committee was formed, Director General of Survey Department Mr. Nagendra Jha as co-ordinator. The other members of the committee were Deputy Director General Mr. Madhu Sudan Adhikari , Deputy Director General Mr. Hridaya Narayan Mishra, Head of the Geodetic Survey Branch Mr. Jagat Raj Paudel, Project Chief Mr. Suresh Man Shrestha, Director Mr. Bishnu Bahadur Thapa, Chief Account Controller Mr. Biswa Nath Dhakal,Chief Survey Officer Mr. Ganesh Prasad Bhatta and Executive Director Mr. Kalyan Gopal Shrestha as invited member.

Installation of QZSS receiver at Nagarkot:

As per the decision of Government of Nepal (Secretary Level) on 11 November 2012 Quasi Zenithal Satellite System (QZSS) receiver is installed in Geodetic Observatory Complex in Nagarkot. JAXA (Japan Aerospace Exploration Agency) and Survey Department mutually agreed to host the QZSS site.

Orientation program on Border issues:

Topographical Survey Branch, Survey Department organized an orientation program on 23rd January 2013 at Birganj. The title of the event was "Technical Aspects of Border Management and the Role of Local Administration." The objective of the program was to focus to the local Governmental organizations for the better border management by enabling the local authorities with technical knowledge & relevant boarder information.

The program was inaugurated by the Secretary of the Ministry of Land Reform and Management, Mr. Gyan Darshan Udash. He addressed the function and offered valuable suggestions. The program was chaired by Director General of Survey Department Mr. Nagendra Jha. Regional Administrator of Central Development Region Mr. Udhab Baskota, Joint Secretary of the Ministry Mr. Krishna Raj B.C. , Chief District Officer of Parsa District, Mr. Kailash Kumar Bajimaya also addressed the function.Chief District Officers, Local Development Officers and chiefs of concerned regional, zonal & district offices were participants. Moreover chief of Nepal Army, Nepal Police, Armed Police Force, Survey Offices, Land Revenue offices, Urban Deevelopment and Building Construction Office of Bara, Parsa, Sarlahi, Rautahat and Chitwan district also participated in the function. Deputy Director General Mr. Madhu Sudan Adhikari and the Chief Survey Officers Mr. Deepak Sharma Dahal and Mr. Ramesh Rajbhandary presented papers in the function.

Similar program was organized in Nepalganj on 7th March 2013. The Secretary of Ministry of Land Reform and Management Mr. Gyan Darshan Udash was the Chief Guest of the function chaired by the Director General of Survey Department Mr. Nagendra Jha. Regional Director of Western Development Region Mr. Suman Sharma participated as special Guest of the function.Chief District Officers, Local Development Officers and chiefs of concerned regional, zonal & district offices were participants. Moreover chief of Nepal Army, Nepal Police, Armed Police Force, Survey Offices, Land Revenue offices, Urban Deevelopment and Building Construction Office of Nawalparasi, Rupandehi, Kapilbastu, Dang, Banke and Bardiya districts participated in the Programme. Technical papers were presented by Deputy Director General Mr Madhu Sudan Adhikari and Chief Survey Officers Mr Deepak Sharma Dahal and Mr Ramesh Rajbhandari.

Survey Office buildings under construction:

Survey Office buildings of Jhapa, Biratnagar, Dhanusha, Rautahat, Bara, Makawanpur, Chitwan, Bhaktapur,Kalanki and Surkhet are under construction as per the annual program of the fiscal year 2069/070. After the completion of these buildings 36 Survey Offices out of 83 will operate from their own buildings.

Improvement of Cadastral System: Scope in Nepal

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Keywords

Cadastral Survey, Total Station, Global Positioning System, Satellite Images.

Summary

The cadastral system in Nepal is developing continuously with gradual speed. Cadastralsurvey started with chain survey and in due course of time, plane table survey was adopted for the survey in spite of its limitations in accuracy and time. Currently, total station has been practiced in few municipalities for this purpose. The paper focuses on the probability of modern data handling technology; Total station, Global Positioning System (GPS), Participatory GIS and Remote Sensing as the appropriate technology for the improvement of existing cadastral system of the country. Current situation of the cadastral system and the technology used, its shortcomings and the suitability of the proposed data handling technology are discussed in the paper.

1. Introduction

Nepal has come through its long history in land survey and management. The land survey was started with the help of chain in 1930 B.S. (1873 AD). Gradually, structural development of the governmental offices working on land administration began and thus, map based land recording system was started after the establishment of Cadastral Survey in Bhaktapur district in 1980 B.S. (1923 AD) After Land (Survey and Measurement) Act, 2019 B.S. (1962 AD) came into effect with the objective of preparing up to date land ownership records that were essential for the collection of land revenue and information about the tenants, the maintenance of map based land records system came into practice. Plane table survey has been adopted and is commonly used for the cadastralsurvey. The problem with the technology is that it cannot give the expected accuracy and also is bringing lots of land disputes. However, the technology is not only the reason for such issues. Moreover, some of the maps are prepared in free sheets without control points, there is always problem in matching the cadastralof one sheet with another, bringing disputes among the villages and districts as well. However, thoughts are emerging to apply modern technology in this field. The paper analyses about some good options for the betterment of the cadastral system.

The objectives of the paper are:

- To analyze technology applied in the field of existing cadastral system in Nepal
- To identify shortcomings of the applied technologies
- To propose the better probable data handling technologies to improve the existing system

2. Cadastral system of Nepal

The cadastral system in Nepal mainly initiated to collect land revenue for the government by identifying the landowners and its tenants. Cadastre has been being gradually established district by district since 1964 (1907 AD) (*Acharya, 2011*).

During the time, cadastral survey was carried to identify the landowners, tenants and to determine the types of land. Three types of land are distinguished: (1) private, (2) public and government, and (3) trust (*Acharya, 2011*).

According to www.cadastraltemplate.org, cadastral systems in Nepal comprise the following major components:

- Cadastral Maps - The graphical cadastral maps at the scale of survey that are identified by the systematic map sheet number and included main features in the parcel.
- Field Book - The field book identify the landowner (s) of each parcel, which is based on the evidence produced during registration of the parcel.
- Land Ownership Certificate - Two copies of land ownership certificate are prepared, the official copy is termed as *Jagga Dhani Darta Sresta*, kept in office and the second copy is termed as *Jagga Dhani Darta Praman Purja*, distributed to the concerned owner.
- File Maps - During the process of land transaction when the parcel is too small and if it is not possible to plot in the map after fragmentation of the parcel, a file map of this parcel will be prepared in a separate sheet in larger scale.
- Plot Register - Plot register is information of each parcel which has been fragmented.

At present, the concept to convert these cadastral maps into computer based digital form has been developed and started in some of the districts. The cadastral maps of 52 among 83 district survey offices have been digitized. The customized application of Arc map termed as SAEx (Spatial Application Extension) has been used for this purpose. However, lack of continuous update of the digital database during the course of transaction has made the database out of date.

2.1 Status of Cadastral Survey

During the initial stage of cadastral survey, nationwide geodetic network was not available and hence the cadastral survey for 38 districts was carried out in the free sheet which is also called as island maps (*Figure 1*). The scale of the map was 1 inch to 100 feet. As the network of national control system was established, cadastral survey for remaining 37 districts was done on the controlled sheet (*Figure 2*).

Figure 1: Cadastral map in free sheet

Source: Acharya, 2011

Figure 2: Cadastral map in controlled sheet
Source: Department of Land Information and Archives

Recently, resurvey of one district among 38 has been completed in controlled sheet. Preparation of a series of cadastral maps of the whole Nepal has been completed with mapping of villages as single block (*Adhikary, 2002*). The total number of parcel is 24,300,000 (approx. including village blocks). Approximately, 9000 ha of village blocks are remaining to be surveyed. A concept has been developed to carry out the survey using Total Station so that it reduces the number of disputes, increases the accuracy of mapping and supports the establishment of land information system (parcel based cadastral information system). The program has been implemented in two municipalities (Banepa and Dhulikhel) since 2006 AD (cadastral survey finished in Banepa).

2.2 Data Handling Technology

2.2.1 Cadastral Survey

Cadastralsurvey was started using chain in the ancient time. Gradually, the technology shifted from chain to plane table survey. By then the plane table became commonly adopted technology for cadastral survey. Initially, since geodetic control points were not established, cadastral survey was done in free sheets as island maps in the scale of 1 inch to 100 feet. 38 districts among 75 were surveyed in free sheets. Initiation of the network establishment started from 1967 (1910 AD)(*Adhikary, 2002*). A geodetic control network having different orders has been established throughout the country by triangulation method. Then after, the cadastral survey was conducted in controlled sheet using fourth order control for the remaining 37 districts. Resurvey of one district was completed in controlled sheet. Thus, now 37 districts in free sheet and 38 in controlled sheets.

The different scales of the cadastral maps prepared in controlled sheets are 1:2500 scale maps for the agriculture land, 1:1250 scale maps for the semi urban land and 1:500 scale maps for the urban land (*Adhikary, 2002*) with permissible error of 62.5cm for 1:2500, 31.25cm for 1:1250 and 12.5cm for 1:500 scales (*Department of Survey, 2003*).

Since plane table have some constrains in aspects of time, cost, clarity and security, use of total stations for cadastral surveying has been practiced in two municipalities. Parcel Editor, customized software for Arc map is used to process the data acquired by total station. 100 Total Stations obtained from Japan Non Program Grant Assistance (NPGA) have been distributed to different district survey offices for the further extension of the technology in other parts of the country.

2.2.2 Shortcomings of the technology used for cadastral survey

Any country follows the technology on the basis of their affordability, ability and need of it. Further, cadastre contain more data on land (also none legally recognized interest) which may not have official character (*Dekker, 2003*). So, the success of the cadastral system can be measured in different criteria as clarity, security, timelines (and completeness), fairness and cost (*Williamson, 1994)*. In spite of the limitations in security, clarity, durability and accuracy, Nepal adopted the plane table survey because advanced technology were very costly and at that time there were not enough human resources trained in other advanced technology. However, plane table survey has different shortcomings as follows:

- **Old technology**: It is very old technology which requires extensive field work as well as office work.
- **Time consuming**: The survey task consume huge amount of time since the surveyor needs to go to field and the helpers with staff needs to go around every parcel. Then in the office, he need to do inking over the lines drawn in the field thus need to give double time for single parcel.
- **More human resources required**: Surveyor himself can never complete the cadastral survey. He needs helper to hold the staff. In the case of Nepal, in the hilly areas, surveyor also hires helper to carry the equipments thus increasing the need of human resources.
- **Costly:** Cost of equipment may be less in comparison to modern technology but the operation cost meets with that of the modern technology. Cost of materials, cost for extra human resource, abstract cost for time and accuracy makes it more costly.
- **Less effective and inefficient for handling:** The area of the parcel is calculated manually. So we may not get the desired accuracy. The original map is prepared within some permissible error. When we do inking over it, the error is never minimised but the same or rather increases. Also the accessories of the plane table are quite inefficient for handling. Today, all the modern technology had replaced the technology and we may not find the accessories of plane table survey like telescopic alidade for maintenance in future if required.
- **Customer's dissatisfaction:** The cadastral survey in Nepal was started in 1964 A.D. with an objective to implement Land Reform Policy and to generate land revenue. At that time land value was low and the methodology of mapping adopted was suitable to meet the requirement

of national policy. In one way or other these cadastral maps have served as a basis of fiscal cadastre. The ever increasing demand of public regarding the more accurate cadastral maps for legal purpose is hard to be addressed by the current cadastral maps.

- **Less secure: physically and technically:** Since the maps produced by plane table survey is graphical paper map, it is not secured physically to arrange in the place or duplicate storage to make it safe from any sort of disaster and also to ensure that unauthorised person cannot damage or change the information. According to Cadastre 2014, "Paper and Pencil – Cadastre" will have gone (*Kaufmann and Steudler, 1998*). So plane table survey is technically unsecured as well. We may not have the equipments, neither pen, ink nor paper in future.
- **Weather dependent:** The survey is totally weather dependent. We cannot work on rainy days, neither on foggy days. Also because of shimmering problem we may not be able to do the survey in mid sunny day.

3. Choice for Data Handling Technology

Accuracy, the degree of conformity with set standards, is observed in cadastral surveys which are very important because, among other things, it helps surveyors to determine equipments and methods to use (*Eugene, 2005*). The options available to the surveyor for carrying out a cadastral survey are either ground survey methods or aerial survey (including remote sensing). The choice depends on the basis of equipments needed, techniques used, accuracy requirements, personnel, time and cost necessary to accomplish the surveys. Graphical (plane table) method has been useful in the past. New sophisticated, scientific and advanced technological instruments which are faster, more accurate and cheaper, have came over the past. However, we should not forget the reality that many of the systems appropriate for developed western countries are neither appropriate nor can they be afforded by developing countries and the major obstacles to cadastral system tend to be management issues, not technological issues (*Williamson, 1994)*. Still, four of the best suited alternate for earlier technology are discussed below.

3.1 Total Station

Application of total station in cadastral survey is increasing. This is highly efficient and accurate for parcel cadastralsurvey (*Tuladhar, 2005*). The technology can be applied for urban as well as rural area in spite of its minor disadvantages. The major limitation for the application in Nepal is the lack of the professional with limited knowledge in handling this technology. As for example if we compare between the cost of operation for this technique and the traditional plane table survey, it remains almost same if we don't consider the price of instrument. It further gives improved accuracy of cadastre and also requires less time for data post processing. Since it gives the digital data, we don't further need to worry about digitizing the acquired data. Also, another positive part is that we can get both numerical and graphical data at a single time.

It provides positional accuracy in centimeter and can be applied for measuring fixed boundaries. It provides better accuracy compared to other traditional techniques. By using this technique, required accuracy (12.5 cm or less) can be achieved. Thus only the trained manpower are required to adopt this technology.

3.2 Global Positioning System (GPS)

The use of GPS has changed the ways surveys and thus can be used in the same way as electronic total stations and direct measurements made between corners and returns directly computed values from the observed baselines (*Londe, 2002*). This is another alternate technology for efficient and accurate parcel cadastralsurvey (*Tuladhar, 2005*). Real Time Kinematic (RTK) GPS is the tool that could survey more points in less time. An accuracy of centimeter level can be obtained from this technology. Reference stations and phase measurements are needed to achieve this accuracy. On the basis of active reference systems connected with telecommunication network, precise coordinates can be acquired which is very useful for cadastralsurveying. Since high accuracy is highly costing, cadastral surveys with this method may be more costly. Availability of control point network all over the country is the positive aspect for the application of GPS.

By this technology, cadastral survey can be done quickly without an additional control point surveying and works out an accurate result of centimeter level without environmental limitations (*Ji-jeon, 2010*). The technology is best preferred in open terrain. In cases where sky obstructions were high, GPS-RTK can have some problems with receiving the signals. However, offset method can be employed to overcome the problem (*Mustafa and Khairudin, 2004*). The technology can come up with output of centimeter accuracy which meets the required accuracy but bit expensive with respect to accuracy.

3.3 Remote Sensing

The use of high resolution remote sensing data like of Quickbird, Geo Eye and IKONOS can greatly enhance the on scale map generation and verification (*Alexandrov et. al, 2004*). The use of satellite images is considerably less expensive than the aerial pictures (*Oğuz, and GAZİOĞLU 2006)*. It can be used mostly for rural area where land value is low and small scale (1:2500) cadastral map is sufficient. Use of remote sensing may give relatively rapid, cost effective and mass production in comparison to field survey techniques and further advantages are provision of historical records (*Tuladhar, 2005*). However, since the cadastral survey of whole country is already finished and digitization of the analogue maps are on the way, the technology can be used more focusing on updating the existing cadastral maps.

According to Alexandrov*, et. al (2004),* the difference between superimposition of vector objects from the available cadastral information over the ortho-rectified image are within the obtained maximal displacement and RMS error. Extraction of the parcel cadastralcan be done more easily in multi-spectral bands and the spatial objects such as buildings, roads, rivers and other physical objects are easily extracted from both multi-spectral and panchromatic bands (*Tuladhar, 2004).* Regarding cost for satellite image, there are other organizations which have satellite images funded for different projects and that can be shared. For the technical cost (software), Free/ Libre Open Source Software (FLOSS) can be adopted.

3.4 Participatory GIS

Participatory GIS are cost effective and considered to have superior effects in terms of relevance, usefulness, sustainability, empowerment and meeting good governance *(McCall, 2004)*.This is the technique where local people are also involved in preparation of the maps. This approach can be used to re-establish the destroyed land records. Good example can be seen through the successful completion of land records re-establishment of different districts like Mugu, Khotang, Palpa etc. where official copy of land ownership certificate (Sresta) were re-established from the proof of the ownership provide by the respective owners. However, resurvey was not done in these areas. Regarding the cost, in comparison to above stated techniques, it is cheap since openly available google maps can be used for this purpose. Printed google images can be taken to the field and demarcation of the cadastralcan be made in the field with close consultation with the local people. This approach is more people centered than technological as it focuses on incorporating community views and understanding in GIS *(Mandara, 2007).* Thus, this technique can be used for example, resurvey of Achham/Arghakhanchi where maps were destroyed during the conflict and need to be resurveyed. Since local people are directly involved in cadastraldemarcation, cases of land dispute also decrease. The technology may not be suitable for cadastral survey of the urban area but could be very efficient where quick rehabilitation or re-establishment of land records are required like that of destroyed area. The approach has been successfully implemented in Ethiopia. Enhanced technology is the use of digital pen. The surveyor goes to the field with the printed image and the pen. There, he digitizes the cadastralin presence of community which reduces the time for re-digitizing.

4. Conclusion

Since the development of cadastral system is very gradual with the use of plane table survey, quick action is necessary to shift the development of cadastral system and thus appropriateness of the four advanced technology are discussed. Without introducing modern technologies in the field of cadastral survey, improvement of cadastral system will never be efficient and effective. The options can have priority according to the accuracy, time, cost and security of the system.

References

Acharya, B.R., 2011, Statutory versus Customary, Institutional Weaknesses in Nepal, GIM International, volume 25, No. 1.

Adhikary, K.R., 2002, Global Positioning System on Cadastral Survey of Nepal,23rd Asian Conference in Remote Sensing 2002, Nepal.http://www.a-a-r-s.org/acrs/proceeding/ ACRS2002/Papers/GIS02-3.pdf (Accessed on 4th February 2011).

Alexandrov, A., Hristova, T., Ivanova, K., Koeva, M., Madzharova, T., Petrova, V., 2004, Application of Quickbird Satellite Imagery for Updating Cadastral Information, http://www.isprs.org/proceedings/XXXV/congress/comm2/papers/160.pdf, (Accessed on 8th February 2011).

Dekker, H.A.L., 2003, The Invisible Line: Land Reform, *Land Tenure Security and Land Registration, Ashgate Publishing Ltd., ISBN 0 7546 36372.*

Department of Survey (DoS), 2003, Cadastral Survey Directive, 2003.

Eugene, H. S., 2005, Searching for an Affordable and Acceptable Cadastral Survey Method, FIG Working Week 2005 and GSDI-8, Cairo, Egypt April 16-21, 2005.

Ji-yeon, J., 2010, Use of Network RTK using VRS for a Cadastral survey on Islands, FIG Congress Sydney, Australia, 11-16 April 2010, http://www.oicrf.org/pdf.asp? ID=9110(Accessed on 8th February 2011).

Kaufmann, J. and Steudler, D., 1998, Cadastre 2014-A Vision for a Future Cadastral System, International Federation of Surveyors (FIG).

Londe, M. D.,2002, Standards and Guidelines for Cadastral Surveys Using Global PositioningMethods, FIG XXII International Congress Washington, D.C. USA, April 19-26 200, http://www.fig.net/pub/fig_2002/JS2/JS2_londe.pdf (Accessed on 8th February 2011).

Mandara, C. G., 2007, Participatory GIS in Mapping Local Context of Conflicts over Pastoral Resources: A Case Study of Dure Haitemba-Babati Tanzania, Faculty of Geoinformation Science and Earth Observation (ITC/UT) Enschede, the Netherlands.

McCall, M. K., 2004, Can Participatory GIS Strengthen Local Level Spatial Planning? Suggestions for Better Practice, Seventh International Seminar of GIS in Developing Countries Malaysia, May 10-12, 2004, http://www.gisdevelopment.net (Accessed on 1st February, 2013).

Mustafa, D. S., and Khairudin, A., 2004, Experiencing the Use of GPS-RTK for Cadastre Surveys in Malaysia, 3rd FIG Regional Conference Jakarta, Indonesia, October 3-7, 2004, http://www.fig.net/pub/jakarta/papers/ts_14/ts_14_3_subari_anuar.pdf, (Accessed on 8th February 2011).

Oğuz, K. and GAZİOĞLU, S., 2006, The Availability of the Satellite Image Data in Digital Cadastral Map Production, XXIII FIG Congress Munich, Germany, October 8-13, 2006, http://www.fig.net/pub/fig2006/papers/ts90/ts9003_kansu_gazioglu_0551.pdf (Accessed on 8th February 2011).

Tuladhar, A.M., 2004, Parcel Based Geo-Information System: Concepts and Guidelines. PhD Thesis, TU Delpth, ISBN 90-6164-224-8, ITC Dissertation series no. 115.

Tuladhar, A. M., 2005, Innovative Use of Remote Sensing Images for Pro Poor Land Management, UNESCAP, Thailand, 8-9 December, 2005.

Williamson, I., 1994, Cadastral System in the Asia Pacific Region-Experiences and Lessons, FIG Land Records Conference/ Geomatics Atlantic `94 Conference, Fredericton, Canada, October 1994, http://www.geom.unimelb.edu.au/research/publications/ IPW/ipw_paper15.html, (Accessed on 8th February 2011).

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  Wider understanding of current
  Technology Trend
  9-15 June 2013
  Tokyo, Japan

Object Based Land Cover Extraction Using Open Source Software

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Keywords

Land Cover, OBIA, Segmentation, Spring

Abstract

Land cover is observed bio-physical cover of the earth's surface and is an important resource for global monitoring studies, resource management, and planning activities. Traditionally these land resources were obtained from imagery using pixel based image analysis. But with the advent of High resolution satellite imagery and computation techniques these data are now widely being prepared using Object based Image Analysis (OBIA) techniques. But mostly only algorithm provided in commercial software and Ecognition in particular is being used to study OBIA.

This paper aims to assess the application of an open source software Spring for OBIA. In this Study 0.5 meter pan sharpened Geo-Eye image was classified using spring software. The image was first segmented using region growing algorithm with similarity and area parameter. Using hit and trail method best parameter for segmentation for the study area was found. These objects were subsequently classified using Bhattacharya Distance. In this classification method spectral derivatives of the segment such as mean, median, standard deviation etc. were used which make this method useful. However the shape, size and context of the segment can't be accounted during classification. i.e. rule based classification is not possible in spring.

This classification method provides satisfactory overall accuracy of 78.46% with kappa coefficient 0.74. This classification method gave smooth land cover classes without salt and pepper effect and good appearance of land cover classes. However image segmentation and classification based on additional parameters such as shape and size of the segment, contextual information, pixel topology etc may give better classification result.

1. Introduction

The most common application of remote sensing is to produce thematic maps, such as those depicting land cover, using an image classification. Simply, land cover (LC) refers to the things what we see through the eyes covering the land. It is the observed (bio)-physical cover of the earth's surface (Di Dregorio & Jansen, 1997). It is the complex mixture of natural and anthropogenic influences and is the composition and characteristics of land surface elements (Cihlar, 2000). These natural and anthropogenic influences results into the classes such as forest, water, wetland, agriculture, built-up etc. in the land cover map.

Knowledge of land cover is an essential component for modeling the earth as a system and is important for many planning and management activities.

Extraction of land cover information from satellite imagery can achieved either by visual image interpretation or using digital image classification approaches. The first global land cover map compiled from remote sensing was produced in 1994 from maximumlikelihood classification of monthly composited AVHRR normalized difference vegetation index (NDVI) data. . (Defries & Townshend, 1994)

Image classification is traditionally done using pixel based classification approaches. But the continuously improving spatial resolution of remote sensing (RS) sensors sets need for development of new methods utilizing this information to making the accurate land use map. In high resolution satellite imagery it is possible to extract information using additional variables such as shape, texture, and contextual relationships besides grey value of pixel which is known as Object Based Image Analysis (OBIA). Assessing the properties of segments by using spatial, spectral and temporal scale is Object Based Image Classification (Blaschke, 2009). The main premise of OBIA is that image pixel are first grouped into objects that corresponds to the real world feature and subsequently classifying these objects based on shape, size, texture, pattern and statistical derivatives of spectral value of objects.

Significant researches have been done in past years about OBIA but most of them used commercial software and Ecognition in particular. Thus this paper aims to highlight the application of an open source software Spring for OBIA of High Resolution Satellite Imagery. The objectives of this study are to

ι) Classify High resolution image using OBIA to extra land cover applying open source software.

ιι) To assess the accuracy of this classification method

2. Study Area and Data

The study area of about 6 km * 7 km is selected a portion of Chitwan and Nawalparasi district of Central development region. River Narayani flows from the boundary of above two districts The study is heterogeneous with all major land cover types such as wetland, forest, built-up, agriculture land, river, pond, etc. The study area lies in extent between $27^0$38’48” latitude and $84^0$19’22” longitude to $27^0$42’39” latitude and $84^0$23’03” longitude.

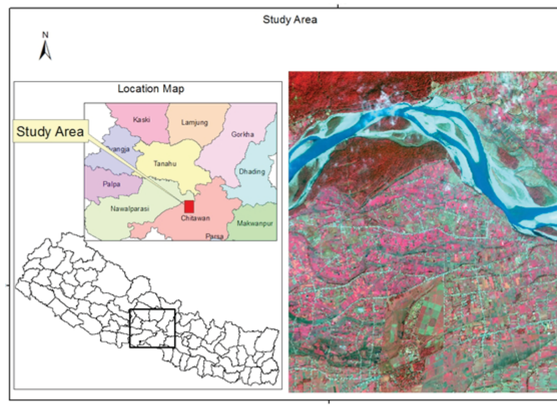

Figure 1: Study Area

Major data that was used in this project was GeoEye image of the study area. It contained Red, Green, Blue and NIR bands. The spatial resolution for panchromatic image is 0.5 m and that for multispectral band is 2.0 m. The dynamic range of each band is 11 bit. The image was acquired on 27th December 2010. We obtained the image of our study area from National Land Use Project based in Thapagaun in Kathmandu valley.

Other data used in this study is topographic data produced by Survey Department.

3. Methodology

Image Preprocessing

Preprocessing is done before the classification of image to remove and minimize the radiometric and geometric errors. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. Geometric corrections include correcting for geometric distortions due to sensor-Earth geometry variations, and conversion of the data to real world coordinates. (Janssen, Weir, Grabmaier, Kerle, Parodi, & Prakash, 2001). Road layer of topographic map was used for the rectification of the satellite image. Road junctions were identified in the image and 12 such points were used. Affine transformation was used to generate new grid for the rectified image. To assign the pixel value for these grids nearest neighborhood algorithm was used.

Image transformation was also used for extraction of features during classification. NDVI, NDWI and Grey-Level Co-occurance Matrices (GLCM) texture were derived for different bands for achievement of higher accuracy in image classification.

Segmentation

Segmentation is defined as the process of completely partitioning a scene (e.g. a remotely sensed image) into non overlapping regions in scene space (e.g. image space) (Schiewe j., 2002). The basic task of segmentation algorithm is the merge of (image) elements based on homogeneity parameter or in the differentiation to neighboring regions (heterogeneity), respectively (Schiewe J., 2002).

Region growing algorithm of Spring was used for segmentation in this project. It makes object with parameter defined by similarity and area. In this algorithm segmentation process starts with seed points. Then similarity criteria are computed for each spatially adjacent region. The similarity criteria are based on a statistical hypothesis test, which checks the average among regions. Then regions are merged into bigger objects as long as the cost is below the similarity value. For the union of two neighbor regions A and B, the following criteria are adopted in spring:

- A and B are similar (average test);
- The similarity reaches the limit defined;
- A and B are spatially close (among the A neighbors, B is the closest, and among the B neighbors, A is the closest).

While segmenting experiment with different parameters was done. Human interpretation and correction is considered as the best way to evaluate the segmentation (Fardia, Royta, Shawakat, & Husnain, 2005) and thus we also followed the same approach to evaluate the segmentation results.

Different parameters for segmentation were tested by hit and trial method until the objects obtained relatively matched the land cover patches.

Figure 2: Segmentation with parameter 10-50

Segmentation with similarity 25 and area 40 (Figure below) worked best in image used in this project. It gave the best compromise between the number of objects and individual land cover information. So the study area was segmented using this parameter.

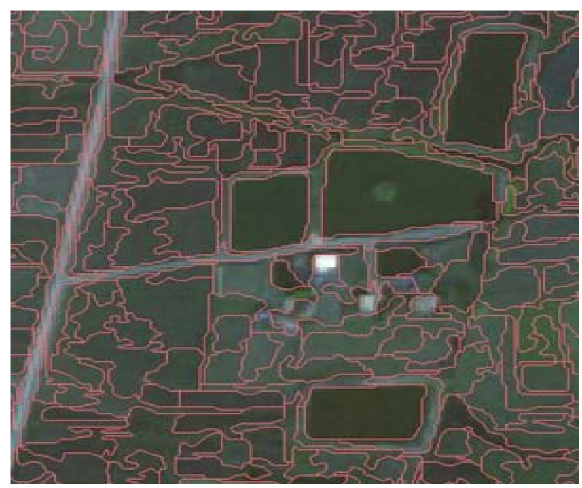

Figure 3: Segmentation with Parameter 25-40

Object Based Image Classification

Supervised classification using Battacharya algorithm was done for this study. Priori classification with seven land cover classes viz. Bare Cultivation, Built-up, Green Cultivation, Forest, Water, Wetland and Sand were selected for the classification. For this first the training data had to be provided. In statistics, the Battacharya distance measures the similarity of two discrete or continuous probability distributions (Battacharya, 1943).That is, it measures the average distance between the spectral classes' probability distributions. The misclassified objects were reassigned to its proper class in the training data and again reclassification was performed in order to refine the land cover classes.

As, it is a supervised classification process which unifies advantage of manual and statistical approach, rather than delineating training areas sample objects are iteratively selected. These sample objects should have the most representative and clearly distinguished features (Lang, 2005).

RESULT AND DISCUSSION

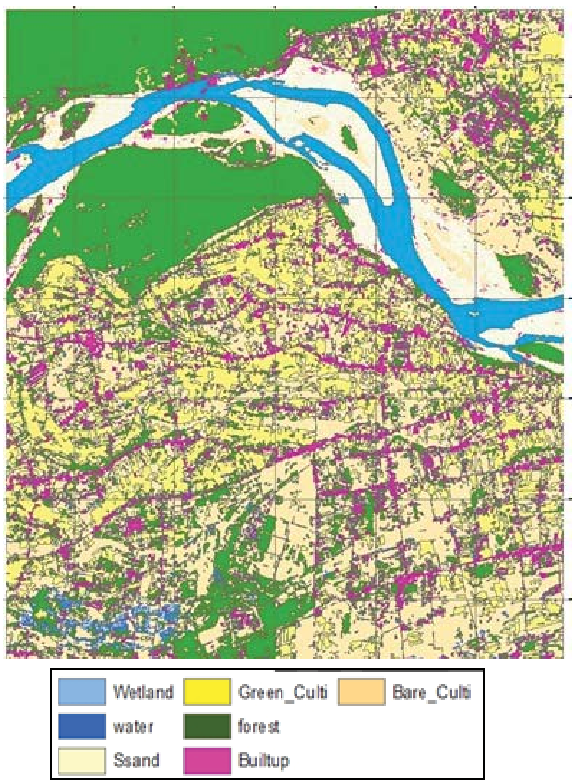

Figure 4: Land Cover

In this study we perform object based image analysis by making object based on size and similarity parameter and classifying them based on the spectral values and their statistical derivatives. This classification method gave smooth land cover classes without salt and pepper appearance. Figure 4 shows the classification result of OBIA with various land cover distribution in map and Figure 5 shows the pattern of land cover in the study area statistically.

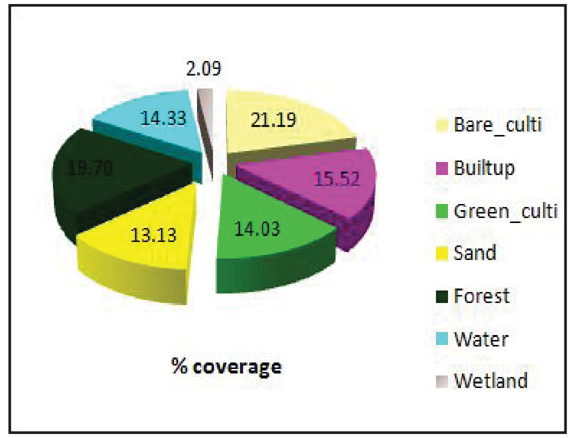

Figure 5: Land Cover Pattern

In order to assess the acuracy, 150 sample points of ground truth collected randomly in the field weere used. The overall accuracy and Kappa statistics from the classification (Table 1) shows that the method can be used for assessemnt of landcover classification. The classification has overall accuracy of 78.6% and Kappa coefficient of 0.74 showing that the results fit the purpose. The higher accuracy of water and forest is due to result of the use of indices such as NDVI, NDWI and texture as supplement in image classification.

Table 1:Confusion Matrix

Accuracy	Land cover types						
	Bare_ Cultivation	Builtup	Green_ Cultivation	Sand	Forest	Water	Wetland
User's accuracy (%)	59.42	83.82	86.11	97.06	65.71	97.56	100.00
Producer's accuracy (%)	87.23	85.07	56.36	70.21	95.83	80.00	63.64
Overall accuracy= 78.46% , Kappa Coefficient= 0.74							

CONCLUSION

Thus this method of OBIA using open source software Spring provides satisfactory overall accuracy of 78.46% with kappa coefficient 0.74. Since real world object are assigned to a class one can get accurate and good visual appearance land cover patches.

The major limitations while classifying using this method is that the shape, size and context of the segment can't be accounted during classification.

Therefore rule based classification is not possible in spring. However spectral derivatives of the segments such as mean, median, standard deviation etc. can be used which makes it useful. The limitation however was accounted by the use of image derivatives such as NDVI, NDWI and GLCM texture.

Land cover classification using free and open sources software greatly reduces the cost of remote sensing applications. But such software requires patience and extensive troubleshooting. Some computer skills are required to make this process successful. Functionalities and algorithms in Spring are also limited in comparison to other commercial image analysis software. Image segmentation and classification based on additional parameters such as shape and size of the segment, contextual information, pixel topology etc may give better classification result. However these functionalities can be added to Spring since it is an Open Source Software.

References

Battacharya, A. (1943). On a measure of divergence between two statistical populations defined by their probability distributions. Bulletin of the Calcutta Mathematical Society , 99-109.

B Blaschke, L. t.(2006). Object based image analysis for automated information extraction. ISPRS Journal for Photogrammetry and Remote Sensing .

Cihlar, J. (2000). Land Cover Mapping of Large Areas from Satellites:Status and Research Priorities. International Journal of Remote Sensing , 1093-1114.

Defries, R., & Townshend, J. (1994). NDVI derived land coverclassification at global scale. International Journal of Remote Sensing , 5.

Di Dregorio, A., & Jansen, L. (1997). A New Concept for a Land Cover Classification System. Alexzendria.

Fardia, P., Royta, N., Shawakat, A., & Husnain. (2005). Evaluation of Aster Spectral Bands For Agricultural Land Cover Mapping Using Pixel-Based And Object-Based Classification Approcah.

Janssen, Weir, Grabmaier, Kerle, Parodi, & Prakash. (2001). In Principles of Remote Sensing (pp. 129-155). Enschede: The International Institute of Geo Information Science and Earth Observation.

Schiewe, J. (2002). Segmentation of High Resolution Remotely Sensed Data Concepts, Application And Problems. Germany.

Schiewe, j. (2002). Segmentation of high-resoluiton remotely sensed data . ISPRS Journal of Photogrammetry and Remote Sensing .

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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 remembered them for their contribution towards the achievement of the goal of the department.

1. Late Mr. Rajendra Rajak - Surveyor
2. Late Mr. Jitendra Prasad Yadav - Surveyor
3. Late Mr. Rajesh Prasad Pandit - Surveyor
4. Late Mr. Ram Tapeshwor Pandit - Helper

Price of some of the publications of Survey Department

1. List of Geographical Names volume I to V - NRs 600/- for each volume.
2. Nepalese Journal on Geoinformatices - NRs. 100/-
3. The Population and Socio-economic Atlas of Nepal (Hard Copy) NRs. 2,500 (In Nepal), € 200 (Out side Nepal)
4. The Population and Socio-economic Atlas of Nepal (CD Version) NRs. 250/-

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Price of Maps

S.No.	Description	Coverage	No. of sheets	Price per sheet (NRs)
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2.	1:50 000 Topo Maps	HIgh Mountain and Himalayan region of Nepal	116	150.00
3.	1:50 000 Land Utilization maps	Whole Nepal	266	40.00
4.	1:50 000 Land Capibility maps	Whole Nepal	266	40.00
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7.	1:250 000 Climatological maps	Whole Nepal	17	40.00
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19	VDC/Municipality Maps A4 Size	Whole Nepal	4181	5.00
20.	VDC/Municipality Maps A3 Size	Whole Nepal	4181	10.00
21.	Orthophoto Map	Urban Area (1: 5 000) and Semi Urban Area (1: 10 000)	-	1 000.00
22.	Administrative Map	Nepal	1	5.00

Price of co-ordinates of Control Points

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Bench Mark	Third Order	Rs 250.00
Gravity Point	-	Rs 1 000.00

Potential Use of GPS Technology For Cadastral Surveys in Nepal

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Keywords
Cadastral Survey, GNSS, GPS, RTK

Abstract

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

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

1. Introduction

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

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

In Nepal cadastral survey of all 75 districts of the country was completed in 1995/96 using traditional graphical method with plane tables and telescopic/ plane alidades. Derived information from the existing maps now are obsolete and do not fulfill the needs of the general public. An innovative survey technique must be adopted for the preparation of new series of cadastral maps for the country in order to create up-to-date land information database.

The traditional graphical surveying methods are now very expensive and would take a long time. In most developed countries GPS survey methods are gradually replacing the traditional field survey works. GPS technologies for cadastral mapping have been applied in many developing nations of the world (e.g. Zimbabwe, India, Malaysia etc.) for the last few decades. RTK GPS technology, one of the latest technologies in the field of digital mapping, will provide accurate cadastral maps with relatively in short period of time and could be reasonably inexpensive. GPS technology probably could be another surveying tool for digital cadastral mapping as well as for developing land information systems for the country like Nepal. It has been noted that the accuracies of the observed points using RTK GPS technology are comparable to those obtained by conventional EDM/Total Station surveying for most cadastral purposes (Wan et al., 1999). Potential use of GPS technology for the preparation of new series of cadastral maps and developing land information systems in Nepal is briefly illustrated in this paper.

2. Need of Technological Changes in Cadastral Surveys in Nepal

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

3. Justification for GPS Cadastre

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

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

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

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

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

4. Basic Concepts of GPS Surveying

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

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

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

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

4.1 Kinds of GPS Receivers

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

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

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

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

4.2 Static and Real-Time Kinematic DGPS

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

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

5. Need to Develop Guidelines for GPS Surveys in Nepal

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

6. GPS Surveys for Control Networks in Nepal

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

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

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

7. General Processes in GPS Technique in Cadastral Surveys

7.1 Equipment Calibration

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

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

7.2. Establishing Control Points

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

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

7.3. RTK GPS Cadastral Field Procedures

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

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

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

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

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

7.4. Post-Processing of GPS Observed Data

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

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

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

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

8. Limitations of GPS Cadastral Survey

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

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

9. Some Recommendations for GPS Cadastre

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

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

References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Replacement of Professional Photogrammetric Workstations with Low Cost or Free of Charge Photogrammetric Software and Services for Image Triangulation and Image Matching

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Keywords

Free Software, Image Triangulation, Image Matching, 123D Catch, PMVS, MATLAB, PMVS, RANSSE, PCM

Abstract

In the modern context of digital technology in the field of surveying and mapping, the technique of digital photogrammetry plays crucial role in all steps of mapping. There are some very expensive as well as low cost and free softwares are available in the market for professional photogrammetric work stations. The image triangulation and image matching is one of the very important steps of photogrammetry for which LPS as a commercial software is available in market. There are some low cost and free software as 123D Catch and Patch Boased Multi View Stereo Softwear (PMVS) also available. So, this paper mainly deals with the accuracy as well as the performance of those software for aerial triangulation and image matching for airborne image data to substitute commercial software for photogrammetric workstations. The accuracy assessment of image orientation, points cloud as well as DSM generated from those points cloud are also performed and compared with all products of LPS as commercial software.

1. Introduction

Photogrammetry is very important nowadays because it is the science of using 2D measurements to extract 3D information about position and geometry of the object (Goldbergs, 2012). There are many products of imagery as 3D city model, land use planning map, landscape map, environmental change application etc that directly or indirectly depend upon photogrammetry products and services (One, 2009). The importance of photogrammetry is also due to the fact that it provides updated digital data quickly for large area coverage.

Digital photogrammetry can be used with digital images as well as scanned photographs. It provides stereoscopic viewing with overlap photographs. It is possible to make 3D measurements very precisely from it. From the few decades' history of photogrammetry, it can be seen that the development of computer technology also advanced the photogrammetry in the area of instrumentation, methodology and integration. Current mapping system of photogrammetry is based on personal computer and workstation environment (Madani, 2001).

Image triangulation provides the exterior orientation parameters of two or more overlapping images. Image matching establishes correspondence between pixels or feature points in two overlapping images. Image orientation and image matching process and production of 3D information is very important to demonstrate and to solve many real world problems.

In production of objects information from image, there is need of reliable software. Some of that software has fully automated functionalities and some are semi-automated. So it needs availability of free or low cost software with support for automated methods to keep costs within reasonable bounds. The software should seek to provide not only this object's information but also provide quality results in semi-automatic or fully automated algorithms. There are different types of softwares packages available in the market which does not contain information on how accurate they are in image triangulation and image matching object measurements to guarantee their reliability and possible comparison with the conventional in most cases cost prohibitive software packages.

Further work needs to be done to see how accurate these free/low cost software are in image triangulation and image matching as well as 3D topographical objects measurements. There are many software available in the market either they are free or low cost or fully commercial. Their performance and accuracy are also different to each other. The Autodesk product 123D Catch (Autodesk, 2012), and PMVS (Furukawa, 2010) software are also available free and low cost. 123D catch software is used for image matching in local coordinates system it computes the 3D scene. PMVS is used for dense point cloud production. This paper tries to test their performance in comparison with fully commercial software as ERDAS LPS. These free softwares are user friendly and also support all familiar operating systems which need for image triangulation and image matching.

2. Image Orientation

The image orientation determines the mathematical relation between the object (terrain) and the image coordinates. The main task of image orientation is to reconstruct the geometric relations between an object point (U, V, W) and its image (X', Y') co-ordinates by calculations based on the collinearity equations. Aerial triangulation is a process of assigning ground coordinates to a sufficient number of image points in the photogrammetric models for a large number of photographs. The aim of aerial triangulation is to determine the parameters of exterior orientation (and additional parameters by self calibration) of a block of images and simultaneously the object coordinates of the points tie, check and control points (Goldbergs, 2012).

This paper tries to demonstrate four major steps for addressing the problem. The tasks are data preparation both image data and ground control points data, image orientation and image matching from both free or low cost software and LPS software, accuracy assessment, DSM creation and comparison.

3. Workflow

Resampled images are uploaded into 123D Catch software. It provides web services for computing 3D scene and provides automatic image matching in local coordinate system. The oriented image in 123D Catch as a scene is exported in .rzi file. The exported .rzi file is used for separate bundle block adjustment in PMVS software for dense point production. In parallel the image orientation is done with original images in LPS software and dense point cloud production is also performed. Some locators has already measured in 123D Catch software to determine the transformation parameters as well as check the accuracy of image orientation and matching. The corresponding global coordinates of locators are measured in LPS project. The point clouds obtained in local coordinates system from 123D Catch, PMVS are transformed into global coordinate system using code written in MATLAB software. Finally, DSM is created from all three sets of points clouds and accuracy assessment is performed.

The local coordinates are measurement indices into a local coordinate space. It is useful for their ability to model independently transformable aspects of geometrical scenegraphs (Wikipedia, 2012b). The global coordinate system is constructed to match the surface of the earth (Commission, 2012).

The workflow diagram for all process is as follows:

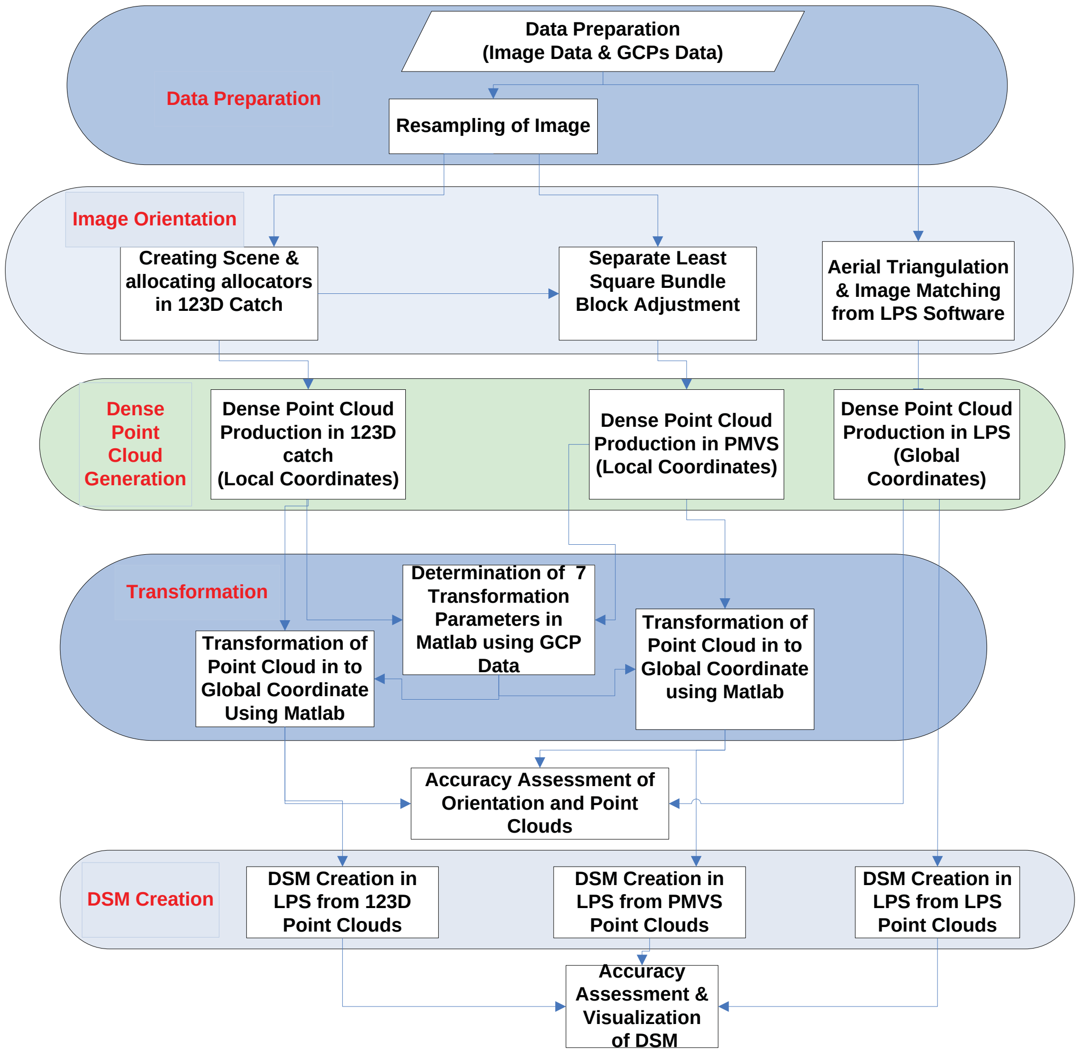


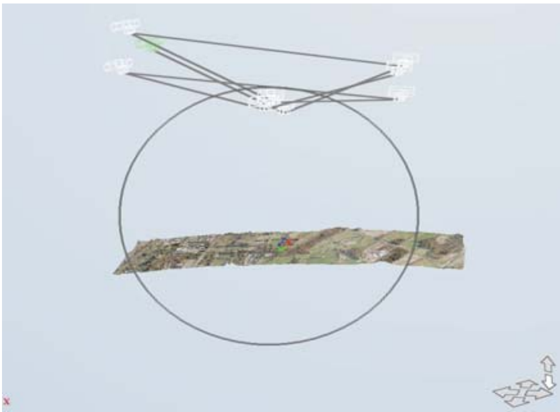
Figure 1: Applied methodology

4. Image Orientation Using 123D Catch Software

The resampled and fiducial marks cropped image data are used for orientation in 123D catch software. The next step is the orientation of the images and creation of the true 3D model of images. For, this the sequence of images in the same sequence of capturing is uploaded into 123D catch software.

This software provides web services so the resampling of images is necessary to reduce the volumes of images for convenience to upload and downloading. After a while it provides 3D scene ready, in which orientation is done by software without announcing the procedure. But normally it uses the "Structure From Motion" (SFM) algorithm (Snavely, 2010), in which the 3D structure is extracted through the two consequence images, considering the correspondence points in images and extracting the camera geometry or corresponding geometry of images (epipolar geometry). The corresponding points are founded by SIFT algorithm. In this procedure, the scale and rotation and illumination deformation of camera and picture capturing devise are not necessarily stable. But as we know, in this method so many wrong points are selected, so we use RANSAC algorithm to detect and eliminate the wrong correspond points.

There are other algorithms than SFM, to calculate the orientation parameters through the correspondent points. The outputs of 3D scene from 123D Catch software with position of aerial camera and locators are shown below:



a

b

Figure 3: 3D scene of Enschede, The Netherlands image with camera position in (a) and locators in (b)

After computing the 3D scene in 123D Catch some well defined reference points are selected and best matches of them in several images are found. Locators (it is three dimensional point stored in the computer and equivalent to tie point) are allocated for this reference points. Local coordinates of this reference points can be determined. Then the models created in 123D catch with locators are exported as .rzi file.

The global coordinates of these corresponding points of locators are determined very precisely manually from LPS software in point measurements tools of already created aerial triangulation model.

From the Fig 3a it can be seen that the 3D scene created by 123D Catch software make the surface curve as convex upward. This is due to the image orientation done in this software without ground control points(GCP). There is not provision to perform image orientation in 123D Catch software with GCP. This is due to on availability of height information with ground control points. Figure 3b shows the measured position of locators in 3D scene of Enschede, The Netherlands image data.

5. Separate Bundle Adjustment by Least Square Adjustment

Separate bundle block least square adjustment is performed to use image orientation in PMVS software format.

6. Dense Point Matching Using PMVS Software

The other method which is different from the global matching methods is PMVS. In this method, the only search around the seed point and in each step it enlarges the search area. The patch matching optimization is usually done through least square algorithm. The point cloud is generated in PMVS software.

7. DSM Generation in LPS Software

The point cloud obtained from 123D Catch, PMVS and LPS software are used for DSM generation. The point cloud generated in LPS is 1m*1m resolution, standard methods are used to generate point cloud in 123D Catch and default settings are used in PMVS to generate point clouds. The density of point cloud of 123D Catch is very low so it is not used for DSM generation and comparison. The DSM is created in LPS software from LPS and PMVS point clouds.

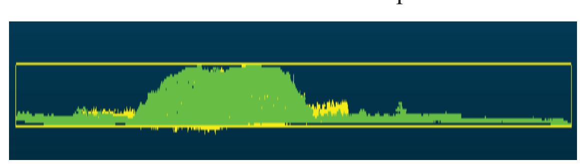


Figure 4: Display of both LPS and PMVS point clouds in point cloud compare software

8. Quality Assessment of Image Orientation and Image Matching

After computing the 3D scene in 123D Catch, some reference points are selected and the best matches of them in several images as locators are found. In LPS, it can be measured some ground control points to calculate the absolute orientation parameters. Then the model is exported as .rzi file and converted into .txt file containing only point's coordinates in local system. It can be used for transformation to get global coordinate system.

The transformation parameters can be determined from local coordinates of manually measured locators and corresponding global coordinates measured in LPS project. To perform transformation the code written in Matrix Laboratory (MATLAB) can be used. There are 3 elements of rotation matrix and 3 translation vector and 1 scale factor (all together 7 parameters). To calculate 7 transformation parameters at least 3 measured points are used and other points can be used for accuracy assessment. Then through these transformation parameters it can calculated the transformed global coordinates of all points cloud. This residuals values show how accurate was this model made, because it has used the measured points on the 3D model and compared them to the measurements by LPS points coordinate. At the end, there are transformed coordinates for all point clouds as from 123D Catch, PMVS, which can be used for other analysis.

9. Quality Assessment of Points Clouds

The main task is to access of the quality of the orientation of the point clouds. Several quality aspects are considered for individual points, point density, gaps or occlusion etc. There are three options in 123D Catch to produce point cloud:

- Mobile: This is suitable for medium resolution mesh. It is fast and suitable for viewing on mobile devices.
- Standard: It is recommended for high resolution textured mesh and used to visualization on the desktop computer.
- Maximum: It is used for very high density mesh. The output may be maximum quality but it takes long processing time.

The mobile and standard method is chosen for output quality to produce point cloud in this project. The mobile as well as standard method provides almost same quality as well as quantity of point clouds for the same resolution of image data. For the following points cloud colour cycle length is 10m i.e. the sequential difference of adjacent colour is 10m.

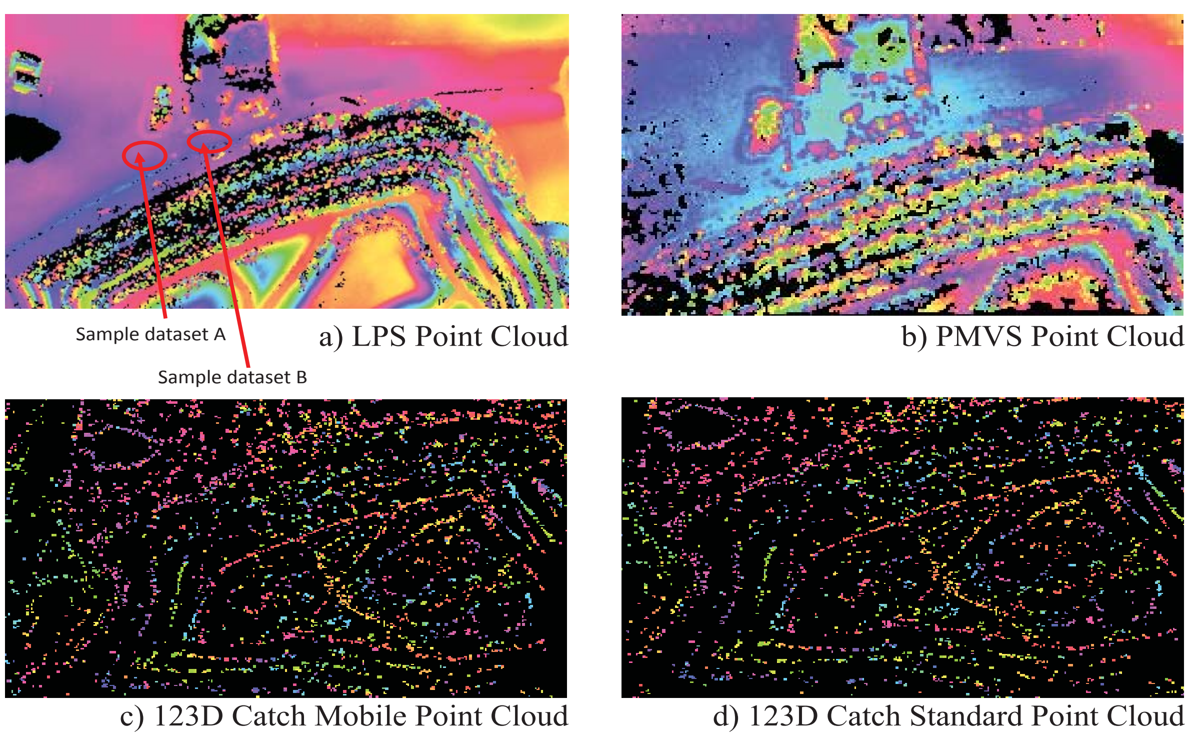


Figure 5: Visualization of Points Cloud of Moers, Germany data in PCM software

It has been observed that LPS can produce more dense point cloud than PMVS as well as 123D Catch. The Figure 5(a) shows point cloud generated in LPS by 1m*1m resolution settings. The point density of 123D Catch either created from both methods as mobile and standard are almost same and low compared to PMVS as well as LPS eATE point cloud. Point's cloud of LPS mostly represents ground surface but PMVS point cloud contains features as buildings, trees etc.

The principal component analysis (PCA) is applied to determine plane parameters. The principal components are the axis of maximum variation of the data. The robust fitting algorithm gives inliers which are used to obtain the point to the plane distances. The Random Sample Consensus (RANSAC) algorithm is used to perform robust plane fitting. The mean and standard deviation of the point-to-plane distances after the plane fitting were computed. The mean of point plane distances is expected to be very small. The standard deviation indicates the random errors of the point (Sande, Soudarissanane, & Khosheham, 2010). The quality of point cloud can be performed by two different perspectives as internal and external quality.

In external quality assessment it can be considered using corresponding lines and corresponding planes to make comparison with the LPS point dataset which is considered as higher accuracy. For plane based accuracy assessment, it can be used the algorithm proposed by Dr. Kourosh (Sande et al., 2010). The two sets of point clouds datasets are imported into Point Cloud Mapper (PCM) software and two groups of corresponding planes are selected into two interfaces. Then these are imported into the Matlab software and used to fit point to plane algorithm to make the points in the selected LPS plane to one plane, then the distance between this plane with the planes of PMVS and 123D Catch plane are calculated.

In internal quality assessment one plane from the point cloud generated by PMVS or 123D Catch or LPS are selected and it is used to fit plane to point algorithm to fit the selected point to one flat plane. Then the distance from the original point plane with the plane after processing are computed. The codes used in Matlab software for internal accuracy assessment and external accuracy assessment.

The samples data from corresponding planes are cropped in PCM software and imported into Matlab software code and processing is performed. The different statistical analysis (Mean, SD, Minimum Distance, Maximum Distance, Median Distance, 25th percentile and 75th percentile) are also computed to perform this accuracy assessment. Different graphs are also plotted for comparison of each dataset. For this statistical comparison different sample data sets are taken from different areas. One sample dataset is taken from relatively plane area and other is taken in slope area.

10. Conclusion

The two datasets as one taken from analogue aerial camera and another from digital aerial camera with different specification are used for study. The images are also used with different resolutions and different area types as mountainous and flat terrain. There are different types of accuracy assessment perform to check the orientation of images, generated point cloud and created DSM from point cloud obtained from 123D Catch, PMVS and LPS software.

123D Catch software provides web services for orientation of image and create 3D scene in local coordinate system. There are three options in 123D Catch to produce point clouds are mobile, standard and maximum. The mobile and standard method is chosen for output quality to produce point cloud in this project. The mobile as well as standard method provides almost same quality as well as quantity of point clouds for the same resolution of image data. The maximum methods give some more dense point cloud compare to mobile and standard methods. The standard methods take long processing time to generate 3D scene.

For image orientation accuracy, it has been observed that for large area the orientation in 123D Catch software makes model as curved surface, this is due to not provision to use ground control point with height information during orientation in this software. So, this software is not suitable for large area and for long strip aerial data. The orientation accuracy is high for continuous rugged surface than plane with high settlement features. It can be observed that the accuracy obtained for planimetric is more accurate than altimetric in image orientation due to curved 3D scene created by 123D Catch software. It has been observed that the well distributed locators in the study area provide good transformation parameters. 123D Catch software not needs intensive training for their operation for image triangulation and image matching as like LPS software.

The 3D model created by 123D Catch software is exported into .rzi file. It contains local coordinates system of point clouds. This .rzi file is also used for separate bundle block adjustment to generate point clouds in PMVS software. This local coordinates point clouds are transformed into global coordinates. LPS as commercial software has also facilities to generate point clouds in required density. The accuracy assessment of 123D Catch points cloud and PMVS point cloud is done compare to LPS point clouds because it has used high resolution image for orientation and considered as more accurate points cloud.

PMVS bundle block adjustment provides high quality of point cloud and relatively more dense point by using .rzi file created from 123D Catch software. 123D Catch point cloud contains more systematic and random errors comparison to PMVS points clouds because the value of mean and standard deviation are high. The DSM created by point cloud of PMVS seems to be more reliable than 123D Catch and LPS. The DSM created from PMVS points cloud contains high pixel values than the DSM of LPS points cloud because PMVS point clouds mostly contains features like buildings, trees etc.

References

Autodesk. (2012). Autodesk 123D Catch. Autodesk 123D Catch Retrieved 22 June 2012, 2012, from http://www.123dapp.com/catch

Commission, U. C. o. F. (2012). US Centennial of Flight Commission Retrieved 19 August 2012, 2012, from http://www.centennialofflight.gov/essay/Dictionary/Global_Coordinates/DI80.htm

Ebadi, H. (2006). Advanced Analytical Aerial Triangulation: K.N.TOOSI UNVERSITY.

Fritsch, D. (1995). Introduction into Digital Aerotriangulation Photogrammetric Week '95'.

Furukawa, Y. (2010, 13 July 2010). Patch-based Multi-view Stereo Software Retrieved 22 June 2012, 2012, from http://grail.cs.washington.edu/software/pmvs/

Bhatta, G.(2009)Applications of open source software in land administration: An initiation with land administration education, Nepalese Journal on Geoinformatics,Volume 8

Gerke, M. (2012). Base Mapping From Images. Module 7, GFM Master Lecture Notes.

Girardeau, D. (2012). 3D point cloud and mesh processing software Retrieved 14 August 2012, 2012, from http://www.danielgm.net/cc/

Goldbergs, G. (2012). Image Triangulation and Orientation. Module 5, GFM Master Lecture Notes.

Google. (2012). Google Maps Retrieved 5 August 2012, 2012, from https://maps.google.com/maps?hl=en

Khoshelham, K. (2012). Quality of Terrestrial Point Clouds Module 13, M.Sc. Lecture Notes.

Madani, M. (2001). Importance of Digital Photogrammetry for a complete GIS. Paper presented at the 5th Global Spatial Data Infrastructure Conference, Cartagena, Columbia.

One, V. (2009, 11 September 2009). Is Photogrammetry Important to the Geospatial Industry? Retrieved 16 August 2012, 2012, from http://www.sensysmag.com/vectorone/?p=3701

Sande, C. V., Soudarissanane, S., & Khosheham, K. (2010). Assessment of Relative Accuracy of AHN-2 Laser Scanning Data Using Planar Features. Retrieved from sensor website: http://www.mdpi.com/1424-8220/10/9/8198/htm

Snavely, N. (2010). Bundler: Structure from Motion (SfM) for Unordered Image Collections Retrieved 12 July 2012, 2012, from http://phototour.cs.washington.edu/bundler/

Suite, L. P. (2006). Leica Photogrammetry Suite Automatic Terrain Extraction. United States: Leica Geosystems Geospatial Imaging.

Tempfli, K. (2008). Digital Surface Model. GFM Master Course, ITC The Netherlands.

Wikipedia. (2012a, 14 August 2012). Box Plot Retrieved 15 August 2012, 2012, from http://en.wikipedia.org/wiki/Box_plot

Wikipedia. (2012b, 16 December 2009). Local Coordinates Retrieved 19 August 2012, 2012, from http://en.wikipedia.org/wiki/Local_coordinates

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Urban Sprawl Modeling using RS and GIS Technique in Kirtipur Municipality

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Keywords

Urban Sprawl; Urban dynamics; Multi-criteria Evaluation; CA-Markov

Abstract

Urban sprawl refers to the urbanization extent, which is mainly caused by population growth and large scale migration and it is a global phenomenon. In developing countries like Nepal, where the population growth and internal migration rate in urban area is high, it has posed serious implication on the resources of the region. Effective and efficient infrastructure planning of an urban environment require information related to the rate of urban growth along with its trend, pattern and extent of urban sprawl. The pattern and extent of urban sprawl is identified and modeled using remotely sensed data along with collateral data. RS and GIS are used to analyze and interpret the urban land use changes. Cellular Automate Markov (CA-Markov) process is used to urban sprawl modeling to identify possible pattern of sprawl and subsequently predict the nature of future sprawl.

1. Introduction

Urbanization refers to process whereby an increasing proportion of country's population comes to live in cities by growth and migration of population transformed from predominantly rural to urban area and closely associated with the level of economic activities, land-use, population distribution and urban facilities (Johnston et al., 2003). The process of urbanization is an universal phenomenon taking place all over the world. In Nepal, unprecedented population growth and internal migration coupled with unplanned developmental activities has resulted in urbanization, which lack infrastructure facilities. This has also posed serious implications on the resources base of the region. The urbanization takes place either in radial direction around a well established city or linearly along the highways. This dispersed development along highways, or surrounding the city and in rural countryside is often referred as sprawl. All developing countries are facing with such phenomenon; due to the increase in population growth, economy, proximity to resources and basic amenities of infrastructure initiatives. The urban sprawl refers to the extent of urbanization and expansion of urban concentrations, it refers more to the pace and magnitude of land conversion to urban use and areal expansion of the city. The extent of urbanization or the sprawl is one such phenomenon that drives the change in land use patterns (Sudhira et al., 2003). Patterns and trends of urban sprawl are identified and modeled using remote sensed data (aerial photographs/ satellite images) along with collateral data. Identification and analyses of the patterns of urban sprawl in advance would help in effective infrastructure planning in urban area. In order to estimate and understand the behavior of such urban sprawls, which is crucial for sound environmental planning and resource management. The study on urban sprawl is attempted in the developed countries (Hurd et al., 2001; Epstein et al., 2002) and recently in developing countries such as China (Yeh and Li, 2001; Masser, 2001); India (Jothimani, 1997; Lata et al., 2001; Sudhira et al., 2003) and Nepal (Thapa & Murayama, 2009;Bhandari, 2010; Rimal, 2011). GIS and RS along with land related technologies are therefore very useful in the formulation and implementation of the land related component of the sustainable regional development strategy, which can be generalized as determination of objectives, resource inventory, analyses of the existing situation, modeling and projection, development of planning options, selection of planning options, plan implementation, and plan evaluation, monitoring and feedback (Yeh and Li, 2001).

The built-up is generally considered as the key feature or parameter for quantifying urban sprawl (Torrens and Alberti, 2000; Barnes et al., 2001; Epstein et al., 2002: Sudhira et al., 2003). The built-up area is determined in the topographical maps/ aerial photographs /satellite images. The integration of GIS, RS and database management systems (DBMS) with geospatial tool are used to analyze and interpret urban sprawl, urban land use land cover (LULC) change and its quantification. The concentration and dispersion of sprawl measurement is computed in GIS environment with consideration of fragmentation, patchiness, porosity, patch density, interspersion and juxtaposition, relative richness, diversity, and dominance of landscape properties. The urban sprawl and its dynamics is the quantification of the change in built-up area by Shannon's entropy index which define the sprawl phenomenon with respect to mathematical relationship. With the development and infrastructure initiatives mostly around the urban centers, the impacts of urban sprawl would be on the resources and ecology. The planning should also focus on a dispersed economic structure for generating balanced ecological, social, and economic system without hampering the resources and disturbing the rural setup. Modeling of the spatial urban dynamics rests mostly with LULC change studies (Lo and Yang, 2002) or urban growth studies. In order to predict the scenarios of land use change, Cellular Automata Markov (CA-Markov) process is used. These processes identify the possible pattern of sprawl and subsequently predict the nature of future sprawl with the availability of historic spatio-temporal data, which is cost effectively and efficiently.

CA-Markov process is a combined cellular automata and Markov Chain prediction procedure that adds element of spatial contiguity as well as knowledge of the likely spatial distribution of transitions to Markov change analysis. These two are termed as the geo-simulation techniques used to produce land use predictions (Sun et al. 2007). However, a CA procedure very specify to the context of predictive land cover change modeling. CA-Markov takes land cover map from which changes should be projected as input; the transition area file produced by Markov from analysis of that image and an earlier one and a collection of suitability images which is produced from multi-criteria evaluation (MCE) in GIS that express the suitability of a pixel for each class of the land cover type under consideration. Then, it begins an iterative process of reallocating land cover until it meets the area total predicted by the Markov process (Eastman, 2009).The logic of CA-Markov is that; the total number of iterations is based on the number of time steps set by the user. Within each iteration process, every land cover class will typically lose some of its land to one or more of the other classes. CA component arises from the iterative process of land allocation that filtering stage with each iteration process in part from a stage reduces the suitability of land away from the existing area of that type. By filtering, a Boolean mask of the class being considered the mean contiguity filter yields a value of 1 when it is entirely within the existing class and 0 when it is entirely outside of it. However, when it crosses the boundary, it will yield values that quickly transition from 1 to 0. This result is multiplied by the images for that class, thereby progressively down weighting the suitability maps of different land use classes as one move away from exiting instances of that class. CA-Markov can simulate land use land cover change among several categories (Li & Reynolds, 1997; Wu & Webster, 1998; Pontius & Malanson, 2005).

2. Study Area & Data used

Study Area

Kirtipur municipality was chosen for the study where urban growth has high rate and urban sprawl has prevalent. There is need of a comprehensive city plan for the establishment systematic dreamland town planning policy. The location of study area is shown in Figure1.

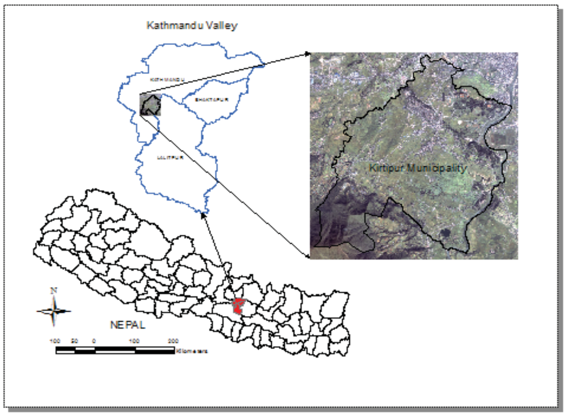


Figure1: Study Area

Its loction is 27º 38’ 37" to 27º41’ 36" N and 85º 14’ 64" to 85º 18’ 00" E with it extent and at present has 19 wards and covers 17.87 sq. km. It is bordered by the Bagmati river with Lalitpur Submetropolitian City to the east, Machhengaun Village Development Committee (VDC) to the west, Kathmandu metropolitan city (KMC) to the north, and Chalnakhel VDC to the south. The town was built initially within a wall surrounded strategically by dense vegetation and then open ground as outer rings.

Data used

The following datasets were used in the study; these are listed below in Table 1.

Table1: Description of Data used

Data Type	Year	Scale / Resolution	Source
Remotely Sensed Data:			
Aerial Photographs	1998	1:5000	DOS
IKONOS	2006	4m	NLUP
GeoEye -1	2012	2m	UBMP
Base Map:			
Topo map	1996	1:25000	DOS
Urban map	1998	1:2000	DOHUD
Ancillary Vector Layers/Data:			
Geology	2007	1:30000	NLUP
Hazard	2007	1:30000	NLUP
Geomorphology	2007	1:10000	NLUP
Land Capability	2007	1:10000	NLUP
Population Data	2011		CBS
Field Data:			
Ground Control Point (GCP)	2012		Field Works
Ground Truth	2012		Field Works

3 Methodology

The availability of high resolution aerial/satellite data made it feasible to monitor and evaluate urban environment consistently at desirable spatial and temporal scales. In this study, digital elevation model (DEM) was generated with contours having 2m contour interval of urban base map. The orthophoto for year 1998 was generated with stereo aerial photographs of scale 1:15000 and DEM along with 36 GCPs collected with DGPS technique. The orthoimages for year 2006 and 2012 were generately satellite images IKONOS and Geoeye1 respectively with RCP file provided by vendors, GCPs and DEM. The land use maps for year 1998 was prepared from orthophoto and for years 2006 and 2012 were prepared from MSS IKONOS and Geoeye1 satellite images respectively with Artificial Neural Network (ANN) supervised classification technique. The road network layers of year 2006 and 2012 were extracted by manual digitization process from orthoimages.

Geospatial tools in GIS were used to quantify LULC changes from classified remote sensing data in space and time to show the spatial pattern and composition of LULC representation as a dynamic phenomenon. The transition matrix and transition maps were generated. Urban sprawl was measured with Shanon entropy index which is computed by (Wilson et al., 2003):

$$E_n = \frac{\sum_i^n p_i \log\left(\frac{1}{p_i}\right)}{\log(n)}$$

Where, pi is the density of land development, which equals the amount of built-up land divided by the total amount of land in the ith of n total zones. The difference in entropy between two different periods of time can also be used to indicate the change in the degree of dispersal of land development or urban sprawl which is computed by (Yeh and Li 2001):

$$\Delta E_n = E_n(t+1) - E_n(t)$$

Where, ΔEn is the difference of the relative entropy values between two time periods, En(t+1) is the relative entropy value at time period t+1, En(t) is the relative entropy value at time period t.

The suitability maps of each land use class were generated using MCE along with analytical hierarchy process (AHP), these suitability maps were standardized with fuzzy set to membership functions type (sigmoid, J-shape and Linear) and membership function shape (monotonically increase, decrease or symmetric).Spatial modeling of sprawl for year 2012 was predicted with LULC maps of 1998 and 2006 using CA-Markov process and validate with reference LULC map 2012. As the validation results has sufficient reliable limit of kappa index of agreement (KIA), LULC maps for year 2020 and 2030 were predicted.

4 Results and Analysis

The land use map for year 1998 was prepared from orthophoto by manual digitization based on photo interpretation elements such as tone, shape, size, texture, pattern, shadow, association, site etc. The land use maps for year 2006 and 2012 were prepared from MSS IKONOS and Geoeye1 respectively by artificial neural network (ANN) supervised classification technique with additional information such as PCAs, NDVI, and NDWI. The overall accuracies for 2006 and 2012 are found 88.67% and 87.67% respectively and KIA (kappa statistics) for 2006 and 2012 are found 0.8449 and 0.8337 respectively. . The land use maps of year 1998, 2006 and 2012 are shown in Figure 2.

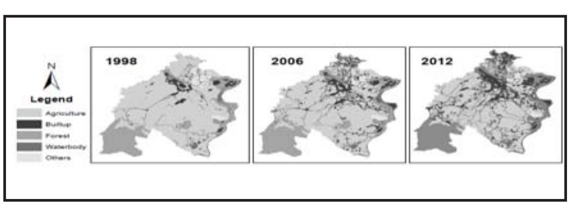
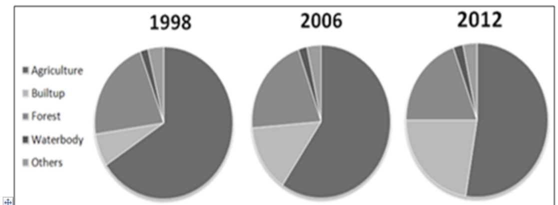


Figure2: Land Use Maps

The post-classification change detection was done and quantified in hectares by individual class, visualized with pie charts with classified images for the three study periods 1998, 2006 and 2012. The quantification of land use maps of year 1998, 2006 and 2012 were represented in pie chart which is shown in Figure 3.



Land use Category	Area in Hectares		
	1998	2006	2012
Agriculture	995.5027	911.7876	806.4543
Built-up	119.0138	218.5567	344.476
Forest	334.4377	321.7198	300.1835
Waterbody	28.4547	31.0728	33.9782
Others	56.7107	50.9824	49.0273

Figure3: Quantification of Land use Maps

The comparison of land use/cover change (LUCC) was also done with statistically with the computation of LUCC in hectares and in percentage of individual class area between two LULC maps of year 1998 versus year 2006, year 2006 versus year 2012 and year 1998 versus year 2012. The change in LULC between 1998-2006, 2006-2012 and 1998-2012 is presented in Table 2.

Table 2: Comparison of LULC change

	Area Change in Hectares			Area Change in Percentage		
Land use Category	1998-2006	2006-2012	1998-2012	1998-2006	2006-2012	1998-2012
Agriculture	-83.7	-105.3	-189.0	-8.41	-11.55	-18.99
Built-up	99.5	125.9	225.5	83.64	57.61	189.44
Forest	-12.7	-21.5	-34.3	-3.8	-6.69	-10.24
Waterbody	2.6	2.9	5.5	9.2	9.35	19.41
Others	-5.7	-1.9	-7.6	-10.1	-3.83	-13.55

Change detection was also analyzed with the map transition option in the LCM of Idrisi Tiaga. The transition map of LULC from 1998 to 2006 and from 2006 to 2012 into all classes to built-up class was prepared and presented in Figure 4.

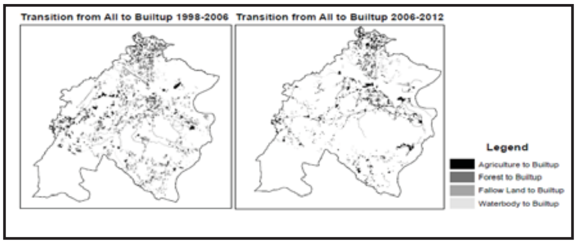


Figure 4: Transition Map

A temporal database can be visualized as a sequence of maps with each time period and changes in LULC shows in dynamic pattern. The temporal dynamics revealing patterns and trends were not possible to distinguish in tabular data. So, spatial expansion (growth) of the built-up areas was represented in maps during the study periods which are shown in Figure 5.

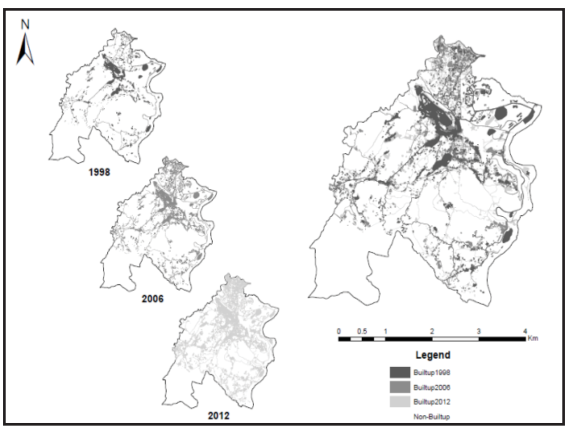


Figure 5: Growth in Built-up Areas

In this study, concentration and dispersion of sprawl computation, circular ring were generated around the city centre with 500 m interval. The number of zones refers the number of buffers around the city centre. Since entropy can be used to measure the distribution of a geographical phenomenon where as the difference in entropy has indicated the temporal change in the degree of dispersal of land development or urban sprawl. The Shannon entropy of urban sprawl in 1998, 2006 and 2012 was computed; similarly difference in entropy between 1998- 2006, 2006- 2012 and 1998-2012 was also computed for determining the trend of sprawl growth. The Shannon entropy and difference in entropy are presented in Table 3.

Table 3: Shannon's entropy and its difference

E_n(Entropy during the 3 Study Period)			ΔEn (Difference in Entropy)		
1998	2006	2012	1998-2006	2006-2012	1998-2012
0.14	0.22	0.31	0.08	0.09	0.17

Urban Sprawl Modeling with Markov Chain was produced the transition probability matrix from the two period images and on the basic of this transition matrix a set of condition probability images for each LULC classes has generated by analyzing with two qualitative LULC maps The Markov transition probability matrix of changing among LULC from 1998 to 2006 with conditional probability error 10 %; is presented in Table 4.

Table 4: Transitional Probability Matrix

	Forest	Water body	Agriculture	Built-up	Others
Forest	0.8568	0.0125	0.0498	0.0769	0.0041
Water body	0.0000	0.8969	0.0662	0.0370	0.0000
Agriculture	0.0118	0.0005	0.8365	0.1511	0.0001
Built-up	0.0129	0.0095	0.0862	0.8901	0.0013
Others	0.0000	0.0000	0.0120	0.1648	0.8231

The suitability map of LULC classes built-up, agriculture and forest for transition rule selection were prepared from MCE-AHP process and for water body and others were generated with distance function considering so that near the existing LULC classes, there are more chance of changing into this class. The weight used in the MCE was computed from the pair wise comparison in the AHP process. In AHP process, each criterion of factor or constraint maps was evaluated with pair wise comparison in decision support system tool in Idrisi Tiaga software. The suitability maps determine that pixels will change as per the highest suitability of each LULC type. The higher the suitability of a pixel, the possibility of the neighboring pixels to change into that particular class is higher. The suitability maps of each LULC were standardized with the fuzzy factor standardization. Therefore a simple linear distance decay function is appropriate for this basic assumption. It serves the basic idea of contiguity. The LULC maps have been standardized to the same continuous suitability scale (0–255) using fuzzy set membership analysis process. The basic assumption for preparing suitability images is the pixel closer to an existing LULC type has the higher suitability. It means a pixel that is completely within vegetation has the highest suitability value

(255) and pixels far from existing vegetation pixels will have less suitability values. The farthest pixels from vegetation will show the lowest suitability values. The standardized suitability LULC images of agriculture, built-up and forest classes with fuzzy function are presented in the Figure 6.

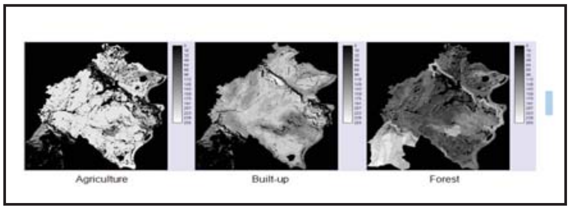


Figure 6: Standardized Suitability Map

The prediction of LULC in 2012 was done using CA-Markov with reference to LULC map of year 2006, Markov transition probability area matrix, standardized group suitability maps and 5x5 contiguity filters. The projected LULC map for year 2012 is shown in Figure 7.

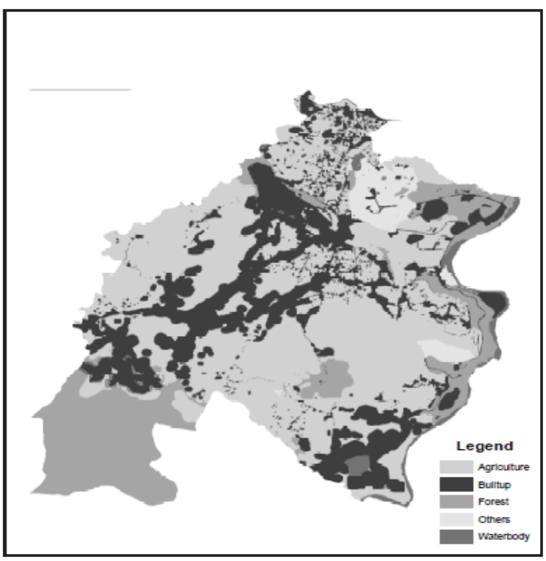


Figure 7: Projected LULC Map 2012

The validation process has been done by comparing simulation of predicted LULC map 2012 with reference to actual LULC map of 2012 based on KIA. Kappa Index gives: Kno, Klocation and Kquantity in order to compare the predicted with the actual land use map. The result of validation shows that Kno, *Klocation and Kquantity* are 0.8815, 0.8673 and 0.8582 respectively.

The future urban sprawl for short period of 2020 is shown in Figure 8.

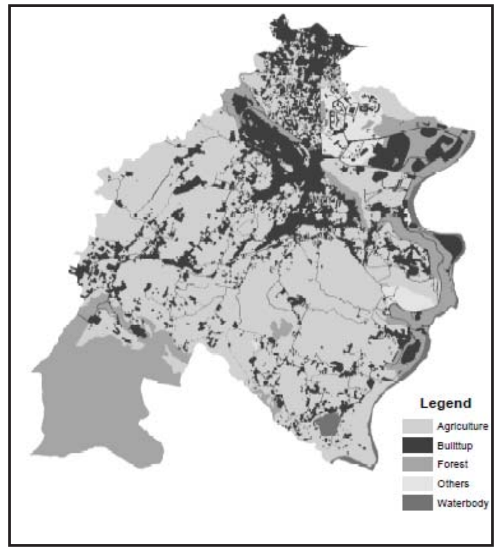


Figure 8: Projected LULC Map 2020

The future urban sprawl for long period of 2030 is shown in Figure 9.

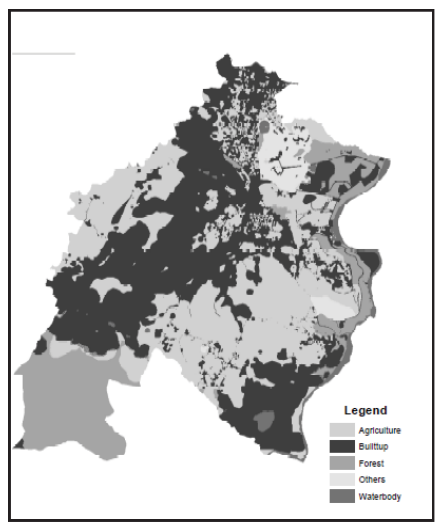


Figure 9: Projected LULC Map 2030

5) Conclusion

The urban sprawl trend shows that urban growth has rapidly increased in North West direction which is mainly influenced from Kathmandu metropolitan city. The entropy value indicates that the degree of spatial concentration and dispersion has high rate and continuously increasing in the study area. Landscape predictions for year 2020 and 2030 are predicted for future developable urban area based on land use policies and environmental factors. The situation assessment of urban growth analysis and simulation of urban sprawl modeling are important information for land managers, urban planners, policy makers, conservation agencies and other stakeholders to play a part in policy formulation for the betterment and conservation consent of sustainable urban development.

References

Bhandari S., 2010, "Urban Change Monitoring using GIS and Remote Sensing Tools in Kathmandu Valley, Nepal", Master Thesis, Universidade Nova De Lisboa, Portugal.

Masser, I., 2001, "Managing our urban future: The role of remote sensing and geographic information systems". *Habitat International journal*, 25, 503-512.

Eastman J.R. 2009, "Idrisi 16 Taiga, Guide to GIS and Image Processing", Clark University; Worcester: MA 01610-1477 USA.

Epstein, J., Payne, K., Kramer, E., 2002, "Techniques for mapping suburban sprawl", *Journal of Photogrammetric Engineering and Remote Sensing*, 63 (9), 913–918.

Hurd, J.D., Wilson, E.H., Lammey, S.G., Civco, D.L., 2001, "Characterisation of forest fragmentation and urban sprawl using time sequential Landsat Imagery", In: Proceedings of the ASPRS Annual Convention, St. Louis, MO, April 23–27.

Johnston R.J., Gregory D., Pratt G. & Watts M., 2003, "Dictionary of Human Geography", Basil Blackwell, Oxford Academy, California.

Jothimani, P. 1997, "Operational urban sprawl monitoring using satellite remote sensing: excerpts from the studies of Ahmedabad, Vadodara and Surat, India", Paper presented at 18th Asian Conference on Remote Sensing held during October, 20–24, Malaysia.

Li, H. & J. F. Reynolds. 1997, "Modeling effects of Spatial Pattern, Drought, and Grazing on rates of Rangeland Degradation: a combined Markov and Cellular Automaton Approach, In Scale in Remote Sensing and GIS", Lewis Publishers, New York.

Lo, C.P., Yang, X., 2002. Drivers of land-use/land-cover changes and dynamic modeling for the Atlanta, Georgia Metropolitan Area, *Journal of Photogrammetric Engineering and Remote Sensing*, 68 (10), 1062–1073.

Pontius Jr, R. G. & Malanson J., 2005, "Comparison of the Structure and Accuracy of two Land Change Models", *International Journal of Geographical Information Science,* 19 (2), 243-265.

Rimal B.,2011, "Urban Growth and Land Use/Land Cover Change of Pokhara Sub-Metropolitan City", *Journal of Theoretical and Applied Information Technology*, 26,118-129.

Sudhira H. S., Ramachandra T. V. & Jagdish K.S., 2003, "Urban Sprawl Pattern Recognition and Modeling using GIS", *International Journal of Applied Earth Observation*, 5, 29-39.

Sun H., Forsythe W. & Waters N., 2007, "Modeling Urban Land use Change and Urban Sprawl: Calgary, Alberta, Canada", Journal *of Networks and Spatial Economics*, 7(4), 353-376.

Thapa, R.B. & Murayama, Y. 2009, "Examining Spatiotemporal Urbanization Patterns in Kathmandu Valley, Nepal: Remote Sensing and Spatial Metrics urban Land-use Change" *International Journal of Remote Sensing,* 26(4), 759-774.

Wilson, E.H., Hurd, J.D., Civco, D.L., Prisloe, S. & Arnold, C. 2003, "Development of a Geospatial Model to quantify, describe and map Urban Growth", *Journal of Remote Sensing and Environment*, 86(3), 275–285.

Wu, F. & Webster, C.J., 1998, "Simulation of Land Development through the integration of Cellular Automata and Multi-criteria Evaluation", Journal *of Environment and Planning B: Planning and Design*, 25, 103-126.

Yeh and Li, 2001, "Growing Region Using Entropy", Journal *of Photogrammetric Engineering and Remote Sensing,* Vol. 67(1): pp 83.

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21st Anniversary Program of NRSPS

The 21st Anniversary Program of Nepal Remote Sensing and Photogrammetric Society (NRSPS) was organized on April 29, 2012. The programme was initiated by Rabin K. Sharma, President, NRSPS. After opening of the programme, Babu Ram Acharya, former Secretary of Government of Nepal released Earth Observation: Volume IV; Annual Newsletter of NRSPS in which two articles: **“Space-based Technology Solutions in Support of Disaster Management”** by Durgendra M. Kayastha; Vice President, NRSPS and **“Insight of Sentinel Asia System”** by Ashok Bhushal , Member, NRSPS were included. The most attractive part of the program was the presentation on the topics **Global Earth Observation System of Systems (GEOSS)** by Anish Joshi, Secretary, NRSPS; **Glacier Lake Outburst Flood (GLOF)** by Samjol Bajracharya from ICIMOD and **Update Land Use Information** by Nawa Raj Subedi, Member, NRSPS.

New Executive Committee

A **new Executive Committee Officials** led by Rabin K. Sharma were elected for the period of 2013-14 during the General Assembly held on 8th February 2013. The officials of the Executive Committee are given in the box left of this message.

Achievements of the New President of NRSPS

NRSPS is proud to record some of the major achievements of the new President of NRSPS for the period 2011-2012 AD. As mentioned earlier, **Rabin K. Sharma** was elected unanimously as a President of NRSPS for the fifth tenure of the Executive Committee of NRSPS. He has been felicitated on a special programme organized by Ministry of General Administration on 28th Bhadra 2069 with a **Dosalla (Silk Shawl) and a Felicitation letter** by **Rt. Hon. Babu Ram Bhattarai, Prime Minister of Nepal** for his contributions to foster Civil Service. He was one of the twenty five retired officials for receiving the award. This felicitation programme was one of the programmes for celebrating the Civil Service Day of the fiscal year 2069/70. He had published a book entitled **“Mapping my Professional Journey”**: collection of sixty articles written by him as well as some articles were jointly prepared with several Co-authors in the past. The book was released by Mr. **Babu Ram Acharya, former Secretary of Government of Nepal** during a special programme on 12th Aswin 2069. This book adds a new dimension in the literature of Geo-informatics. Furthermore, Asian Association on Remote Sensing (AARS) awarded him with a **Medal of CHEN Shupeng Award** by **Prof. Tong Quinxi, Chairman** of the CHEN Shupeng Award Foundation on 26th November 2012 for his long and outstanding contributions on the development of remote sensing in Asia at the opening ceremony of the 33rd Asian Conference on Remote Sensing (ACRS) held at Pattaya, Thailand from November 26-30, 2012.

Major Programmes for the Year 2013

The Society planned for carrying out the following programmes for the year 2013:

1. Commemorate Anniversary Program
2. Dissemination of Information on Space Technology Application
3. Networking with Related Agencies and Institutions
4. Amendments of the Statutes of NRSPS
5. Presentation Program on some relevant themes
6. Launching Membership Driven Program

ACTIVITIES OF NEPAL GIS SOCIETY 2012

Nepal GIS Society (NEGISS) is a non-profit forum of GIS professionals and users in Nepal registered under the Government of Nepal on July 22, 1995. The inception of the Society is attributed to the felt needs of GIS professionals for a common forum for advancing the use and for sharing professional experiences in addition to dedicating to larger mandate of engaging on advocacy for optimized management of spatial data resources among others. Since the establishment the Society, it has been working for the development of GIS awareness activities and its application in the country.

Society has carried numbers of activities in the year 2012.

- GIS Training was conducted upon request of DDC Panchthar for the Local Development officials in the 1st week of March 2012. Dr. Krishna Poudel and Bhola Nath Dhakal were the resource persons.
- Week long training between18-23 March 2012 was held at National Planning Commission Secretariat Singhadurbar. The training was coordinated by Dr. Krishna Poudel. Mr. Madhav Adhikari, Bhola Nath Dhakal and Dhruba Bahadur Bogati were the resource persons.
- GIS training on demand to cover the needs of the Officials of the Directorate of Agriculture Extension was held at the GIS Lab of the Society in the month of April 2012. Seven professionals of the Directorate were participated.
- On the auspicious occasion of the 18th anniversary of the Society a week long training was organized between July 15 to 20, 2012. In the same occasion one day workshop on 'GIS Application in Disaster Management' was organized on 22 July 2012. Papers were presented by Dr. Dinesh Pathak, Govinda Joshi, Indra Sharan KC and Santosh Kokha Shrestha. Prof. U.M. Malla and Prof. Ram Kumar Panday delivered remarks.
- Society had organized a week long special training from 09 to 14 October, 2012 for the university students with partial funding support from ICIMOD on the request of SERVIR-Himalaya Youth Forum alumni.
- On the auspicious occasion of the International GIS Day, Society marked the occasion by organizing training from 20 to 30 November 2012. Workshop on 'GIS Application' was organized on 30th November 2012. Mr. Himalal Shrestha, Ms.Manju Munankarmi and Ms. Sajana Maharjan presented their academic outputs.
- On the auspicious occasion of the 18th Anniversary of the Society a book on "GIS in Local Development" (in Nepali), written by Dr. Krishna Poudel, and published by Nepal GIS Society was jointly released by Prof. Upendra Man Malla, President of Nepal Geographical Society and Advisor NEGISS, and Prof. Ram Kumar Panday, President of Centre for Nepalese Geographers.
- Society has successfully completed assignment of Directorate of Agriculture Extension to review small irrigation database and written a book on "Small Irrigation Systems in Nepal" jointly by Dr. Poudel, President of the Society and Mr. Suresh Sharma, Agriculture Extension Officer of DAE, Government of Nepal.
- Society has completed the updates of Safe Abortion Sites map of Nepal for the CREHPA in October 2012. Geographical coordinates and elevation of each sites based on the reference maps and documents have been updated.
- Society is a member of DePNET, Nepal and attended numbers of meeting, workshops, and seminars organized by DePNET and disaster related issues. Attended meetings of the GIS Users Group organized by UNDRR at the Pulchowk. Space Technology Application meeting was attended by Dr. Poudel, organized by Ministry of Science and Technology.
- Society is now becoming the hub of visitors to know the GIS activities in the country. Different National and International experts/consultant and personnel visited Society office.
- Society has its own documentation library where large number of books provided by ICIMOD and publication of other organization, well equipped GIS Training Hall, ArcGIS Software Supported by Nepasoft Solution Pvt. Ltd. and Internet facilities.
- Society publish annual bulletin regularly marking with news, events activities including short features articles related with the GIS Application.

Nepal Surveyors' Association (NESA)

NESA CEC
Secretariat

Mr. Madhusudan Adhikari
President
Mr. Ambadatta Bhatta
Chief Vice President
Mr. Saroj Chalise
General Secretary
Mr. Prakash Dulal
Secretary
Mr. Durga Phuyal
Secretary
Mr. Sahadev Ghimire
Treasurer
Mr. Dadhiram Bhattarai
Co-treasurer
Mr Hari Prasad Parajuli
Member
Ms. Jyoti Dhakal
Member

NESA CEC
Other members

Mr. Ram Sworup Sinha
Vice President
Eastern Development Region
Mr. Tanka Prasad Dahal
Vice President
Central Development Region
Mr. Gopinath Dayalu
Vice President
Western Development Region
Mr. Ramkrishna jaisi
Vice President
Midwestern Development Region
Mr. Karansingh Rawal
Vice President
Farwestern Development Region
Mr. Premgopal Shrestha
Member
Ms. Geeta Neupane
Member
Mr. Laxmi Chaudhari
Member
Mr. Kamal Bdr. Khatri
Member
Mr. Bijubhakta Shrestha
Member
Mr. Sahadev Subedi
Member
Mr. Balam Kumar Basnet
Member
Mr. Nawal kishor Raya
Member
Mr. Santosh Kumar Jha
Member
Mr. Khim Lal Gautam
Member

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 it's 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 non governmental organizations*
- *To work for protecting the professional rights of surveyors in order to give and get equal opportunity to all professionals with out 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 ill image 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 ratification 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, 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

On 18th Bhadra 2069, the Surveyors' day was celebrated organizing different programs including sports & blood donation.

Price of Aerial Photograph and Map Transparency

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

In case 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*

Image Data:

Digital orthophoto image data of sub urban and core urban areas mintained in tiles conforming to map layout at scales 1:10 000 and 1:5 000, produced using aerial potography of 1:50 000 and 1:15 000 scales respectively are also available. Each orthophoto image data at scale 1:5 000 (couering 6.25 Km^2 of core urban areas) costs Rs. 3,125. 00 . Similarly, each orthophoto image data at scale 1:10 000 (covering 25 Km^2 of sub urban areas costs Rs 5,000.00.

Price of SOTER Data	*Whole Nepal*	*NRs : 2000.00*

Participants of the 5th Joint Project Team Meeting for Sentinel Asia Step-2, S. Korea on 13-16 November 2012. The Director General Mr. Nagendra Jha Participated from Survey Department.

Participants of Short Term Training on "Towards Improvement Governance of Land Information in Himalayan Nation" on 29 October - 23 November 2012, Land Gate International, Perth, Australia.

Mr. Nagendra Jha Director General of Survey Department with the participants of International Workshop on the Space Technologies for World Heritage, Beijing, China on 9-28 October 2012.

Secretary Mr. Dinesh Hari Adhikari, Joint Secretary Mr. Krishna Raj B.C. and Chief Survey Officer Mr. Ganesh Prasad Bhatta participating the SMART Geospatial Expo, 2012 and High Level Geospatial Forum held in Seoul, South Korea, from October 9-12, 2012.

Survey Officer Mrs. Roshani Sharma participating in the workshop on Modern Tools for Earthquake, Vulnerability reduction from 11 to 12 June 2012, Peshawar, Pakistan.

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
  - District, Zone and Development Region
- Digital Topographic Data at scales 1:25,000 & 1:50,000
- Cadastral Plans
- Orthophoto Maps
- Orthophoto Digital Data
- SOTER Data
- VDC Maps (Colour)
- Topographic Digital Data at scales 1:100,000 1:250,000 1:500,000 1:1,000,000

Available Services

- Establishment of control points for various purposes of Surveying and Mapping
- Cadastral Surveying
- Photo Laboratory Services
- Surveying and mapping for development activities
- Topographic and large scale mapping
- Digital geo-spatial database support
- GIS Development

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