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**Cover Page**

Inaguration program of international workshop on “Capacity Building and Education Outreach in Advanced Geospahal Technologies and Land Management”, which is one of the first ever event of such kind in the history of center.

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# EDITORIAL

Please, find the second issue of the "Journal of Land Management and Geomatics Education" presented herewith. At the publication of the first issue, just a year back, we promised to come annually and here we are as we promised. The happiness is immense!

This journal was introduced with the aims to include research and informative articles in the sector of Land Management and Geomatics Education. However, we have considered wide range of themes, apart from education, to be included. Our vision is to develop this journal as a competent scientific journal of this domain and working hard in this line. Since the very issue, we are closely working with the renowned Geomatics and land management academicians and professionals in/from Nepal, forming a team of Guest Editors, in order to enhance the quality of the journal year by year and ultimately to meet its vision. We encourage Nepali researchers, academicians, students and professionals to make use of this platform to publish their research outcomes. We believe, the journal will be of great help for the students, researchers, professionals and enthusiasts of land management and Geomatics profession to update their professional and academic knowledge.

This issue of the journal is enchanted with the nice variety of the noteworthy articles focusing on the Land Management issues and applicability of recent geospatial technologies used in Geomatics sector of Nepal. Major highlights are use of remote sensing and GIS techniques on solving geospatial problems such as forest fire analysis, squatter settlements and labour migration impact on land use change. Moreover, Land Management and administration issues such as capacity development in Land Administration is also addressed.

Articles from the eminent authors and enthusiast researchers have been important sources for the dissemination of the current progress and need in land management and Geomatics domain. On behalf of the Editorial Committee, I would like to express my sincere gratitude to all the noble authors for their contribution. The invaluable guidance and advices from the Advisory Committee and tireless efforts of the colleagues from Editorial Committee are noteworthy to publish this journal. The contributions of esteemed Guest Editors and their motivations have been good source of the inspirations for this publication. I, on behalf of the Editorial Committee, would further like to acknowledge all the contributors for this publication of this issue of the journal. I would, specifically, like to acknowledge the constant follow-up, guidance and inspiration we received from the Chair of the Advisory Committee and the Executive Director of the Land Management Training Center, Mr. Ganesh Prasad Bhatta to bring the journal in this form.

Lastly, On behalf of Editorial Committee, I would express that it would be our great pleasure to receive critical feedbacks on the content and quality of the journal, and would like to request for the valuable articles, and constant support for the upcoming issue of this journal.

Enjoy this issue and see you again with the third issue of the journal next year!

Happy 52nd Anniversary of the Land Management Training Center!

Thank you!

**Tanka Prasad Dahal**

Editor-in Chief

July, 2020

# FOREWORDS

As we celebrate 52nd Anniversary of the Establishment of Land Management Training Center, let me invite all my fellow colleagues to pause for a moment and experience the joy of being associated with this glorious institution. On this very special occasion, I am delighted to present the 2nd issue of the "Journal of Land Management and Geomatics Education", as promised in its first edition. Let me also take a moment to thank and congratulate entire staff of the Center and extend sincere thanks to those who have contributed, in the past in different capacities, to bring the Center to this level in its services for 52 years.

In the previous issue, I highlighted the proud history of this institution. Continuing with that legacy, this year also proved to be yet another remarkable year that witnessed some outstanding achievements. The Center organized an International Workshop on "Capacity Building and Education Outreach in Advanced Geospatial Technologies and Education Outreach", which is the first ever event of such kind in the history of the Center. Similarly, the Center, for the first time, organized training for local level leaders and technical staffs on local level land management. This year, we introduced multiple number of training courses which were the highest in its history along with other major initiatives for research activities. Further expanding the collaboration with Kathmandu University, we signed a Memorandum Of Understanding to commence Master of Engineering in Geoinformatics for the first time in addition to ongoing programs including courses of, Diploma of Geomatics Engineering, Bachelors of Engineering in Geomatics Engineering and Masters in Land Administration. As an effort to support Administration, the extended Memorandum of Understanding also commenced Master of Engineering in Geoinformatics for the first time. Even during the global pandemic of COVID-19, the Center remained active by continuing its training programs through online platform, which enhanced the Center's capacity to conduct distance training courses. In line with the Government of Nepal's initiative to mark "Visit Nepal 2020", the Center initiated Visit LMTC 2020 program for its alumni, which counts about 7,000. The Center is overwhelmed to see the encouraging responses from the alumni as expected. The Center is proud to note that other stakeholders and larger public has been giving us positive feedbacks for the recent changes we have brought about in the institution. In a nutshell, the Center is using all its might in developing the Center as the "Center of Excellence in Land Management and Geomatics Education".

We are committed to cultivate this Journal in such a way that it creates its own space as a standard scientific Journal published in Nepal. Since we are still in infancy, we admit that there shortcomings but we are confident that our dedication and hard work will eventually establish this Journal as a unique Journal that meets all the scientific criteria practiced across the academic community all over the world. Leading Geomatics academicians and professionals from Nepal including Mr. Janak Raj Joshi, Dr. Jagannath Aryal, Dr. Dev Raj Paudyal, Dr. Arun Kumar Pratihast, Dr. Subash Ghimire, Dr. Reshma Shrestha and Mr. Uma Shankar Panday were kind enough to contribute as Guest Editor of the Journal. Their inputs have contributed tremendously inpolishing the Journal and we hope we will meet the requirements soon in the upcoming issues.

I would like to express my sincere appreciation to the fellow colleagues, the members of Advisory Committee, and the Editorial Committee for their invaluable contribution in bringing out this issue. More importantly, I extend my sincere gratitude to all the Guest Editors for their invaluable efforts on reviewing the papers and guiding us to improve the quality of the Journal. Special thanks are due to Mr. Tanka Prasad Dahal for facilitating the overall process of this publication, Er. Sanjeevan Shrestha for his tireless efforts to bring the Journal in stipulated time, and Er. Bhuwan Ranjit for her sincere contribution in preparing the organizational report to be incorporated in this issue. At the same time, I would like to thank all the authors for their resourceful professional contribution. I am confident that such a support and professional contribution will be continued in the upcoming issues too. I further encourage my fellow colleagues from the Center as well as the professionals of Land Management and Geomatics to contribute to the journal by providing quality articles in the future. I am confident that you will find this journal a 'must read' one.

Enjoy Reading!

Ganesh Prasad Bhatta
Executive Director
Land Management Training Center
July, 2020

# Table of contents

VOL. 02 | ASADH 2077 (JUNE/JULY 2020)

**Original Articles**


- A collaborative model and "knowledge transfer vehicle" for capacity development: geo-information and land administration education at kathmandu university jointly with land management training center **7**
- Assessment of pre-processing methods of digital elevation models for stream delineation **13**
- German school of thoughts on geography and its implication in Nepal **20**
- Comparison of early season characteristics of nepalease forest fires retrieved by MODIS and VIIRS **28**
- Impact of labour migration on land use change: a case of Nepal **33**
- Ultra-High RESolution UAV images for Land pooling **39**
  - Identifying suitable resettlement areas for squatters using multi criteria evaluation **46**

# A Collaborative Model and "Knowledge Transfer Vehicle" for Capacity Development: Geo-information and Land Administration Education at Kathmandu University jointly with Land Management Training Center

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## ABSTRACT

Capacity Development (CD) is seen as a key component to bring effectiveness, efficiency, and sustainability in any discipline. In this respect, the importance of capacity development has been highlighted by various scholars, both in the technical and managerial aspects of land management. Education in geo-information and land administration become very important to integrate with the overall management of land in the country context. Therefore, it becomes a dire need to think in these settings. Moreover, a conceptual approach is required, to cope with the various challenges that can come across while producing quality human capacity. Therefore, an innovative approach to capacity development has been adopted by Kathmandu University (KU) jointly with the Land Management Training Center (LMTC), Nepal. This paper seeks to describe the existing collaborative model of capacity development in geo-information and land management. The paper provides insight into how the model has served as "Knowledge Transfer Vehicle" by being able to outreach in seven provinces of Nepal. In addition, it reveals that the collaborative model has supported in providing educational opportunities and contributes to the transition phase of federalism and decentralization of the Land Administration System (LAS) in Nepal. Also, the model has contributed to the "Equity" dimension, which is one of the themes under "Kathmandu University, Silver jubilee Initiatives, and Vision 2030".

* This article is reviewed version of article presented in International Workshop on "Capacity Building and Education Outreach in Advanced Geospatial Technologies and Education Outreach"

## KEY WORDS

*Capacity Development, Geo-information, Land Administration, Kathmandu University, Land Management Training Center, Equity, Inclusiveness, Federalism*

## 1. INTRODUCTION

### 1.1 Capacity Development:

Capacity Development (CD) is increasingly seen as a key component to bring effectiveness, efficiency, and sustainability in any discipline. In a general context, capacity development can be expressed as enhancing the ability of people to work in an effective, efficient, and sustainable manner. Capacity development can be considered at three levels, the individual, organizational and institutional levels (Enemark et al., 2004; Samarakoon & Inomata, 2008). At the individual level, CD refers to the procedure of changing attitudes and imparting technical knowledge, developing specific skills, ability to knowledge exchange, and accountability on the work (ownership). Similarly, at an organizational level, it is about enhancing the overall organization performance and functioning capabilities including the ability of an organization to adapt to change. The capacity development at the institution level is about the ability to support organizational changes. Besides, CD emphasizes the overall policy framework which consists of individuals and organizations that operate and interact with the formal and informal institutions. Therefore, for the proper functioning of the whole system, CD in all three levels is important.

### 1.2 A dire need for capacity development in geoinformation and land administration

A need for capacity development in geoinformation and land administration has been found as a global agenda. Georgiadou and Groot (2010) have highlighted that geospatial technologies and capacity to handle that technology at various levels including institutional, organizational, and individual levels are required, to cope with the global level issues related to biodiversity, climate change, land degradation and also the global spread of diseases. Nonetheless, the global pandemic situation due to COVID-19 has given more emphasis on the requirement of developing geospatial human capacity to combat during and post COVID-19 crisis (Shrestha et.al, 2020). Similarly, Enemark (2005) has highlighted the necessity to capacity assess, capacity developing, and capacity development sustainability of land professionals to achieve a sustainable

land administration system. A conceptual framework was developed by Enemark et al. (2004), to develop overall capacity in land administration as illustrated in Table 1.

| Capacity Building in Land Administration | | |
|---|---|---|
| Level | Dimension of capacity Assessment | Dimension of Capacity Development |
| Societal/ Systems level | Policy Dimension<br>Social and institutional dimension<br>System dimension<br>Legal and regulatory dimension | Land policy issues<br>Land administration vision and system<br>Land administration systems<br>Land tenure principles<br>Legal principles |
| Organizational/ Entity | Cultural issues<br>Managerial and resource issues<br>Institutional issues and processes | Institutional infrastructures<br>Spatial Data Infrastructures(SDI)<br>Professional institutions |
| Individual Level | Professional competence<br>Human resource needs<br>Educational resource | Education programs<br>Sandwich or franchise programs<br>Training programs<br>CPD programs<br>Virtual programs<br>Other measures<br>Educational and research center |

*Table 1. Enemark and Williamson (2004)*

The requirement to develop capacity in the sector of geo-information and land administration has been identified at the national level in Nepal. The market study was carried out in 2010 by Kathmandu University to assess to need for human resources in land administration and land management. The study has highlighted the requirement of skilled human resources in the scenario of federalism. Nepal has six metropolises, 11-sub metropolises, 276 municipal councils, and 460 village councils (Government of Nepal, 2019). In the transition phase of federalism, there is a need for immense human capacity in the sector of land administration and geoinformatics that facilitates in decentralizing of land administration services in the three-tier government system (federal, state, local).

To fulfill this necessity, the undergraduate program in geomatics engineering has been started in 2007 at the Kathmandu University (KU). The graduate program in Land Administration was started in 2013 and the graduate program in geoinformatics has been started recently in 2019. All the courses are offered jointly with the Land Management Training Center (LMTC) based on the Memorandum of Understanding (MOU). The MOU is defined as a type of agreement between two (bilateral) or more (multilateral) parties. Further, it articulates a convergence of will between the parties by indicating that there is an intended common line of action. In addition, the diploma level education was started jointly with KU, LMTC, and CTEVT in which KU plays the role of facilitator. There are financial subsidies from the Nepal Government which has been allocated in each program.

### 1.3 Knowledge Transfer Vehicle

The main elements of the knowledge management process are knowledge acquisition, knowledge storage, knowledge transfer, and utilization of knowledge (Gonzalez & Martins, 2017). Among these four elements, knowledge transfer has huge importance. “Knowledge transfer” is the objective seeking communication of knowledge among knowledge sender and knowledge recipient. The recipient of knowledge should have a cognitive understanding and can apply knowledge. To obtain the smooth transfer of knowledge between the sender and recipient, the knowledge transfer mechanism is paramount. The particular knowledge transfer mechanism is the vehicles via which the knowledge is transferred. Taking into consideration of KU-LMTC collaborative model, the model has become a “Knowledge Transfer Vehicle” that supports the transition phase of federalism and decentralization of the land administration system in Nepal.

### 1.4 Aim of the Study

The main aim of this study is to describe the existing collaborative model (KU-LMTC) for capacity development in geoinformation and land administration. The paper provides insight on how the model is being able to outreach by considering the vision of equity and inclusiveness and supportive in the transition phase of federalism and decentralization of the national Land administration system in Nepal.

The following section 2 describes the existing collaborative model between KU-LMTC. Then section 3 highlights the past and present scenario of geo-information and land administration education at Kathmandu University. Section 3 presents the analysis of the outcome of the model.

## 2. AN INNOVATIVE COLLABORATION BETWEEN KATHMANDU UNIVERSITY AND LMTC

Collaboration is a concept in which two or more entity involves a target to achieve a common goal. In this era of rapid technological development, no single entity can have all the internal capacity and capabilities in the form of human resources, technical resources, and financial resources (Powell et al., 1996). The collaboration can be on a different level such as individual, and organizational. The collaboration between KU and LMTC is inter-organizational.

The KU is an autonomous, not-for-profit, self-funding public

institution. It is governed by the KU Act in December 1991. It has its mission statement as "*to provide quality education for leadership*". The vision is "*to become a world-class university devoted to bringing knowledge and technology to the service of mankind*"(Kathmandu University, 2019a). Further, KU aspires to serve the nation with the norms like "*from the campus to the community*." The University has set the vision as "Silver Jubilee Initiatives-Vision 2030" mainly in six cross-cutting thematic domain, namely quality, innovation, equity, identity, impact, and global engagement in order to develop the University as world-class university (see for details in (Kathmandu University, 2019a)). The University consists of seven Schools which are School of Science, School of Engineering, School of Arts, School of Law, School of Education, School of Medical Science, and School of Management. The department of Geomatics Engineering is under the School of Engineering in which the education on geo-information and Land administration is delivered. The niche of MOU between KU-LMTC is in producing quality human resources in Bachelors in Geomatics Engineering, Masters in Land Administration, and ME/MS in geoinformatics. All the mentioned programs are running under the Department of Geomatics Engineering (Kathmandu University, 2019b).

Land Management Training Center (LMTC), established in 1968, under the Land Management, Cooperatives, and Poverty Alleviation, is the governmental institution that has the mandate to produce human resources and conduct evidence-based policy research activities in the field of Geo-information Science. Apart from joint academic courses with KU, LMTC has been conducting two types of training programs. One is long-term training programs which are Senior Survey Training, Junior Survey Training, and Basic Survey Training. In addition to long term training, the center has been running short term flexible professional courses in geo-information and land management as per the requirement of professional development activities capacity in the government organizations (Land Management Training Center, 2019)

**2.1 Human Resources:**

The human resources refer here is about the expertise to deliver the lecture on a different subject. The availability of qualified and skilled teaching faculties is a significant contributor to the quality product. Human resource sharing between KU and LMTC is one of the important pillars in which this collaboration is based on. The courses were designed in the "T" model (Ehlers, 2013). The horizontal bar of "T" denotes the ability to act successfully across disciplines, contexts, and systems. The vertical bar of "T" denotes in-depth knowledge in one field. For instance: project management, entrepreneurship, internship are courses offered to represent a horizontal bar of "T" whereas, spatial data acquisition (surveying, photogrammetry), spatial data analysis (GIS, digital image processing), spatial data storing (DBMS, SDI) and spatial data dissemination (WebGIS, cartography), digital cadastre are courses offered representing vertical bar of "T". The capacity to deliver the "T" model courses are fulfilled from the expert of specific courses available at LMTC and KU by providing lectures to the undergraduate and graduate students.

**2.2 Technical Resources:**

Besides sharing human resources, another major pillar on which the MOU is based on the sharing of the technical resources. Technical resources, here, refers to the surveying equipment (Theodolite, Total Station, GNSS, UAV, etc), Geo lab which consists of computer hardware and software related to geo-information, photogrammetry, surveying, and remote sensing.

**2.3 Physical Resources:**

Physical resources refer to physical infrastructures like lecture rooms, seminar hall, library, a student hostel, and surveying field. Under this collaboration, the third important pillar is the physical resource sharing.

## 3. SETTING THE SCENE: PAST TO CURRENT PATH OF EDUCATION AT KATHMANDU UNIVERSITY IN GEO-INFORMATION AND LAND ADMINISTRATION

Taking into consideration of the need for capacity in handling geoinformation technology and its application in tackling land-related issues, the intervention on capacity building was made in 2007. The intervention was about developing a "Center of Excellence" at the Kathmandu University in producing human resources in the sector of geo-information and land management (KU & LMTC, 2007).

The MOU between KU-LMTC has been signed for the graduate program namely, Land Administration, in 2014. Under this MOU, the target was set to produce batches of 2014 to 2017. Before signing the MOU, the market study was carried out in 2010 which shows the need to strengthen the capacity of land professionals for supporting the federalism scenario of Nepal (Kathmandu University, 2010). After conducting the market survey, the detailed implementation plan, including the role of the University of Twente, was prepared (KU -LA Implementation Committee 2012). Later, the MOU was signed between KU and LMTC for the implementation of the graduate program in LA. Under the specific MOU, a 100% scholarship for 10 government employees was allocated. The financial support was provided by the Government of Nepal. Recently, the MOU was signed to produce a graduate in two programs (Geo-informatics and Land Administration), from the batches of 2019 to 2022. The MOU reflects about providing 100% scholarship to the government employee considering the scholarships are provided for five government candidates in each program (KU-LMTC, 2019).

The undergraduate program in Geomatics Engineering was started in 2007 under the framework of MOU. Under the first MOU, the geomatics batches from 2007 to 2010

were produced in the geospatial field. 75% of the total fee is waived for 24 students (KU et al., 2007). Under the second MOU, the geomatics batches from 2011 to 2014 were brought into the market. The 100% scholarship was provided for two government employees who were in the engineering services under the category of survey whereas 50% scholarship was given for eight students from four development regions except for central regions and 33% scholarship was provided for 10 students based upon the merit score of entrance exam conducted by KU namely Kathmandu University Common Admission Test (KU-CAT) (KU-LMTC, 2011). Under the third MOU, the geomatics batches from 2015 to 2018 were produced into the market of geo-information. In this MOU, 35% scholarship was given to 20 students according to the merit list of KU-CAT and including all five development regions. However, the scholarship was provided to maximum four students in each development region (KU & LMTC, 2015). Recently, the MOU has been signed to produce batches of 2019 to 2022. The MOU explicitly consists of inclusive criteria as shown in Table 1 (KU-LMTC, 2019).

## 4. COLLABORATIVE MODEL AS A "KNOWLEDGE TRANSFER VEHICLE"

Figure 2 illustrates a conceptual framework of the collaborative model between KU-LMTC. The model is developed based on MOU signed in 2019.

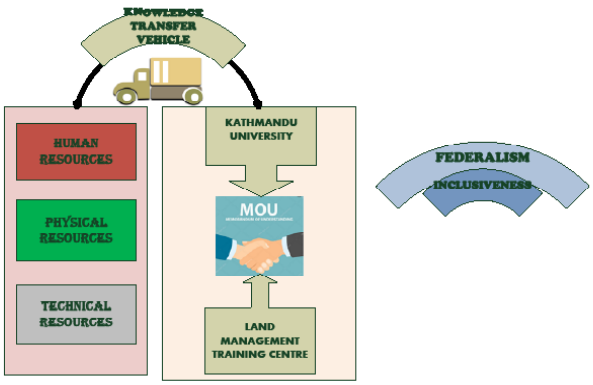


*Figure 2: Collaborative Model and Knowledge Transfer Vehicle*

The collaborative model of KU-LMTC is a "Knowledge Transfer Vehicle" for educating geomatics engineering. Based on the MOU, the KU-LMTC shares the physical, technical, and human resources as elaborated in sections 2.1, 2.2, and 2.3. With this joint effort, there are more than 220 geomatics engineers including LA masters graduates were graduated from KU.

### 4.1 Inclusiveness

The collaborative model is based upon the inclusive criteria. The inclusiveness has been defined in terms of gender, deprived community, and ethnicity. Table 2 shows the inclusive criteria which are geographically inclusive as well because each quota for female, ethnic group and economically deprived is allocated for all province. Similarly, three intake seats based upon the score of the entrance exam has been distributed equally in all seven provinces (KU & LMTC, 2019).

| Inclusive Criteria | Number of Intakes | Scholarships |
|---|---|---|
| Employee of Nepal Government | 4 | 100% |
| Inclusive Quota (3 from each province)<br>Female-1<br>Ethnic Group-1<br>Backward region/ Economic deprived-1 | 24 | 35% |
| Provincial Open Merit (3 from each province) | 21 | |
| Open Merit | 8 | |
| Total | 57 | |

*Table 2: The inclusive criteria and the number of intake from each province*

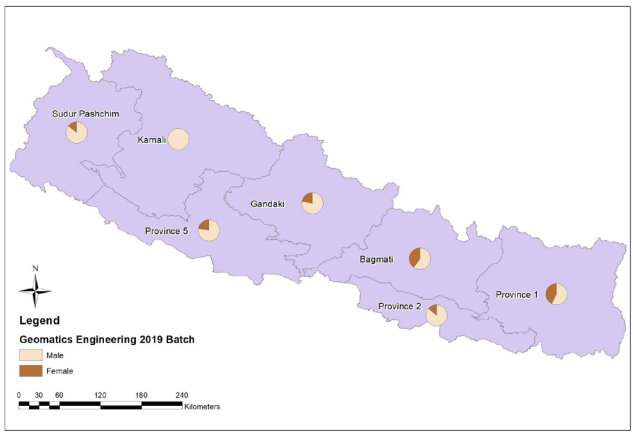


*Figure 3: The distribution of students in Geomatics Engineering Batch 2019*

Figure 3 shows the female candidate is accommodated from all the provinces except from province 6. There was no application received from a female candidate from province 6. In the situation, if there is no female candidate from that particular province, the scholarship will be transferred to the female candidate of another province based upon the entrance score (KU-LMTC, 2019).

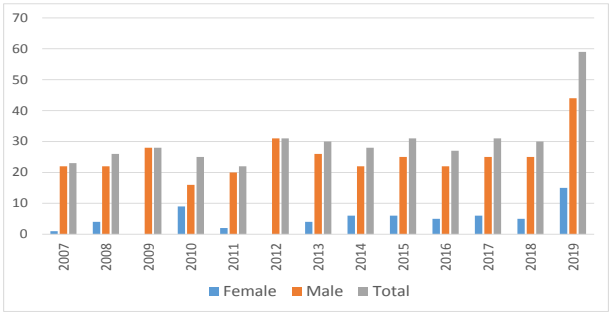


*Figure 4: Students of Bachelors in Geomatics Engineering*

As illustrated in Figure 4, the participation of female candidates is less significant through all the batches. In 2009 and 2012, there were no female candidates. However,

the inclusive criteria would support a female candidate to join in the Geomatics Engineering.

**4.2 Supports federalism of the Land Administration System**

The model further supports the decentralization of the land administration system of the country. The country needs a technical expert in 736 local level land offices i.e. 276 municipal councils and 460 village councils. The geographical equity criteria defined within this knowledge transfer model support in the transition phase of federalism.

## 5. RECOMMENDATION AND THE WAY FORWARD

The current level of capacity development seems to be at the individual level. Though the capacity developed at the individual level will be the input at the organizational level in the long run, it is important to develop capacity at another level as well. So, the integration of the Enemark et al. (2004) framework and KU-LMTC knowledge transfer vehicle can be of the further study area that is required to explore.

It is recommended to have further study in the aspect of the "impact" that the current education has given in the field of geoformation and land management.

In addition, the other component of knowledge management like knowledge acquisition, knowledge storage, utilization of knowledge should be equally taken into consideration for the sustainable management of the geo-information and land management education at Kathmandu University.

## 6. ACKNOWLEDGMENTS

The authors would like to acknowledge Prof. Dr. Ram Kantha Makaju Shrestha (Vice-Chancellor, Kathmandu University) for inspiring us to write the article. Further, we would like to acknowledge the reviewer of this paper.

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# ASSESSMENT OF PRE-PROCESSING METHODS OF DIGITAL ELEVATION MODELS FOR STREAM DELINEATION

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## ABSTRACT

Digital Elevation Models (DEMs) are widely used in hydrological modelling. However, a pre-processed DEM is warranted to result out such hydrological models where "sinks" are filled to facilitate smooth surface flow. This study examined the invasiveness and effects on Delineated Hydrological Networks (DHNs) of three pre-processing methods on a Swedish subarctic mire. The three methods considered were: 1) ArcGIS Fill Method (AFM), 2) Breach-Fill Method (BFM), and 3) Optimized Pit Removal Method (OPRM). The results showed that AFM proved to be the most invasive approach, followed by BFM and OPRM, respectively. Lower spatial resolutions decreased the Figure of Merit and Correctness of the delineated networks across all three methods, although a quantitative relationship could not be established without an independent reference hydrological network. AFM did not breach across the infrastructure in the right locations and flattened out small-scale topography, yielding it an unsuitable method for this study area. OPRM generated a highly detailed DHN but did not breach across the infrastructure in the right locations. BFM detailed DHN as well and breached correctly. Based on the performance of these three methods, the study recommended their use considering the spatial resolution of the DEM used, topographical location, and infrastructure blockage.

## KEY WORDS

*DEM, DEM breaching, DEM pre-processing, stream delineation*

## 1. INTRODUCTION

Digital elevation models (DEMs) are used for a variety of scientific applications, such as the modelling of hydrological features (e.g. Li and Wong 2010). However, before a DEM can be used further, it needs to be pre-processed to make it hydrologically correct. A common step taken is the filling of "sinks", cells surrounded by higher elevations (Zandbergen 2006). Surface depressions are hereby treated as DEM errors and increased to the lowest elevation value surrounding the cell to ensure stream network continuity (Lidberg et al. 2017). Within the context of areas upstream of dam-like features, as well as when using high-resolution DEMs, using this default approach is problematic, as it not only removes artefacts, but also any real depressions constituting meaningful landscape features (Wu and Lane 2017). Accounting for small-scale topographical differences is relevant when modelling subarctic wetlands, since they are characterised by palsas and fens, i.e. local elevations and depressions associated with permafrost degradation, and their location governs local hydrology and further permafrost thaw (Olefeldt et al. 2013). The choice of a manual threshold value for sink filling (the "z-value") might thus be able to better preserve original surface topography than the default approach (e.g. Lode and Leivits 2011).

There are a number of studies (for e.g.: Lindsay and Creed, 2005; Lidberg et al.,2017; Poggio and Soille, 2012) that show how different pre-processing methods affect a DEM. There has always been a line of questioning regarding the most efficient way of pre-processing methods for the stream delineation. Therefore, the following study aims to explore three pre-processing methods (PMs) for DEMs at five different resolutions for a subarctic wetland in Northern Sweden. The first approach is a simplified method where all sinks are filled, subsequently called the "ArcGIS Fill" Method (AFM). The second approach is the "Breach-Fill" Method (BFM), an algorithm developed by the authors, which constitutes a combination of breaching culverts in the vicinity of known locations, and sink-filling at a minimum-impact depth to preserve topography; the third approach utilizes the advanced "Optimized Pit Removal" Method (OPRM), a tool obtained from the Center for Research in Water Resources (CRWR 2013). This study investigated the effect of using PMs and DEMs of different spatial resolutions on hydrological network (HN) delineation and invasiveness of different PMs.

The findings of this research provide an overview on how the sinks in DEM could affect the stream network delineation process and how such cases should be handled. Furthermore, the research provides an answer to the pre-processing methods that most accurately channelize water across road impoundments at culvert locations allowing smooth stream network delineation. In addition, the research reveals how the landscape extent was affected by the different pre-processing methods by computing the difference in absolute volume between the original and the pre-processed DEMs.

This manuscript is organised in different headings and sub-headings. Material and methods section provide an overview on data and methodology adopted. The next section provides result derived from each method. Finally, the stream networks from DEM of different resolution and pre-processing methods were discussed in the discussion section followed by the statement of the main findings in conclusion section.

## 2. MATERIALS AND METHODS

### 2.1 Description of study site and datasets

The study site comprises the 19.5 km2 large Stordalen catchment, a subarctic mire, 10km East of Abisko, Sweden (68°21'N, 19°03'E) (Figure 1). The topography of the area is mountainous (806m asl) with steep igneous and metamorphic rock slopes in the southern part, and a low-lying altitude (342m asl) underlain by discontinuous permafrost, in the northern part (Mzobe et al. 2018, Olefeldt et al. 2013). The latter consists of a spatially heterogeneous landscape of palsas and fens, which are subject to permafrost degradation and its associated ground subsidence (Mzobe et al. 2018, Wu and Lane 2017). The area is intersected by a road and a train track, equipped with culverts. As culverts are not captured by DEMs, the infrastructure becomes an obstacle for smooth passage of water from those following stream network.

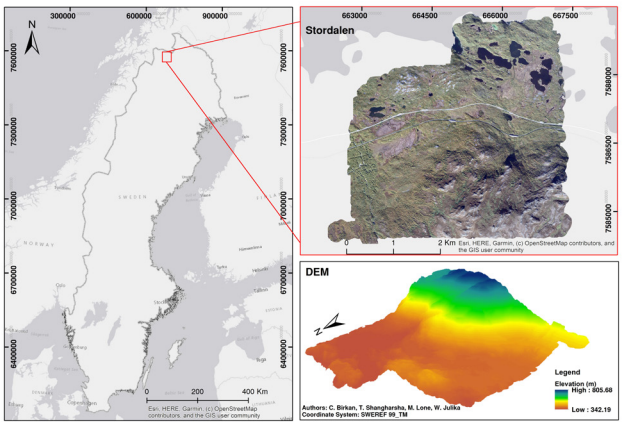


*Figure 1: Overview of the study area, showing its location in Sweden, the orthophoto, and the area's topography*

DEM datasets were obtained from different sources (Appendix A). Shapefiles containing lakes in the area and ten culverts were complemented through digitizing one additional culvert and several lakes, based on an orthophoto (Sept. 2016). All data was clipped to the extent of the 1m DEM and projected to the Swedish Reference Frame (SWEREF99 TM). The project was executed using ArcGIS 10.5 and the ArcHydro package; scripts were coded in Python 2.7.

### 2.2 Outline of the three pre-processing approaches

#### 2.2.1 "ArcGIS Fill" Method

Here, all sinks were filled without setting a z-value (Figure 2) to create a depressionless DEM meaning that the DEM is free of sinks. Infrastructure blockage was resolved without further processing. Whereas the method is commonly used (e.g. Tarboton and Ames 2001), small-scale topographical differences within the landscape may be flattened out.

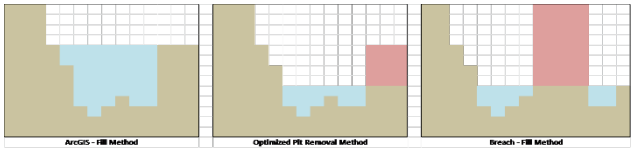


*Figure 2: Schematic representation of the three approaches, including filling (blue) and breaching (red)*

#### 2.2.2 "Breach-Fill" Method

In this approach, the z-value was determined using the raw DEMs by excluding lake areas. After creating a flow direction raster (D8-method), sinks and their contributing areas were detected, as well as sink depth (Mark 1988). Subsequently, the optimal z-value was found following an iterative process (Figure 3), identifying the lowest value that still enabled stream connectivity (Table 2).

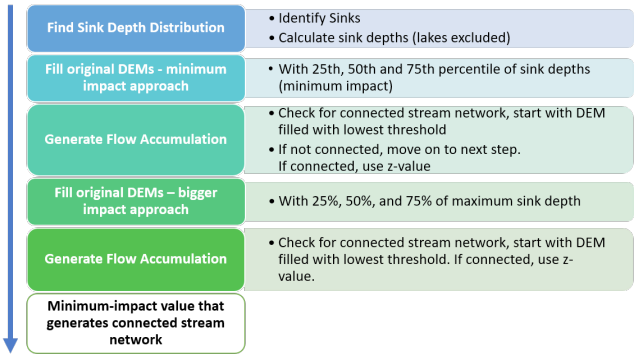


*Figure 3: Workflow for finding optimal sink depth*

**Table 2: z-values used for BFM**

| Resolution | Z-value | % of max. sink depth |
|---|---|---|
| **1m** | 0.56 | 25 |
| **2m** | 0.575 | 25 |
| **5m** | 0.702 | 25 |
| **10m** | 2.6 | 25 |
| **20m** | 7.5 | 75 |

An algorithm developed as a part of this research available at (https://github.com/shangharsha2929/ArcPy_DEMBreach.git) was used in identifying the most suitable culvert inlet/outlet point within a search radius of 20m (30m for 1arc-second DEM) around the approximate locations from the dataset. The inlet location is identified by finding the pixel in the upslope area with the highest flow accumulation (pixel A); the outlet location was found by searching the downslope area for the pixel with the highest elevation that is also lower than in pixel A. Infrastructure was breached by creating a linearly interpolated line between pixel A and B using Inverse Distance Weighting (IDW, Figure 4). After breaching, sinks were filled using the previously determined z-values.

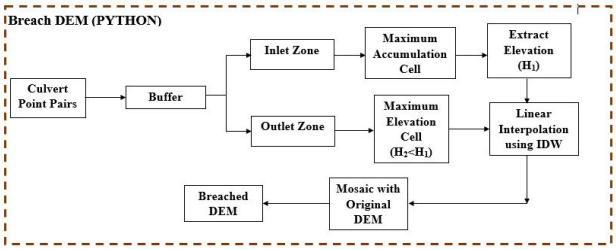


*Figure 4: Overview of BFM algorithm*

### 2.2.4 "Optimized Pit Removal"

OPRM is based on an externally developed tool for ArcGIS (CRWR 2013); the version used here removed sinks through a combination of breaching and filling while minimizing a cost function representing net elevation change (Figure 2). Contrary to BFM, OPRM breached throughout the entire study area. An overview of the complete workflow is shown in Figure 5.

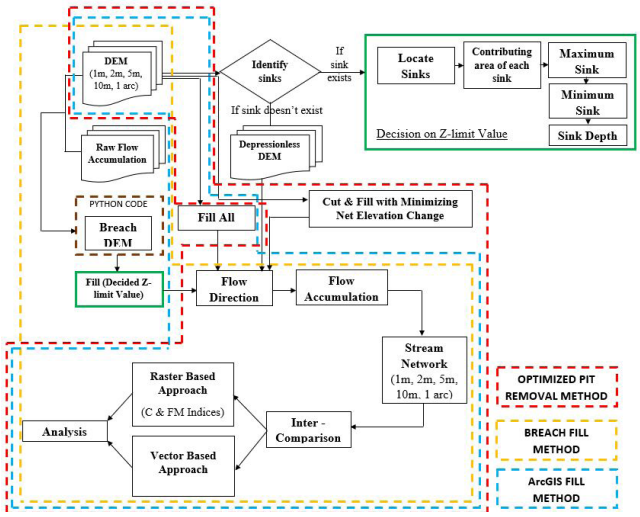


*Figure 5: Workflow for the three methods and subsequent accuracy assessment*

### 2.3 Hydrological network delineation and accuracy assessment

Hydrological networks (HN) were delineated by calculating flow direction and flow accumulation. For the 1m DEM, the ArcGIS-default stream definition threshold of 1% of total flow accumulation was determined; the same area threshold (110,000m2) was then used for HN delineation of the remaining DEMs. The effects of both PMs and spatial resolutions on Delineated Hydrological Networks (DHNs) were assessed. The accuracy assessment follows the raster-based approach taken by Zhao et al., (2018) and Li and Wong (2010), using the Correctness (C) and Figure of Merit (FM) indices (Eq. 1 & 2). Prior to calculating the indices, the datasets with the DHNs were resampled to match the 1arc-second data.

$$C = \frac{{}^{N}R \cap D}{{}^{N}R} \times 100\% \ (1); \quad FM = \frac{{}^{N}R \cap D}{{}^{N}R} \times 100\% \ (2)$$

Where NR is the number of cells in the Reference Hydrological Network (RHN), NR∩D is the number of pixels of the RHN intersecting the DHN, and NR⍰D is the number of pixels in the union of both RHN and DHN networks (Zhao et al., 2018). C measures the proportion of the RHN correctly captured by each DHN, and FM measures the degree to which the RHN is represented by DHN. Due to the low quality of available stream

vector data, the 1m DEM was considered as the RHN when comparing the effect of spatial resolution. Therefore, only relative agreement was evaluated.

### 2.4 Invasiveness of PMs

The invasiveness of each method was assessed by calculating its associated cost (Eq. 3 as shown below).

$$(Raster_{Preprocessed} - Raster_{Original}) \times Width_{Cell} \times Lenght_{Cell} \ (3)$$

Values per pixel were summed to get a total score per resolution per method. If the method also involved breaching (i.e. OPRM & BFM), both absolute and net change were calculated to account for negative changes. Lake areas were excluded from the analysis as it is characterized as the region of depression being filled and this will result in unrealistic filled volume.

## 3. RESULTS

### 3.1 Effect of PMs on stream delineation

Figure 6 compares the HNs produced for the 1m DEM for all three methods. While both BFM (yellow) and OPRM (pink) produced a similar overall pattern, the OPRM algorithm failed to breach through the infrastructure in several instances, and instead redirected five stream branches to follow the road ditches (1). Both methods retained mire topography, whereby OPRM led to a more pronounced meandering pattern throughout the low-lying areas than BFM did. In contrast, AFM flattened topography, creating a false HN flowing in parallel lines across the mire (2). Both the HNs of OPRM and AFM successfully crossed the infrastructure in three occasions, albeit at a shifted location from the real-world culvert location (3). Quantitative agreement between all three rasters was similar, whereby

AFM and OPRM showed a slightly better agreement (FM = 0.728), whereas BFM and OPRM were least similar (FM = 0.663).

### 3.2 Effect of DEM spatial resolution on stream delineation

#### 3.2.1 "ArcGIS Fill"

Figure 7 illustrates the agreement between the RHN (yellow), and the four other DHNs (red). Irrespective of DEM spatial resolution, all DHNs based on AFM contain sections of straight-line artefacts, where complete sink-removal led to flattening of the mire in the western part of the study area (4). In the case of the 1arc-second DEM, this phenomenon occurred in additional locations (5), making it a more pronounced problem when using the coarse spatial resolution. In contrast, with decreasing resolution, infrastructure blockage is crossed more easily, with fewer spurious streams parallel to the infrastructure (6). Overall agreement even between the 2m-DHN and RHN is rather low (FM = 0.479). With decreasing resolution, accuracy between the RHN and DHN further decreases, being lowest for 1arc-second (FM = 0.07).

#### 3.2.2 "Breach-Fill" Method

In contrast to the other methods, BFM (Figure 8) was specifically designed to breach the infrastructure, and successfully did so, avoiding the generation of longer spurious streams parallel to the road, with the exception of short sections in the LiDAR DHNs (7). The generation of false straight stream segments was avoided for all resolutions but ASTER 1arc-second (8). FM and C indices obtained are only slightly lower than the AFM, with agreement between the HNs ranging from FM = 0.479 and C = 0.644 (2m) to FM = 0.056 and C = 0.09 (1arc-second), following the same trend of decreasing accuracy for coarse spatial resolutions.

#### 3.2.3 "Optimized Pit Removal"

For OPRM, spurious stream generation occurred parallel to the infrastructure (9) more than in the other methods for all resolutions but the 1arc-second DEM (Figure 9). Additionally, OPRM led to more pronounced stream meandering and this generates different ways sinks are resolved in the low-lying areas, leading to distinct stream geometries across the two main mires (10). The difference increases as resolution gets coarser, with the 1arc-second DEM HN barely resembling the RHN across the mire landscape. Overall agreement between the HN raster datasets is higher than the other two methods; FM and C are highest for the 2m DEM (0.528 and 0.676 respectively) and lowest for 1arc-second DEM (0.072 and 0.109 respectively).

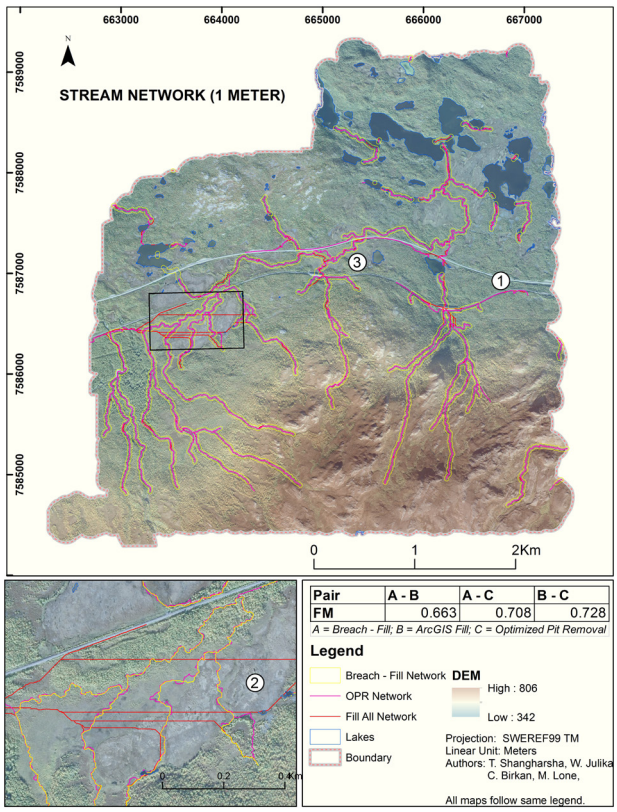


*Figure 6: Shows the three RHNs with a map inlet in a mire area where the distribution varies in contrast of the mountainous area.*

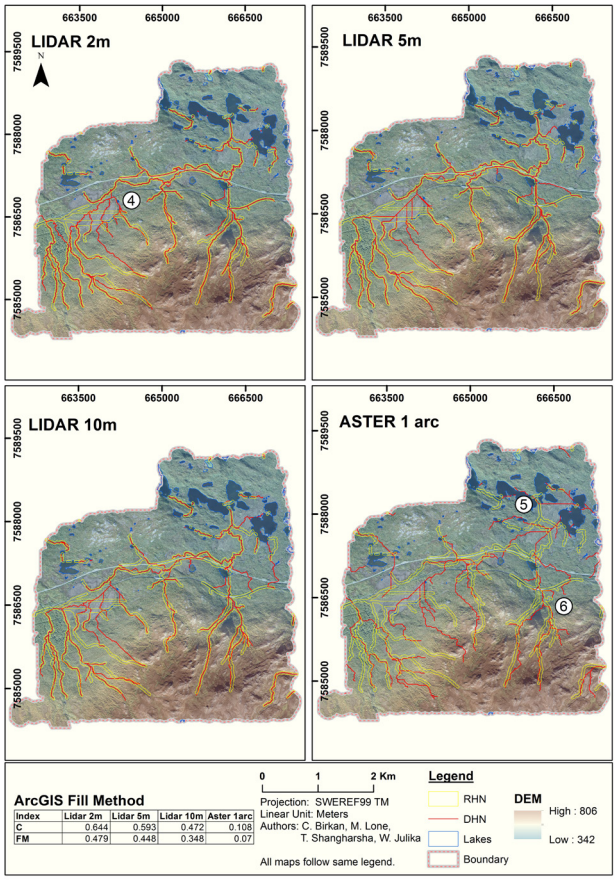


*Figure 7: The four DHNs with the RHN derived by AFM and the table with the values of correctness (C) and Figure of Merit (FM).*

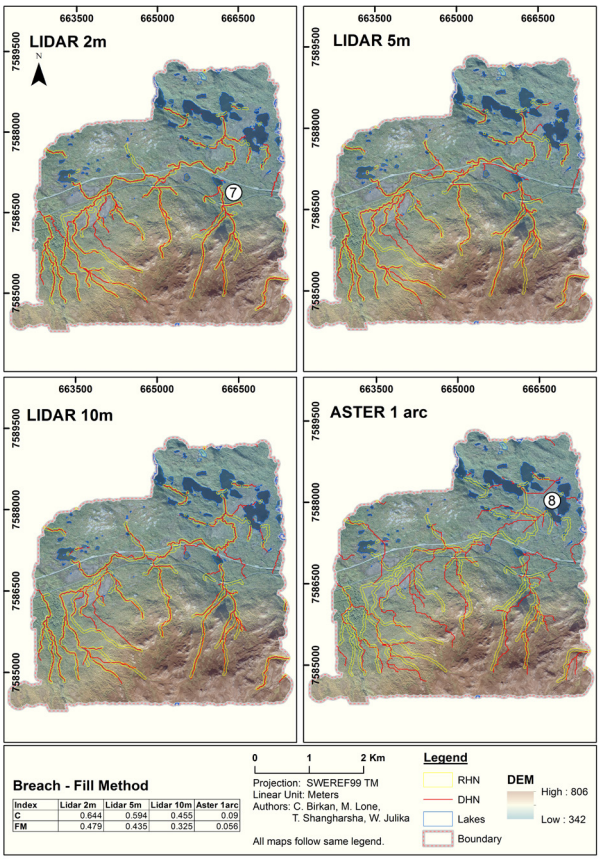


*Figure 8: The four DHNs with the RHN derived by BFM and the table with the C and FM indices.*

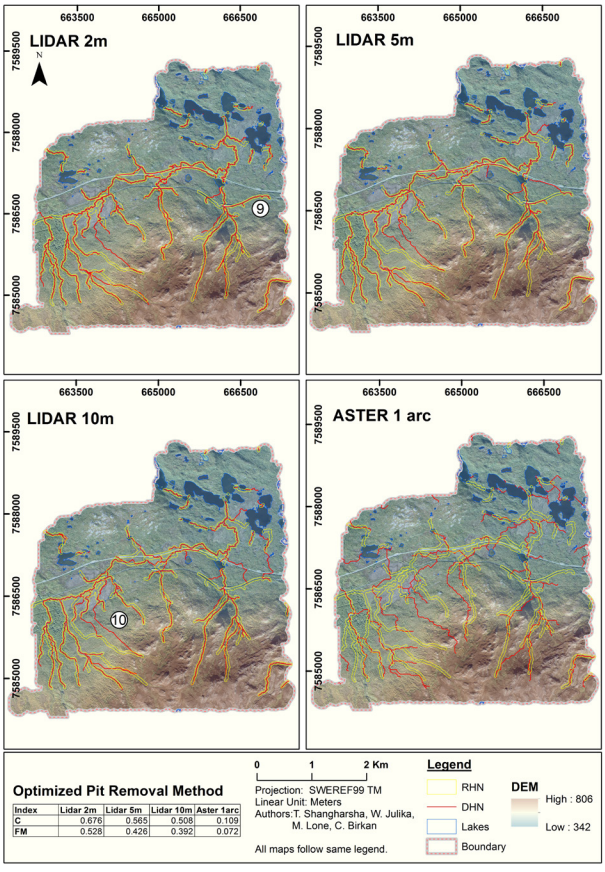


*Figure 9: The four DHNs with the RHN derived by OPRM and the table with the C and FM indices.*

### 3.3 Invasiveness of PMs

The invasiveness on the 1 arc-second DEM (Figure 10) is of substantially higher magnitude than the invasiveness on other resolutions (Figure 11). Absolute volume change was smallest across all spatial resolutions for the OPRM and largest for AFM. The value for BFM always laid in between, but were closer to OPRM than to AFM in all cases but one (1arc-second). 1arc-second DEM being the exception, invasiveness of AFM decreased with a lower spatial resolution. For the other methods, invasiveness decreased from 1m to 5m resolution, but went up again at 10m resolution.

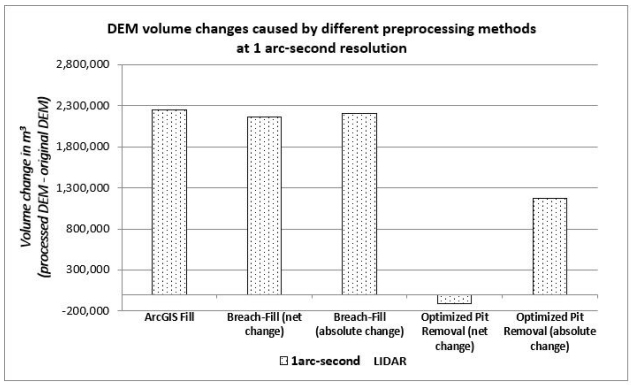


*Figure 10: Volume changes for the different methods at 1arc-second resolution*

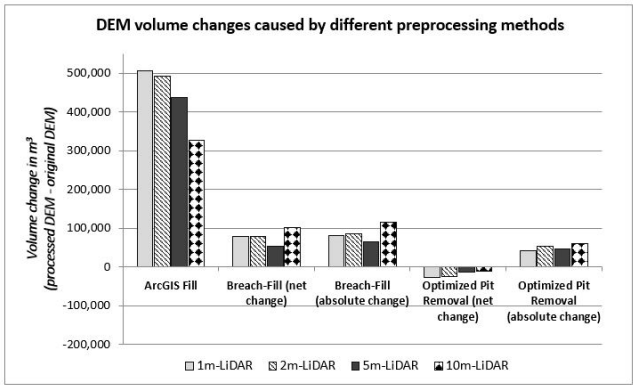


*Figure 11: Volume changes for the different methods and 4 spatial resolutions*

## 4. DISCUSSION

### 4.1 An inter-comparison of PMs

The straight stream geometry resulting from AFM highlights the need for a method that better preserves landscape features. Especially when modelling HNs in larger, relatively flat areas, AFM proves an unsuitable PM. When time constraints or knowledge of culvert locations are limited, or when the study site is mountainous throughout, AFM is able to provide a fast and easy way to generate continuous HNs while both resolving sinks and infrastructure blockage.

BFM and OPRM are preferred if a high level of DHN geometrical detail is desired, as both successfully avoid straight-line generation. The optimal of these two methods

depends on the application; BFM requires knowledge of culvert location and in-depth analysis of a suitable z-value which is time-consuming. In this light, OPRM provides a fast and relatively easy to use minimum-impact solution to ensure stream continuity. However, choosing OPRM constitutes a trade-off where user-control of culvert location and z-value is lost, and in several cases, OPRM is unable to recognize the need to breach the road. If infrastructure blockage is of lesser concern, OPRM provides a faster alternative to BFM, whereas for the Stordalen site, BFM is the only method that breaches in the correct locations of culverts.

The invasiveness on the 1arc-second DEM was disproportionately high, possibly because the raw DEM had an integer format. Sinks were always filled with at least 1m, yielding large volume changes. The 1arc-second DEM disregarded, the results of this part of our research showed that OPRM was least invasive, followed by AFM and then BFM. OPRM showed a particularly high local invasiveness in breached areas. An advantage of BFM compared to OPRM is that it minimizes the invasiveness from breaching, limiting it to user-defined locations. As the majority of the BFM-invasiveness was found in areas that were filled rather than breached, we suggest BFM-invasiveness could be mitigated by choosing a z-value lower than the 25% of maximum sink depth cut-off used in this study. The spikes in invasiveness at the 10m spatial resolution of both OPRM and BFM remains unexplained. The results of AFM invasiveness show that a cautious approach should be taken when using DEMs with a high resolution.

### 4.2 Effect of spatial resolution of DEM on stream delineation

In general, our results suggest that spatial resolution has a positive effect on stream delineation across all PMs, as FM and C always increases with decreasing cell size. This result is striking, as Li and Wong (2010) found that FM and C become higher at coarse spatial resolutions. This difference can be attributed to the fact that the HNs were resampled in this study to match the 1arc-second resolution, whereas Li and Wong (2010) did not apply this. A larger cell size therefore automatically leads to a higher chance of overlap between the RHN and DHN in their study. A note to be made is that the 2m and 1arc-second DEMs were generated from different sources and, using different sensors. The effect of spatial resolution was therefore not completely isolated, meaning a quantitative conclusion on its effects cannot be drawn. This study also showed that the effect of infrastructure blockage decreases with decreasing spatial resolution when AFM is applied. The success of breaching when using BFM is not dependent on the spatial resolution of the DEM, whereas the effect of OPRM is; the resolutions dictate how sinks are resolved in low-lying areas, impacting the resulting DHN to a large extent.

### 4.3 Limitations and future research

A key limitation of this study is the absence of high-quality reference stream vector data (e.g. Lantmäteriet) capturing the complex hydrology in Stordalen. This led to the fact that the 1m DEM was used as a reference in the accuracy assessment, creating a bias in this study. A correct RHN may show whether the pronounced meandering pattern produced by OPRM is corresponding to ground truth data. A preliminary comparison with the available orthophoto revealed that this was the case in some locations, whereas the less meandering streamflow of BFM showed a better correspondence to ground truth in other cases.

Furthermore, future research could look at the effect of spatial resolution in a more quantitative way, for example by merely comparing the indices derived by the LiDAR DEM from Lund University, resampled at many different cell sizes. The existence of an accurate vector-based or raster-based RHN, which currently does not exist for this area, is hereby crucial. A more detailed study on the optimal z-value when used in combination with BFM could significantly decrease the invasiveness of this PM and improve the accuracy of the resulting DHN. In the case of the Stordalen study site, BFM with a better z-value might prove to be a better PM than OPRM.

## 5. CONCLUSION

This study showed that the optimal pre-processing approach of DEM is dependent upon many variables. These variables are temporal resolution, technical knowledge, topography, and spatial resolution. AFM proved to be the most invasive approach, followed by BFM and OPRM respectively. Lower spatial resolutions decreased the FM and C of the DHNs across all three methods, although a quantitative relationship could not be established without an independent RHN. We suggest that BFM should perhaps be chosen when the study area has low-lying areas and infrastructure blockage. If this is not the case, or if there is limited knowledge of the study area, OPRM is preferred. When possible, pre-processing invasivess and resulting DHNs should always be carefully assessed before the final pre-processing approach is chosen, and the method of choice should always be justified.

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## 7. APPENDIX

Appendix A. Metadata of DEM and other data used in this study

| Dataset (year) | Description | Source (Distributor) | Resolution | Notes |
|---|---|---|---|---|
| **lidar1mS.tif (2008)** | LiDAR DEM | Lund University | 1 m | Obtained with helicopter at 500 m altitude. Interpolated using IDW (see Hasan, Pilesjö, and Persson 2012) |
| **LantMateriet2mS.tif (2009)** | LiDAR DEM | Lantmäteriet (SLU) | 2 m | Obtained with airplane at 1700-3500 m altitude. Linearly interpolated to TIN, then to raster. |
| **lidar5mS.tif (2008)** | LiDAR DEM | Lund University | 5 m | See lidar1mS.tif |
| **lidar10mS.tif (2008)** | LiDAR DEM | Lund University | 10 m | See lidar1mS.tif |
| **aster20mS.tif (2011)** | RADAR DEM | ASTER (NASA Earthdata) | 1 arc-second (~20 m) | Two tiles, merged. https://search.earthdata.nasa.gov |
| **genömflöden.shp** | culverts | Lund University | N/A | Edited by marking location north and south of barrier |
| **lakes.shp** | lakes | Lantmäteriet | N/A | Edited by digitizing from orthophoto |
| **Ortofoto.tif (2016)** | orthophoto | Lantmäteriet (SLU) | 0.25 m | Aerial photos https://maps.slu.se/get |

# GERMAN SCHOOL OF THOUGHTS ON GEOGRAPHY AND ITS IMPLICATION IN NEPAL

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## ABSTRACT

Long journey on development of geography faces many paradigm shifts with respect of interrelation of human being to environment. Basically the German thought paved important mile stones in conceptual development of geography. However, Geography is the complex concept of study about human relation with environment on the earth with main theme as location, place, human interaction, movement and region. But to describing themes of geography, we have to consider that no one theme can be understood without the others. The themes are connected with one another, as are all components of our world. The five themes of geography and ten geographic ideas which changed the world concepts are taken as key aspect with introducing ideas of different German geographers. Which tries to contrast on German thoughts on Geography. Diversity in geographical location and place motivates dynamic culture, population interactions and population movements in Nepal. It has both positively opportunity and negatively challenges. So, the study of terrestrial unity, humanitarianism and interaction between man and nature and its implications are emerging modern geographical thoughts which will be beneficial to grabbing opportunity and minimizing challenges i.e. implementation of federal structure of country, management of migration and urbanization, sustainable use of natural resources. Three paradigms; paradigm of area or region, paradigm of man-environment relationship and paradigm of space are major geographical issues identified in this study to grabbing opportunity and overcoming challenges in Nepal with respect to German school of thoughts

KEYWORD

*Paradigm shift, Geographical thought, German School of thoughts*

## 1. INTRODUCTION

Geography has meant different things to different people at different times and in different places (Livingstone, 1992). The differences were for the concepts, branching of the disciplines and approaches for conducting the researches. The schools of environmental determinism, possibilism, cultural determinism and areal differentiation led geography to four opposite directions deviating from the main tract of the development of the discipline.

Geography is the relational study about human and place. The history proofs that science of geography, different ideas to explain human-environment relationship. Mainly, environmental determinism is the key issue to geographers on side of the constructive and destructive power relation of man in human-environment interaction (Onal, 2018).

The German geographer Johann Christopher Gatterer, who identified the drainage basins as natural regions and used them as the frame of organization for geographical texts. From Gatterer the idea was picked up by several authors in Great Britain. The river basin was widely used as the framework for identifying what we would now call systems of interrelated elements (Martin, 2005).

Long journey on development of geography faces many paradigm shifts with respect of interrelation of human to environment. Basically the German thought paved important mile stones in conceptual development of geography. Diversely, French school of geography, American school of geography, British school of geography and Soviet school of geography and German school of thoughts are prominent milestone where this paper aims to comparative overview of thought development in Nepal with respect to German school of thought.

## 2. GENERAL THEMES OF GEOGRAPHY

Geography is more than memorizing names and places. Geographers organize space in much the same way that historians organize time. To help organize space, geographers are concerned with asking three important questions about things in the world: Where is it? Why is it there? What are the consequences of its being there? (Rosenberg, 2013).

### 2.1 Five themes of Geography

Geography is the complex concept of study about human relation with environment on the earth. Defining limited and selected themes of geography may be nonsense to satisfaction to all. But to describing themes of geography, we have to consider that no one theme can be understood without the others. The themes are connected with one another, as are all components of our world. No part of our world can be understood in isolation.

Geographers (1984), has explained the geography by categorizing it into five themes namely location, human/environment Interactions, place, moment and

regions. Though it was explained in five silos, the overall understanding of geography is difficult to achieve in isolation as each themes is interconnected with each other. The brief explanation of each theme is as follows.

1) Location: Position on the Earth's Surface (Absolute/ Relative).
2) Place: Physical and Human Characteristics.
3) Human/Environment Interactions: Shaping the Landscape.
4) Movement: Humans Interacting on the Earth.
5) Regions: How They Form and Change (Geographers, 1984).

**2.2 Ten Geographic Ideas That Changed the World**

When geographic ideas change the world in our heads, the impact can be read on the ground and in our lives. In these thought-provoking, witty essays, some of America's most distinguished geographers explore ten geographic ideas that have literally changed the world and the way people think and act. They tackle ideas that impose shape on the world, ideas that mold our understanding of the natural environment, and ideas that establish relationships between people and places. Every one of these ideas has had and continues to have a deep effect on the way we understand the world and our place in it. A compelling introduction to the discipline of geography, this collection will change the way you look at both geography and the world (Hanson, 1997). The Ten Geographic Ideas are listed as:

1) The Idea of Map
2) The Weather Map: Exploiting Electronic Telecommunications to Forecast the Geography of the Atmosphere.
3) Geographic Information Systems.
4) Human Adjustment.
5) Water Budget Climatology.
6) Human Transformation of the Earth.
7) Spatial Organization and Interdependence.
8) Nested Hexagons: Central Place Theory.
9) Megalopolis: The Future is now.
10) Sense of Place

(Hanson, 1997) tries to cover overall themes of geography in Ten Geographic ideas, which can be described in four categories i.e. idea of map, human behavior, spatial aspect and urban trend.

**2.2.1 The Idea of Map, the weather map and water budget climatology**

A map is a symbolic depiction emphasizing relationships between elements of some space, such as objects, regions, or themes. Joseph Partsch more focused on use of accurate maps for systematic study of geography. He argued on favored of the idea of large maps, with full of physical and non-physical information. Carl Ritter describe geography as an empirical and descriptive science concerned with systematic or 'general features as, e.g. atmosphere, movement of water etc. through the weather map: exploiting electronic telecommunications to forecast the geography of the atmosphere. He predicted previously that geography as study of weather and atmosphere.

**2.2.2 Human Adjustment, Human Transformation of the Earth and Sense of Place**

Increasing numbers of population growth, concentration in megacities, development of the techno sphere and numerous novel chemical substances, industry, and agriculture have played catalyst to dynamic human's movement. Ratzel, the 'founder' of political geography and is often recognized as the father of modern political geography, viewed the man-nature relationships in a balanced way. He gave a new definition to human studies in a systematic way. Out of his works, particularly 'Anthropogeography' and 'Political Geography' are mentioned. He discussed the human behavior and adjustment with place on important theme on geography.

**2.2.3 Spatial Organization, Interdependence and GIS**

Spatial organization is the way a group or phenomenon is arranged on the surface of the Earth. Geographers like to split things into functional regions, or areas defined by business and economic activities around a focal point or node. A society's degree of spatial exclusion practices seems to be inversely related to the degree to which that society may be regarded as open (Jensen, 2009). The concept of Chorology i.e. the study of causal relations between geographical phenomena occurring within a particular region and the spatial distribution of organisms is originated during modern German Geographic concept. The principles behind spatial arrangement of phenomena, their causal connections, inter-relationships, which could give geography a true scientific status, were yet to be established (Sapkota, 2017 ). GIS is compatible tool for management, analysis and retrieve data about human and location.

**2.2.4 Megalopolis, Nested Hexagon and central place theory**

In geographical concept, Megalopolis refers to a cluster of densely populated cities stretching over a large region, where Christaller's central place theory model assumes that each settlement situated in the center of the region will try to lead and serve for its neighbors. Logically this should result in a circular complementary space or region. Christaller assume that the threshold for customers who shop in hardware stores is fifty miles, and then it would follow that on a flat plane, it should be able to find hardware stores in centers located fifty miles apart. Such an arrangement on the landscape, however, would leave areas that are not served by any hardware facilities. Thus, the most efficient shape for a service area (in the Christaller model) is not a circular, but a hexagon.

## 3. PARADIGM SHIFT IN GEOGRAPHY

A paradigm shift is a fundamental change in the basic concepts and experimental practices of a scientific discipline (Kuhn, 1962). Kuhn mainly argues on characterize a scientific revolution, to the activity of normal science, which he describes as scientific work done within a prevailing framework or paradigm. Nowadays in the sector of geography, geographic space there is manifest need to accept an integrated approach both in geographic space and how we investigate it (Koutsopolos, 2011).

### 3.1 Classical Geography in Germany

Classical geography adopts the positions of Ritter. In spite of appearances, it owes little to Humboldt: from him it has borrowed the practical methods of symbolization, a taste for precise scientific description, but no general concepts. Humboldt's cosmologic vision of geography is lost in the classical period: geography is now concerned with small, local integrations, and has given up explaining distributions on a global scale.

This content will try to describe some of most popular classical geographers of Germany, who in the late nineteenth century made significant contribution to systematic studies, both in physical geography and human geography.

#### 3.1.1 Alexander von Humboldt (1769–1859)

Alexander von Humboldt was the most famous German of his time, was celebrated as a geographer, explorer, and naturalist; he was less well known for his valuable contributions to the development of the social sciences. He is widely recognized for his works on botanical geography which laid the foundation for biogeography.

**Box- 1: The Humboldt's major concepts on geography**

**The Humboldt's major concepts on geography:**

- Geography considers earth's surface as a home of man;
- Geography is a science of spatial distribution of the world-phenomena (the basic concept of geography);
- General geography is Physical geography, and includes man wherever he is part of nature;
- Geography is the study of inter-relationships, i.e. relation between living (organic) and non-living (in-organic) worlds;
- Geography is the comprehension (understanding) of the world phenomena;
- There exists heterogeneity of phenomena in geography, and the geographers' task is to search for similarities or general (common) rule of their existence; and
- The 'unity of nature' is a characteristic feature of geographical studies

#### 3.1.2 Carl Ritter (1779 –1859)

Along with Alexander von Humboldt, Carl Ritter is considered one of the founders of modern geography. From 1825 until his death, he occupied the first chair in geography at the University of Berlin. Ritter describe geography as an empirical and descriptive science. According to Ritter, geography deals with the local conditions and embraces three attributes of a place, viz.

(1) Topographical: dealing with the natural divisions of the earth; (2) Formal: concerned with systematic or 'general features as, e.g. atmosphere, movement of water, etc.; and (3) Material: which describe the geographical aspects of natural history and cover distribution of human beings, minerals, plants, animals, etc.

Humboldt and Ritter are together popularly known as the 'Fathers of Modern Geography' or 'Founders of Modern Geography' or 'First Masters of Modern Geography'. The period of German School before Humboldt and Ritter may conveniently be called as "Pre-Classical" and that after them as "Post Classical". Major contributions as; Peter Apia's Heart Map, a Mappa Europae (map of Europe) in 1536 of Sebastian Münster, Cluverius' Map are important milestones in development of geography.

### 3.2 The Post Classical Geography in Germany

After Ritter's death, geography in Germany lacked a focus to give it unity. The drastic change in concept on classical geographical thought was developed with new geographical theme as morphology of landforms, general geography, political geography, man land relations, and determinism. Passage's cultural geography, Köppen's climate boundaries, Schott's geographical positions of trigonometrically points, Christaller's central place theory, Kjellen.s the study of the territories, Karl Haushofer's geographical materialism are important contributions where this paper aims to highlight about scholars: Oscar Peschel, Richthofen, Ratzel, Gerald are main scholarly foundations of new geography in Germany.

#### 3.2.1 Oscar Peschel

Oscar Peschel, professor of geography at Leipzig in 1871 was the first new professorship created after the death of Ritter. Peschel in early age had already established his reputation as an editor and a writer. He had been the assistant editor of the Allgemeine Zeitschrift at Augsburg and from 1854 to 1870 was the editor of Das Ausland , a periodical that printed articles about foreign countries and about problems of foreign affairs. He had written on the history of ancient geography, and on this basis the Historical Commission of the Royal Academy of Sciences invited him to write a book on the history of geography to form a part of a series on science in Germany (Martin, 2005).His systematic studies about features together with lakes, islands, valleys, and mountains were published in 1870.Peschel's main theme are concerned as follows:

- The morphology of landforms.

- The study of the influence of landforms on human history.

His early death, at the age of 49, caused irreparable loss to the emerging 'new geography' in Germany.

**3.2.2 Ferdinand Von Richthofen**

A geologist, Baron Ferdinand von Richthofen, became the leading figure in the introduction of the new geography into the universities of Germany. He was an experienced field observer. As a young man he had carried out geological studies in the Alps and the Carpathians (Martin, 2005).

He distinguished the different methods of study in areas of different size, which he named (in order of decreasing size): Erdteile (major divisions of the earth), Lander (major regions), Landschaften (landscapes or small regions), and Ortlichkeiten (localities).He was one of the forerunners of 'new geography' in Germany.Richthofen's travels in China between 1868 and 1872, which he conducted under contract to the Bank of California. Initially his research had little to do with value-free geographical investigation but was dedicated to the geological survey of the Chinese coal reserves. In "China" coining of 'Silk Road', Richthofen did indeed develop a few important guidance for regional geography that continued to be influential far into the twentieth century.

**Box- 2 The major contribution of Richthofer**

**The major contribution of Richthofer:**

- Research works in the Alps and which carried out on geological studies in the Carpathians.
- After working in China, he sailed across the pacific to California, where he spent six years in active geological studies.
- He defined the nature of the relations between volcanic rocks and the occurrence of gold which he studied in Hungary.
- Richthofen is known for his valuable work on China which was published in five volumes, between 1875 and 1912.
- The work also contained a large atlas of China. The work on China was a landmark in the contemporary geographical literature.
- Method of locating minerals and fuels
- Richthofen attempted to distinguish between the 'general geography' and 'special geography'.
- Richthofen was very much concerned by the contemporary problem of geographical methodology – 'should geography be concerned only to describe the unique features of particular regions or should it concern with the formulation of generalizations or theory'?

**3.2.3 Friedrich Ratzel**

Friedrich Ratzel, basically concerned with the works of human, particularly the products of human's social life in relation to the Earth. He was the greatest single contributor to the development of the geography of human. He made significant contributions to ethnography that is today highly esteemed by cultural anthropologists. He published a book on Chinese emigration in 1876, especially that which occurred in California. Later in 1878 and 1880, he published two volumes on the United States (Physical and Cultural Geography with Reference to Economic Condition). Late 19th century, Ratzel was initiated determinism concept through his book 'Anthropogeographie' (1982). He adapted Darwinian arguments to states, which he treated as organisms that struggle for land (Lebensarum or living space).

Ratzel is also called the 'founder' of political geography and is often recognized as the father of modern political geography. He viewed the man-nature relationships in a balanced way. He gave a new definition to human studies in a systematic way. Out of his works, particularly 'Anthropogeographie' and 'Political Geography', there emerged two new doctrines, viz. 'Environmental Determinism' and 'Geopolitiks'. The main interest of Ratzel was in geology, zoology and comparative anatomy (the science of body structure of organisms). He became popular among geographers because of his work on:

(1) Man-Nature relationships; and

(2) Political Geography.

Ratzel explored human relationships with the physical surroundings in a systematic manner (a mix of the ideologies of both Humboldt and Ritter). The findings of his work are based on empirical observations as he approached all human-nature relationships through travel and direct contact with the realities.

**3.2.4 George Gerald**

George Gerald was professor of geography at Strassbourg from 1875 until his retirement in 1910. He attempted to develop the views of Kant and Peschel in an effort to develop geography as an exact science. He favored the complete exclusion of humans from the field of geography. He maintained that geography should be exactly what the word Erkunde (Explore) implied, study of the whole Earth without reference to humans. He concluded that physical sciences could formulate exact laws, but no such laws could ever be formulated which could account for the behavior of human groups. He was more focuson the study of the physical aspects of the Earth. He kept the contemporary dichotomy between human geography and physical geographyalive for a longer period

**3.2.5 Joseph Partschthe**

Joseph Partschthe forerunner of the modern geomorphology is credited with the first use of the term to refer to the

origin and development of the Earth's landform. He was born in Leipzig in 1858. He studied natural sciences at the University of Leipzig, beginning in 1875. He went to Munich in 1880 to work under Karl Zittel, and there he became a private doyen at the University in 1883. He was Professor of Geography at the University of Vienna from 1885 to 1906.

**Box- 3the major contribution of Joseph Partschthe**

**The major contribution of Joseph Partschthe:**

- Identification of four separate ice-ages in the Alps, and a book to this effect was published in three volumes from 1901-09.
- He studied the population capacity of the Earth, in terms of the carrying capacity of specific land units.
- The study of geography would remain incomplete unless there is the provision of accurate maps showing the major features that are associated with areas. He focused on Systematic study of geography with use of accurate maps.
- He favored the idea of large maps, full of physical and non-physical information.
- The distinguished architects of modern German geography.

**3.2.6 Albrecht Penck**

Albrecht Penck, versatile genius and a great scholar of his time is long remembered for his valuable contribution to the development of modern physical geography. He was a phenomenon in himself as the philosophy he developed in the realm of physical geography had not only struck the German geography alone, but also the geography outside Germany.

He was the forerunner of the modern geomorphology for he is credited with the first use of the term to refer to the origin and development of the Earth's landform. Penck was without doubt one of the scholastic giants of the last generation. His greatest contributions to knowledge were his studies of the Ice Age and its fluctuations, but he was, throughout his life, a professional geographer.

**3.2.7 Immanuel Kant**

Immanuel Kant (1724–1804) argued that the supreme principle of morality is a standard of rationality that he dubbed the "Categorical Imperative" (CI). Kant characterized the CI as an objective, rationally necessary and unconditional principle that we must always follow despite any natural desires or inclinations we may have to the contrary.

## 4. GERMAN SCHOOL OF THOUGHT

German geography contributes major early development of the subject as a regionally oriented discipline in the 19th century. Carl Ritter, Alexander von Humboldt, Ferdinand von Richthofen, Albrecht Penck, Friedrich Ratzel, Hermann Wagner, Joseph Partsch, Alfred Hettner are symbols of geographical approach mainly the subject's of as Länderkunde, a specifically German variant of Regional Geography. The development narrative approach, of physical and human geography through the medium of space is a successful Länderkunde, representing the best in current research and studies (Wardenga, 2006). Major German school of thoughts claims about issue of unity and diversity with physical and humanistic approach, concept of chorology and landscape themes.

**4.1 The problem of Unity and Diversity**

Unity in diversity is a concept of "unity without uniformity and diversity without fragmentation" that shifts focus from unity based on a simple acceptance of physical, cultural, linguistic, social, religious, political, ideological and/or psychological differences towards a more complex unity based on an understanding (Sidaway, 2016).

**4.2 The Concept of Chorology**

The objective of the chorological point of view is to know the character of regions and places through comprehension of the existence together and interrelations among the different empires of reality and their varied manifestations, and to comprehend the earth surface as a whole in its actual arrangement in continents, larger and smaller regions, and places (Hartshome, 1959:13). The study of the causal relations between geographical phenomena occurring within a particular region, contributed on the spatial distribution of organisms. The goal of the chorological point of view is to know the character of regions and places through comprehension of the existence together and interrelations among the different realms of reality and their varied manifestations, and to comprehend the earth surface as a whole in its actual arrangement in continents, larger and smaller regions, and places (Hartshome, 1959:13).

**4.3 Geography as Landschaftskunde**

The concept of 'cultural landscapes' can be found in the European tradition of landscape painting. The word "landscape" itself combines "land" with a verb of Germanic origin, "scapjan /schaffen" to mean, literally, "shaped lands". All of Hettner's methodological considerations ultimately pursued the aim of establishing geography as a subject entirely devoted to Länderkunde and of describing the entire earth in a unified and standardized manner as a complex of regions at different scales i.e. "landscape", "landscape science" and areal differentiation(Wardenga, 2006).

### 4.4 The Concept of Chorology Applied to General Geography

It was Alfred Hettner, who elaborated Richthofen's concept of chorology. His earliest methodological statement was published in Volume 1 of the Geographische Zeitschrift, a professional periodical that he founded in 1895 and of which he was the editor until 1935. Hartshorne quotes Hettner's first statement of the nature of geography as follows: "If we compare the different sciences we will find that while in many of them the unity lies in the materials of study, in others it lies in the method of study. Geography belongs in the latter group; its unity is in its method. As history and historical geology consider the development of the human race or of the earth in terms of time, so geography proceeds from the viewpoint of spatial variations (Hartshome, 1939:97).The examination of the areal associations of things of diverse origin, can be applied to general geography as well as to studies of segments of the whole face of the earth (Martin, 2005).

### 4.5 Climate and Landscape

Penck's suggestion concerning the imprint of climate on the landscape inspired a number of studies at different scales to elaborate on the hypothesis. One of those who contributed to Landschaftskunde, not only in the detailed investigation of small areas but also at the global scale, was Siegfried Passarge .Passage's field study of the landscapes of the Kalahari Desert was published in 1904. His interest in the treatment of landforms as a part of a broader geographical study of landscape led him to call for empirical landform description rather than the genetic method proposed by Davis (Passarge, 1919-20).

### 4.6 The Geography of the Oceans

Oceans have held changeable spaces in the thoughts of societies, always connected to particular cultures and shifting in line with leading world views and developing socio-economic and technological capacities (Gee, 2019). Regularities of pattern also exist in the oceans, and the first comprehensive treatment of this subject was by the German ocean geographer Gerhard Schott, who from 1894 to 1933 worked in the Deutsche Seewarte in Hamburg (Schott, 1912, 1935).

## 5. GEOGRAPHICAL THOUGHTS IN NEPAL

Geographical thought provides a clear and accessible introduction to the key concepts, ideas and figures in both physical geography and human geography which try to an essential introduction to the theories that have shaped the study of societies and space. Fundamentals of geographical thought constitutes an investigation into

the way in which geographic subject matter was recognized,

perceived, thought about, and evaluated over the course of centuries.

### 5.1 Regional geography

The concept of the region is complex because the region makes a complex interconnection between numerous geographical, social, economical, cultural, political and other factors. Until the 1960s, regional geography remained a popular discipline, and this subjective the research conducted in Nepal in the 1960s.Regional geography is important because of its area of analysis of areal differentiation to clarify a specific situation in a particular locality. Dr. Harka Gurung is one of the leading geographers of Nepal, whose study was remarkable in that joint geological evolution and human habitations and changes to understand the specific characteristics of Pokhara and variations within the valley. Regionalism concept can also be involved in cultural regions since there is always a counter-culture in regionalism. Hark Gurung's publication "Regional Development Planning for Nepal" started a new vision of regionally balanced development in the country.

### 5.2 Cultural and Physical Geography

When Toni Hagen first set foot in Nepal in 1950, he came as a development expert. Over the next nine years that he travelled about 14,000 km across the length and breadth of Nepal by foot, conducting its first reconnaissance survey, he grew to become a valued friend of the country (Thapa, 1999).The most important geographical development works that helped make Nepal known to the outside world with contributions of Toni Hagen and Pradyumna Prasad Karan. Their efforts are still considered the leading steps of geographical information on Nepal. Hagen travelled the country extensively and surveyed its geology, regional divisions and physiographic. His book Nepal: an important milestone in understanding the geographical diversity and human habitations in these diverse physiographies besides being illustrated by some stunning photographs (Karan, 1960).

Mountaineer and Researcher Barry Bishop used the concept of 'cultural ecology' in studying life and livelihoods in the Karnali region in the 1960s. His book and articles on the Karnali is considered seminal works on cultural ecology and its application.

### 5.3 Phytogeography and climate

Phytogeography is concept of the distribution and composition of various plants differs from area to area and from season to season. Vertical differentiation of plants according to altitude has been an interesting feature of the Nepali landscape to have attracted geographers and plant ecologists identically. The huge and diverse range of altitudes in the short north-south horizontal distance and the existence of the extremely high east-west trending of the Himalaya alter the normal climatic pattern seen in such geographical areas.

### 5.4 People and Population

The majestic natural beauty of the Himalaya Mountains has

inspired wonder and religious devotion in people around the world. Pradyumna Prasad Karan was one of the earlier geographers to show cultural developments and patterns in the Himalaya. Even though his thought covers the entire Himalayan region, it deals with Nepal quite widely (Thakur, 2019). Karan's study also depicts the Himalayan region as one where population movement takes place on a wide scale. He says that migration is constantly occurring from rural to urban areas and from urban to urban areas.

**5.5 Political ecology**

Conservation of diverse landscape is at the attention of public policy debate given its geo-ecological and socio-economic distinction and its real and seeming environmental degradation (Dipak Bishwokarma, 2016). The concept of 'political ecology' has also been applied in Forests, People and Power with the impact of participatory forestry on livelihoods in the context of Nepal and India (Oliver Springate-Baginski, 2007).

## 6. IMPLICATIONS IN NEPAL FROM GERMAN SCHOOL OF THOUGHTS

From the very beginning, modern geography as a field of scientific learning has occupied a strange status between natural and physical sciences- focused on particular types of natural processes or circle of facts on the one hand, and the social. Thus, as a discipline focused on the study of man's relationships with nature in particular segments of the earth surface, geography represent a fusion discipline that belonged neither to one nor to other (Rana, 2013).

Diversity in geographical location and place motivates to being diversity on dynamic culture, population interactions and movements in Nepal. It has both positively opportunity and negatively challenges. So, the study of terrestrial unity, humanitarianism and interaction between man and nature and its implications are emerging modern geographical thoughts which will be beneficial to grabbing opportunity and minimizing challenges i.e. implementation of federal structure of country, management of migration and urbanization, sustainable use of natural resources. Three major paradigm of thoughts can specified to cover different modern thoughts.

**6.1 Paradigm of Area or Region:**

The regional development that is the capacity to develop faced with new challenges and, as a result, it continues to advancement. It is an important transformation or change in emphasis in the character of regional development. Some have characterized this qualitative renovation as a shift from an 'old' paradigm of local development that sought to balance covering regions to a 'new' paradigm, normally labeled 'place-based development', which attests that all places can grow when policymaking is familiar to spatial particularities (Pugalis, 2016). Mainly the concepts of areal-differentiation, landscape/landschaft, chorological viewpoint, and regional concept can be reviewed on recently developed government structure in Nepal to develop its social, economical and environment prosperity.

**6.2 Paradigm of Man-Environment Relationship:**

In geographical research, influence of the human-environment relationships stepped by the end of the 19th to the beginning of the 21st century, which significantly affected our way of thinking about man-environment relations. Different scientific approaches and paradigms in geography had influential thoughts and helped the shaping of a paradigm. The research development on human-environment relations has assessed in geography from time to time, but the connecting paradigms had also different stories through time and space.

The impact of determinism had the greatest influence, where possibilism has also had a significant impact on geographical discipline. The important historical development through postmodern, poststructuralist, and postcolonial approaches changed radically the basis of human-environment research (Margit Kőszegi, 2015). Paradigm changes with concepts as determinism, possibilism, ecological, behavioral approaches, radical and

humanistic approaches may be crucial concept for socio-cultural development to country like Nepal, where exists diverse society and places with in short geographical distances.

**6.3 Paradigm of Space:**

Space and place together define the nature of geography. Spatial analysis or the explanation of spatial organization is at the forefront of geographical research. Geographers appear to be confident of both the meaning of space and the methods suited to its analysis. In present growing political and revolutionary change situation in Nepal, study and analysis of spatial distribution and spatial organization can remarkable for further social, cultural and economical development with rural to local regions (Sapkota, 2017 ). Geographical space analysis can visualize and forecast of population distribution, migration trend, and economical places for entire sustainable development of country.

## 7. CONCLUSION

In the journey of conceptual development of global geography, Germans school of thought contributed stepwise diverse paradigm concepts as determinism, concept of chorology, geography and Landekunde, climate and landscape and geography of oceans. Such concepts became the foundation and milestones for global modern geography with specifically region, man-environment relation and space paradigm to forwarding sustainable development.

In recent changing political and revolutionary development situation in Nepal, the study and policy implication of concepts about areal-differentiation, landscaping, chorological viewpoint and regional concept can be pillars to strengthening federal structure. For societal justice and

environmental balance the human-environment interaction approach may guide sustainable development with consideration analysis of spatial distribution and spatial organization.

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**Annex 1 Geographers and their contributions of German School of thoughts**

| S.N. | Geographers | Contribution |
|---|---|---|
| 1 | Alexander von Humboldt | Earth's surface as a home of man, Unity of Nature |
| 2 | Carl Ritter | Geography as Empirical and descriptive Science |
| 3 | Oscar Peschel | The morphology of landforms |
| 4 | Ferdinand Von Richthofen | Landschaften (landscapes or small regions) |
| 5 | Friedrich Ratzel | Man-nature relationship and political geography, Environmental Determinism |
| 6 | George Gerald | Human and physical geography |
| 7 | Joseph Partschthe | Origin and development of the Earth's land reform |
| 8 | Albrecht Penk | Modern Geomorphology |
| 9 | Immanuel Kant | Categorical Imperative |

# COMPARISON OF EARLY SEASON CHARACTERISTICS OF NEPALEASE FOREST FIRES RETRIEVED BY MODIS AND VIIRS

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## ABSTRACT

Frequent forest fire in the dry season in Nepalese forest has a great impact in ecosystem functioning and biodiversity loss. Numerous forest fire due to natural and manmade cause damage and prohibit regeneration of important tree species and non-timber forest products in one hand disturbs the habitat of wildlife in other. Satellite based forest fire monitoring and damage assessment is not new in world but gaining momentum in Nepal in last few decades. As there are so many technologies are evolving to fire detection and monitor, every of them are not feasible to practice due to technical capacity and easy access. Visible Infrared Imaging Radiometer Suite (VIIRS) is the new satellite which provides the data with higher resolution of 375m, 750m than that of MODIS. Incidence of forest fire in early season of 2016 was extracted from Fire Information for Resource Management System (FIRMS) website and analyzed in the Geographic Information System (GIS) environment. Incidence of fire captured by VIIRS was higher in the number of incidences than that captured by Moderate Resolution Imaging Spectroradiometer (MODIS). The incidences were used to make a hotspot map and categorized in four different categories of Low. Medium, High and Very high.

## KEY WORDS

*Hotspots, Forest fire, Hazard zonation, GIS, VIIRS, MODIS*

## 1. INTRODUCTION

Fire is an important factor in the ecology of forest, grassland and savannah especially in the geographically diverse country like Nepal. Forest fires plays a crucial role in shaping species distribution and contributed to the persistence of fire dependent species, and helped in the natural evolution of species. But sometimes, the forest fore goes beyond the human control and cause the large negative impacts on the environment and socioeconomic condition of communities. Groot et al., (2007) noted that forest fires can have a wide range of negative impacts on the human safety, health, regional economics, global climate change and fire sensitive ecosystems. IPCC (1995) noted that the effect of biomass burning aerosols and aerosols from the industrial activities has increased the uncertainty in assessing the anthropogenic climate change (Kaufman et al., 1998 as cited in Manyangadze, 2009). In case of Nepal, uncontrolled forest fire is an important driver of forest degradation. Recurrent forest fires severely damage and prohibit regeneration and growth of seedlings, destroy non-timber forest products and, in some cases, encourage invasive species (Parajuli et al., 2015). Thus, detection of forest fire with high accuracy and its spatial distribution is very important for the forest managers and ecologists to understand the fire dynamics so that necessary action can be taken in time.

Satellite based forest fire detection and monitoring has provided a long-term information regarding the forest fire since very long by acquiring the image of earth. Active fire data from space borne sensors have been available since 1980s (Ichoku et al., 2012; Matson and Holben, 1987; Setzer and Pereira, 1991) various sensors collect data with different spatial resolutions and their spectra span wavelengths the visible through infrared (Li, Wu and Xiong, 2016). The series of U.S. polar orbiter environmental satellites provided a crucial contribution to the international suite of sensors flown by various space agencies on both polar and geostationary platforms (Justice et al., 2013; Csiszar et al., 2013).

There are different platforms to provide the global fire data. Routine global active fire observations are now available for over a decade from the 1 km resolution Moderate Resolution Imaging Spectroradiometer (MODIS) instruments aboard the NASA Earth Observing System (EOS) Terra and Aqua satellites with spectral bands specifically configured to detect fires (justice et al., 2002). MODIS represent a major advance in fire observations, allowing the production of 1 km global fire detection product with fewer saturated pixels, and improved geolocation and orbital stability compared to its predecessors (Justice at al., 2011). Visible infrared imaging radiometer suite (VIIRS) aboard the Suomi-

National Polar-orbiting partnership (S-NPP) satellite which was launched in 2011 October is another platform to study the fire occurrence, its frequency, burnt area and emission made by it. It detects the fire event within the spatial resolution of 750m and 350m spatial resolution. The new generation U.S. operational medium resolution imager, the VIIRS (Cao C., 2013), provides radiometric measurements in the mid-wave infrared around 4 micrometers that, similar to heritage sensors, offer useful information for the detection and characterization of the active fires during both day and night time parts of the satellite orbit. The initial assessment made by Csiszar et al., 2013, between 15 February and 15 June 2013, VIIRS produces approximately 26% and 70% more detections than MODIS in 3 pixels and two and single pixel aggregation.

MODIS and VIIRS instruments have different but comparable geometric performance and VIIRS is in its early stage of performance. VIIRS performance is comparable or superior to that of the MODIS Aqua in corresponding bands in all key performance areas except crosstalk (Madhavan et al., 2016). This study makes the comparison regarding the number and extent of forest fire detection in between VIIRS and MODIS during early stage performance of VIIRS satellite. Hotspot map is prepared using both of the fire data retrieved by VIIRS and MODIS for greater understanding of performance. As the VIIRS provides the fire information with greater accuracy and number, it can be successfully used in the resource management.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Fire incidents were analyzed all over the Nepal in from year 2001 to the latest data available. Nepal lies between latitudes of 26˚22' and 30˚27'N, and longitudes of 80˚ 40' and 88˚ 12' E. Nepal is varied within the altitudes of 57m and 8,848m inbounded by India and China (Figure 1). The diverse forest types ranging from tropical species to alpine vegetation species which made Nepal's forest more prone to the forest fire also contributed by lack of awareness among people and inaccessible terrain conditions.

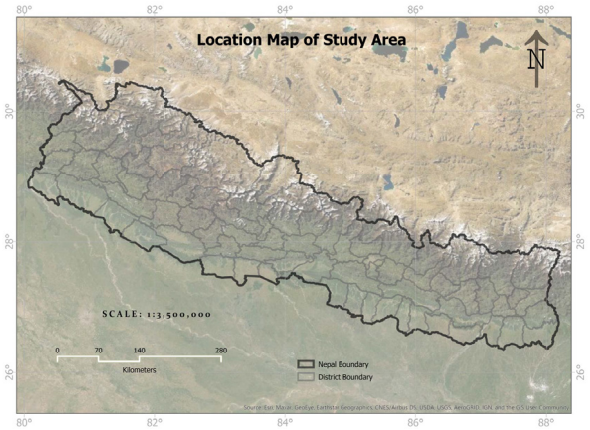


*Figure 1: Map of study area*

### 2.2 Data, Tools and Software

MODIS collection 6 and VIIRS active fire datasets were extracted from the Fire Information Resource Management System (FIRMS) websites: ftp://ba1.geog.umd.edu/collection6 and http://firms.modaps.eosdis.nasa.gov respectively. The digital layer of Nepal was collected from Department of Survey, Nepal. The FIRM's data were collected in Shape file format. Processing of spatial extent of fire events and hotspot analysis were carried out in ArcGIS Pro 2.0.

| Feature | VIIRS | MODIS |
|---|---|---|
| Orbit | 824km, sun-sync, near polar | 705km,sun-sync, near polar |
| **Scan rate** | 33.6rpm, cross track | 20.3rpm, cross track |
| **Size** | 1.3m*1.4m*0.9m | 1m*1.6m*1m |
| **Weight** | 263 kg | 250 kg |
| **Power** | 154 w | 225 w |
| **Data Rate** | 10.4 Mbps (peak) | 11 Mbps (peak) |
| **Quantization** | 12 bits | 12 bits |
| **Design Life** | 7 years | 5 years |
| **Resolution** | 750m , 375m | 1000m, 500m, 250m |
| **Bands** | 22 | 36 |

*Table 1: Differences between MODIS and VIIRS*

### 2.3 Research Design and Methods

The fire events captured by MODIS between 1 January 2001 and 25 June 2020 and that of VIIRS between 1 January 2013 and 25 June 2020 were analyzed. The hotspot analysis was carried out in GIS environment. The workflow chart is presented below (Figure 2).

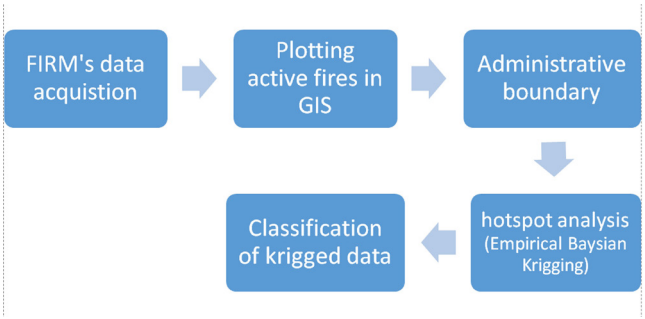


*Figure 2: Methodological process adopted in the research*

The FIRM's Active forest fire data acquired from FIRMS was subsetted for Nepal boundary for both MODIS and VIIRS detections during the mentioned time frame. The Shape File data received was further merged together making a single worksheet for each data of annual archive to prepare complete spatio-temporal dataset of fire orrurrence and processed further in GIS environment. The overlay of the administrative boundary i.e. district made easier to compare the density of the fire occurrence geographically and calculated using GIS for each of the districts. The data simultaneously processed to find out the hotspot areas

where major fire occurred during this period using GIS function of Empirical Baysian Krigging for both the data sources considering the confidence level and .

## 3. RESULT

### 3.1 Active Fire Map

We used mountain geoportal to analyze short term active fire from 01 January to 28 march 2016. Altogether 897 active fire incidents were detected in the given duration of time (Figure 3). This shows the higher incidence in lowlands. Greater accumulation of inflammable materials and higher temperature may be the reason.

### 3.2 Fire Hotspots

Both MODIS and VIIRS based forest fire hotspot map was prepared in GIS environment. The whole country was analyzed according to the confidence of forest fire. Higher the confidence value, higher the risk of forest fire. Altogether five categories are made for hotspot generation. The deep red denotes the area of higher risk whereas the light red areas with less risk of forest fire. Hotspot map varies between MODIS and VIIRS. VIIRS hotspot map shows there are less intermediate confidence of forest fire than extremes.

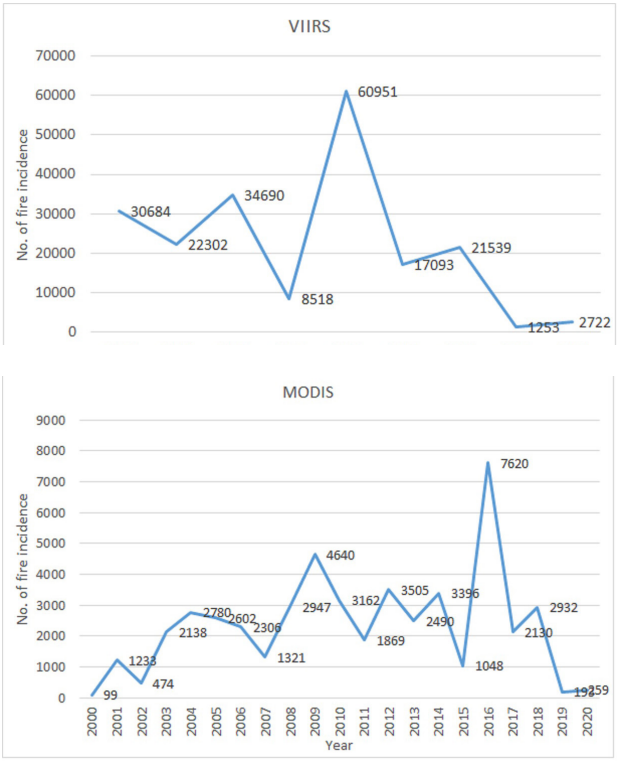


*Figure 3: Fire Incidences over the years A) VIIRS and B) MODIS*

### 3.3 Fire Incidents

The graph of the forest fire incidences detected through MODIS and VIIRS shows that the trend is similar but the frequency is higher in VIIRS such as in the year 2016 VIIRS detected 60951 and MODIS detected 7620 fire incidences (Figure 4). Even VIIRS is in its early stage of performance as compare to MODIS, we found the great variation in fire incidents captured by MODIS and VIIRS. In the date of March 20 of 2016, there were only 76 fire incidence of different intensity captured by MODIS whereas in the same date VIIRS gives the fire incidence approximately 10 times higher. It is due to higher spatial resolution of VIIRS satellite; the detailed comparative performance of VIIRS satellite is yet to be explored (https://earthobservatory.nasa.gov/IOTD/view.php?id=77025). The fire incidences are recorded more precisely by VIIRS as compare to the MODIS detection due to the spatial coverage of the data i.e. 375m of VIIRS as compare to the 1km of MODIS (Figure 4).

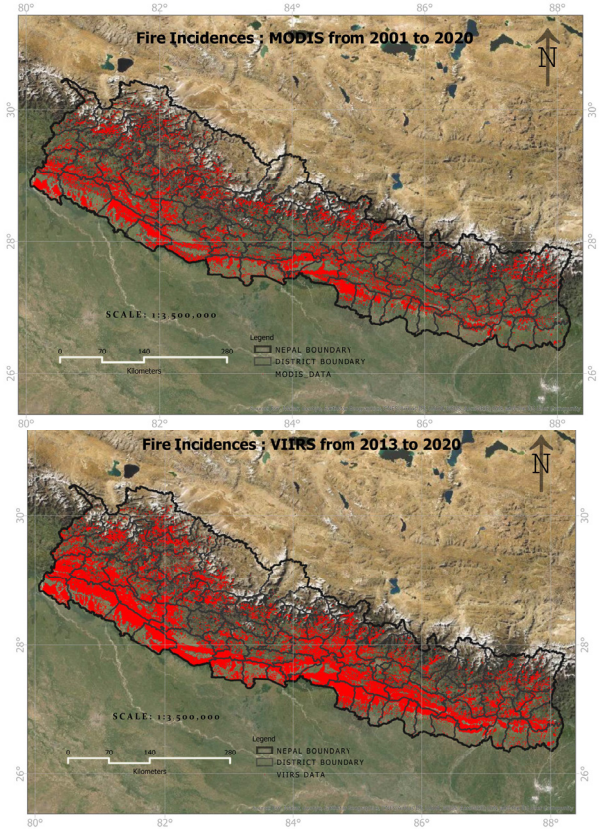


*Figure 4: Fire incidents during the study period (A) MODIS (B) VIIRS*

### 3.4 Hotspot Mapping

The hotspot maps prepared separately using VIIRS and MODIS data within the time shows that quite different each other. As the VIIRS provides the detailed information provided by the spatial resolution at 375m pixel. The hotspot maps are quite different and the results shown in the maps have different interpretation which ultimately and precisely provides the hotspot information of the forest fire occurrence (Figure 5). As compare to the MODIS hotspots, VIIRS hotspots are more realistic scenarios of the real ground fire experiences.

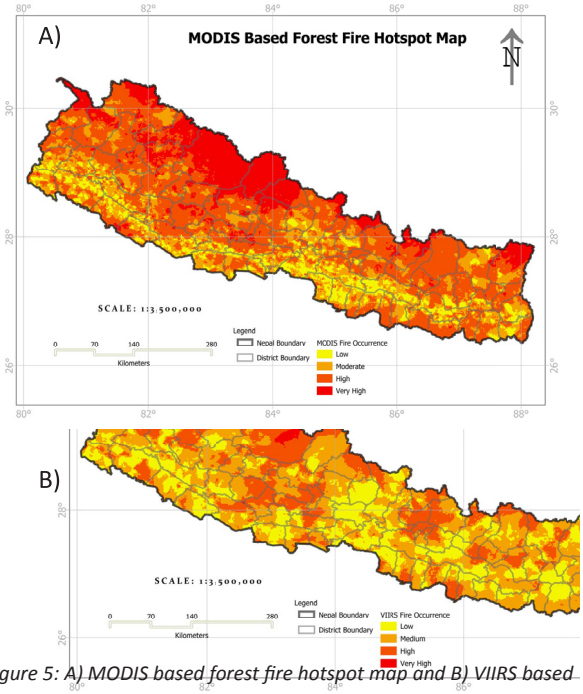


*Figure 5: A) MODIS based forest fire hotspot map and B) VIIRS based forest fire hotspot map*

## 4. DISCUSSION

Satellite based forest fire assessment has been mostly carrying out by MODIS products previously. VIIRS was launched in 2011, so it is in its early stage of performance. The spatial resolution attempted by VIIRS data is supershed to the MODIS coverage of 1km resolution. The detection of the forest fire within the 1km resolution data and 375m resolution data makes comparatively different picture as VIIRS detects small size fires with increased confidence level. The other chances of being over reported due to the pixel size if we consider to detect the fire incidences only. Thus, the new arena for the reporting of forest fire needs to focus on the burnt area reporting rather than the point based incidence reporting.

The previous attempts to observe the forest fire through detection of forest fire using MODIS (Parajuli et al., 2015), burnt area assessment using MODIS products (Shrestha and Dhonju, 2014) and Landsat Thermal anomaly and hyperspectral (Li and Xiong, 2016) data may be complemented using VIIRS data for the reporting of forest fire for not only to report fire occurrence but also to report the burnt areas and emission due to forest fire to the atmosphere.

## 5. CONCLUSION AND WAY FORWARD

### 5.1 Conclusion

The study has compared the fire occurrence captured by MODIS and VIIRS. Study shows VIIRS captured the forest fire incidence 10 times greater than MODIS. Based on the GIS based hotspot maps, active forest fire map of MODIS shows 897 forest fire incidents within about 3-month time interval.

Satellite based forest fire mapping and hazard zonation is primary work to be done for hotspot detection and precaution to be taken. VIIRS satellite is launched since 2011 and performing well in its early stage. VIIRS products and outputs can be used for forest fire analysis and mapping in coming days. The outputs can also be used for Carbon emission and contribution to climate change. As VIIRS gives result with higher accuracy can be used extensively in forest fire detection and management. However, there are some issues between VIIRS and MODIS sensors due to the spatial and spectral resolution

1. MODIS data has limited detection accuracy as it has coarser resolution of 1km.
2. VIIRS data has higher detection precision however it has higher chances of false detection.
3. VIIRS gives the idea of major fire problem in the ground at the district level (Figure 6B)

### 5.2 Recommendation

Counting only the number of forest fires is not sufficient for the forest fire management, should go for the advance analysis such as hazard zonation, hotspot analysis, damage assessment, carbon emission due to fire.

Technologies have provided opportunity to go into the depth of 375m resolution, need to develop in-ground facilities and other infrastructures for the better fire management

The false detection due to the higher resolution may be further refined using other parameters of the data i.e. confidence level, land cover (i.e. forest, grassland, agriculture, park areas). National level fire detection, monitoring and control action plan should be developed for the reduced damage due to annual forest fires.

## ACKNOWLEDGEMENT

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# IMPACT OF LABOUR MIGRATION ON LAND USE CHANGE: A CASE OF NEPAL

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## ABSTRACT

Labour migration is a common phenomenon in the developing and underdeveloped countries. The active labour forces are migrating from Nepal for employment. Nepal is one of the top five countries in the world that contribute to the national economy with remittance. This paper focused on how labour migration and remittance plays a role to change the land use decision at unit (parcel) level.

The case study was carried out in the *Waling Municipality* of Syangja district, mid-hill area of Nepal. Questionnaire survey, interview, focus group discussion and observation technique were applied for identifying the role of labour migration and remittance on land use decision. LULC change in the study area was discovered with land use map of 1998 and land use map of 2014. The change was also conformed to the orthophoto of 1996 and remote sensing imagery of 2014 (worldview-2) using the visual image interpretation technique supported by field observation. The change in land use was also verified based on the parcel fragmentation data and building approval data by respective survey office and municipality.

The result indicates that the relation between land-use change and labour migration is positively correlated. Labour shortage and remittances play major roles over the land use decision at the household level. *Bari* land is getting change to barren to bushes and ultimately to the forest, forest and built-up area are expanding and cropping pattern and crops are also changing. It is concluded that the decision on land use at the individual land unit (parcel) level changes due to the significant amount of labour migration in the mid-hill area of Nepal.

## KEY WORDS

*Labour migration, Land use change, Land use decision, remittance*

## 1. INTRODUCTION

*Labour migration is generally defined as a cross-border movement for the purpose of employment in a foreign country* (Migration, 2010). It can also be defined as the movement of persons from their home state to another state for the purpose of employment (Karubi, 2012). People move for migration to improve their lives and the lives of their family to learn skills and to gain new experiences, to find better jobs, and to reduce insecurity and disaster (Kollmair & Hoermann, 2012). More than 15 million people or about 3 per cent of the total population live outside of their birthplace or country (Ratha, Mohapatra, & Silwal, 2011). According to a report published by World Bank in 2011, the top remittance recipient country is India followed by China, Mexico, Philippines and France. Countries like Tajikistan (35 per cent), Tonga (28 per cent), Lesotho (25 per cent), Moldova (31 per cent) and Nepal (23 per cent) are even contributing to their national economy (Ratha et al., 2011). At the international level, migration is not seen only as a risk factor (e.g. against national security and human right) but also recognized as a factor that enhances the potential benefits in the countries involved in sending and receiving populations (Kollmair & Hoermann, 2012).

Remittance is the important sources of income of the household, particularly for the developing countries. Remittance is defined as the sum of the selected balance of payments flows (Alfieri & Havinga, 2006). Remittances improve living conditions, education and health in the communities of origin. It helps to protect difficulties. It also contributes to reducing the poverty of the home country (Alfieri & Havinga, 2006; Kollmair & Hoermann, 2012).

Assessment of the impact includes the process of analyzing, monitoring and managing the planned and unplanned policies, programs, projects and any change processes raised by those interventions (Wehrmann, 2011). Land-use change occurs with different causes such as local condition, social

factor, site-specific factor, family condition etc. (Briassoulis, 2010; Davis & Carr, 2010; Dijk et al., 2013). Due to labour migration at family level: income, education, employment, attitudes etc are changed, whereas at the societal level: population structure and population dynamics, income, technology are changed which consequently effect on the land use (Alfieri & Havinga, 2006, Davis & Carr, 2010).

Labour migration in developing countries is increased globally from the past few years (Alfieri & Havinga, 2006). Due to lack of the opportunity and employment at home and at the same time availability of the opportunity at abroad, people are migrating (Jha, 2010; K. Paudel, S. Tamang, & K. K. Shrestha, 2014). Migration of labour helps to enhance the economic status of the family (Alfieri & Havinga, 2006).

The objective of the study is to assess the impact of labour migration on the land-use change as well as To find out the trend of labour migration and land-use change in the study area

## 2. PROBLEMS AND ISSUES

Nepal is predominantly an agrarian country; agriculture is the main source of livelihood. Also, it is the major contributor to national GDP ( gross domestic product ), contribute about 33 per cent to the GDP and 77 per cent working population used to engage in it (Maharjan, Bauer, & Knerr, 2013). But nowadays labour migration for employment is increasingly becoming an important livelihood strategy for farm household in rural Nepal (Maharjan et al., 2013). Due to the migration of the labour, the impact is shown on-farm production, the finding of the study suggest that more farmer tend to neglect substances i.e. self-sufficiency farming when there are alternative sources of income additionally when household income is insufficient farmer show more interest in livestock farming than in crop farming (Maharjan et al., 2013; K. P. Paudel, S. Tamang, & K. K. Shrestha, 2014). With the change in the livelihood strategy of rural people from past, agriculture-based to present, foreign employment-based livelihood strategy direct as well as the indirect impact can be seen in the labour and land-use dynamics of rural area.

## 3. THE CONCEPTUAL FRAMEWORK

The conceptual framework of the research is shown in figure -1. The land can be used for different purposes such as agriculture, forest, residential, industrial, commercial etc (Land use Policy 2012). However, the use of land is influenced by many factors such as local factor, site-specific factor, family factor and social factor (Briassoulis, 2010). Out migrated labour gains the skill and knowledge, so the education level and attitude at the family level, is improving as well as influences (Briassoulis, 2010). So these factors support to change the existing land use decision.

The agriculture land and its productivity is the function of land, labour, capital, and skills (Colin Thirtlea, Linb, & Piessec, 2003). With the migration of the labour the amount of labour forces decreases, at the same time, there is increased in the capital with remittances. When society gets money then they invest in different sectors like real estate, home accessories, education, health etc these also directly or indirectly improving the family and societal factors. Consequently helps to change the land use decision at an individual land unit level.

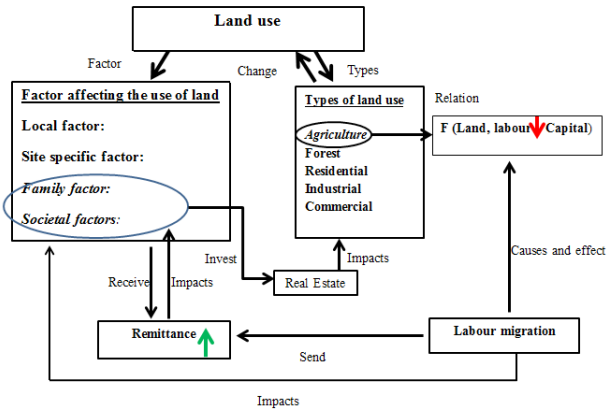



*Figure -1: Conceptual framework*

## 4. METHODS

The case study was carried out in *Waling* municipality of *Syangja* district. This district lies in the western development region of Nepal. This is one of the hilly districts, the region has the highest number of absent population (Kollmair & Hoermann, 2012). It is, therefore Syangja among this region was selected for the study. In this district among 68881 households, 34207 households have at least one member in foreign employment, the data shows that 49.66 Per cent household has their member in foreign employment this data justify for the case study site (S. office, 2014).

Among Syangja district, Waling municipality was selected because this municipality is productive among other VDC/ Municipality in Syangja district (D. A. office, 2014). Both urban, semi-urban and village area are available so the phenomena of land use with labour migration can be observed on all types of land use in this area. The map of the study area is shown in figure -2.

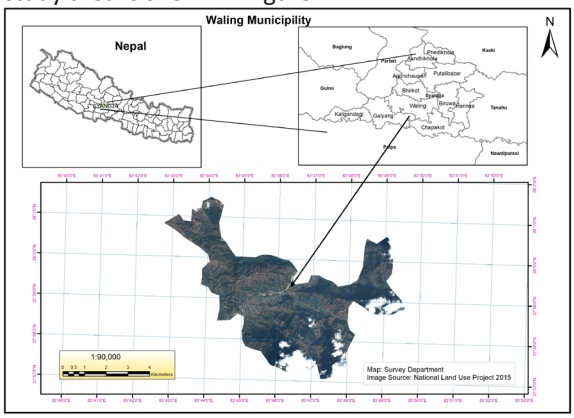



*Figure-2: Location Map of Study area*

## 5. METHOD ADOPTED

The methodology adopted for this study is shown in the figure-3. The figure is divided into two parts, upper and lower bounded by a dotted line. The upper part above the dotted line shows the LULC change detection and lower part, below the dotted line, show the cause behind LULC change especially focusing on labour migration, remittances and land use decision.

The land-use change between 1998 and 2015 was distinguished with the land use map. The LULC between 1996 and 2014 was also identified using visual image interpretation technique by orthophoto 1996 of 0.5m resolution and remote sensing image of 2014 of 2m resolution based on the field observation during the study period. The parcel fragmentation data of the major area of the municipality (i.e. ward 1, 2 and 3 was collected from the Survey office *Waling* in five years interval. The building approval data of the one-year interval was also collected from the *Waling* municipality. Based on these data the land use, land cover change was noticed. From the questionnaire, the data related with the *socioeconomic*

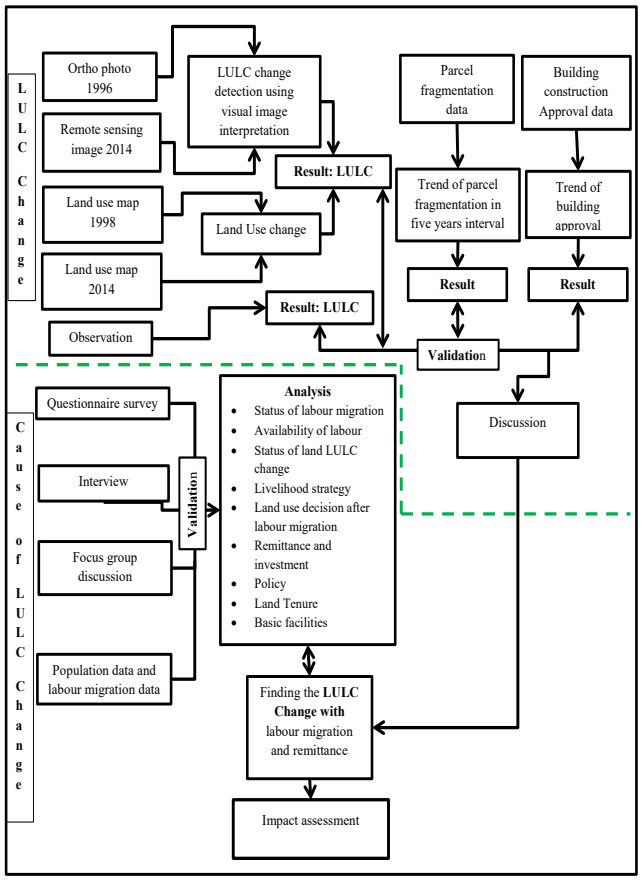


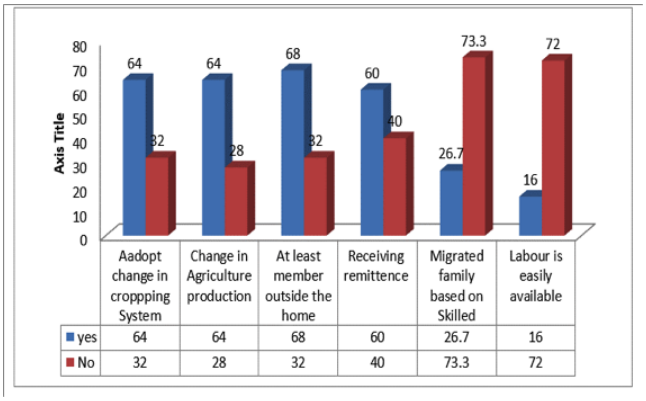

*Figure-3: Data analysis and validation methodology*

status of the household, level of labour migration, land-use change, livelihood strategy, land use decision after labour migration, availability of labour, remittances and investment, awareness about government policy was collected and analyzed. The similar data collected from the questionnaire was also collected through interview and focus group discussion. The result obtained from the questionnaire was validated using the data obtained from the interview, focus group discussion and observation.

Finally, the impact of labour migration on land use decision and the cause behind such change was identified using both types of data and assessment was done whether the land use was changed with labour migration and remittance.

## 6. RESULT AND ANALYSIS

### Analysis of cropping pattern, migration and remittance




| | Aadopt change in croppping System | Change in Agriculture production | At least member outside the home | Receiving remittence | Migrated family based on Skilled | Labour is easily available |
|---|---|---|---|---|---|---|
| yes | 64 | 64 | 68 | 60 | 26.7 | 16 |
| No | 32 | 28 | 32 | 40 | 73.3 | 72 |

*Figure-4: Situational examination on cropping trend, migration and remittance*

Figure 4 gives the situational analysis describing cropping trend, migration, remittance and accessibility of labour.

From Figure 64 per cent respondent said that they adopt change on cropping pattern and 32 per cent haven't changed cropping pattern on their agriculture land.

Again, Figure shows whether the amount of production is changing from the past. This specifies that 64 per cent disclosed that they adopt change in the cropping pattern and 28 per cent haven't adopted any change in cropping from 20 years.

Thirdly, the chart describes the Level of labour migration in the study area. The chart indicates that 68 per cent of the household have at least one member outside the home and 32 per cent household have no member staying outside the home.

Similarly, the figure shows the household whether they receive remittance. The chart shows that 60 per cent of the family is receiving remittances and the remaining 40 per cent of the family does not receive remittances.

Yet again, Figure shows the types of migrated labour based on their skill. It shows that 73.3 per cent are unskilled and 26.7 per cent are skilled labour. This also gives an idea that the maximum number of unskilled labour are migrating for foreign employment.

Lastly, the diagram shows the availability of labour. 72 per cent respondent mentions that labour is not easily available

for farming, 16 per cent of the respondent answers that labour is available for *Parma.*

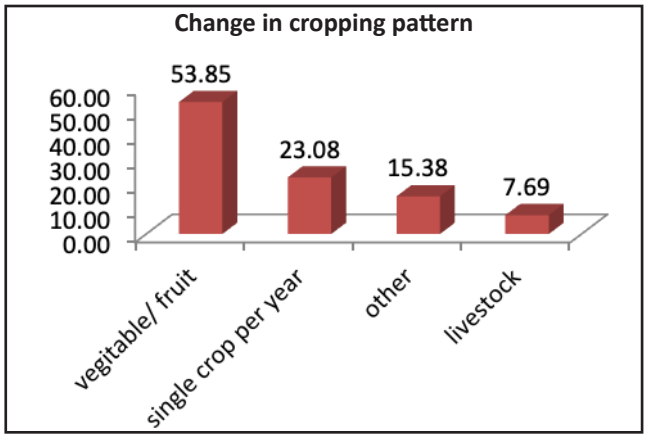



*Figure 5: Change in cropping pattern*

Figure 5 shows the change in cropping pattern adopted by the respondent. 53.85 per cent said that they start vegetable/fruit farming instead of traditional cropping. 23.08 per cent said that they only grow up the single crop, 7.69 per cent have livestock farming than cropping.

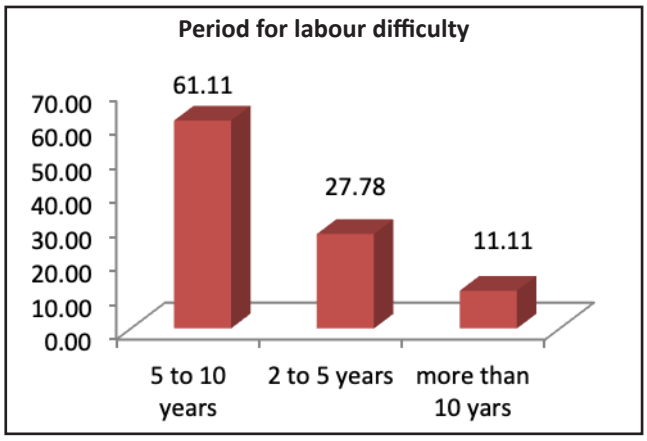



*Figure 6: Years behind the labour unavailability*

Figure 6 shows the time that is difficult to get the labor market. 61.11 per cent responded that they are facing the labour problem from 5 to 10 years, 27.78 per cent from 2 to 5 years and 11.11 Per cent from more than 10 years.

Land-use change: Role of labour migration and remittance

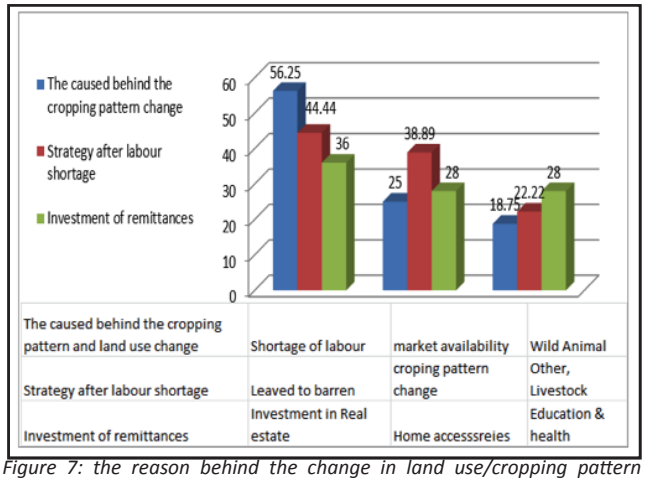



*Figure 7: the reason behind the change in land use/cropping pattern change*

Figure 7 provides a clear picture to understand the cause behind the land use/cropping pattern change, the strategy adopted by the household after the labour shortage and investment of the remittances. Firstly, the chart shows the cause of the cropping pattern change and land-use change. 56.25 Per cent respondent said, the shortage of labour is the cause behind the land-use change, 25 Per cent said that market availability and better income is the cause and 18.75 Per cent said laziness, the problem of wild animals are the cause behind the land-use change. Secondly, figure 7 shows the strategy adopted after the labour shortage on agriculture farm. 44.44 Per cent respondent left their land to barren, 38.89 Per cent reply that they change the cropping pattern, 11.11 Per cent of the household start livestock farming instead of the crop. Finally, Figure 7 shows the investment of remittances by remittances receiving household. The figure shows that 36 Per cent remittances receiving household invest their remittances on real estate, 28 Per cent on home accessories and 28 Per cent on education/health.

From Figure 7 it can be concluded that the foremost reason for cropping pattern change is the deficiency of labour. In reverse, the major strategy adopted after the labour unavailability is left to barren. Which strongly implies the cause behind land use and cropping pattern change is the labour migration. Besides they invest the maximum amount of remittances to real-estate symbolize the increase in the urban area.

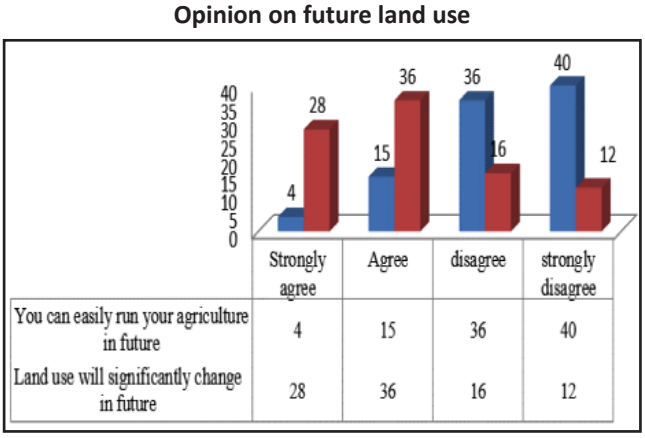



*Figure 8: Agriculture hurdles and significant changes in future*

Figure 8 express respondent outlooks on future land use. The Figure shows the respondents vision over their sureness to conduct agriculture in future and their vision on overall land-use change in the study area. The two views are opposite to each other. The Figure shows that only 4 Per cent are strongly agreed to run agriculture in future where 36 Per cent have disagreed and 40 Per cent are strongly disagreed. This implies household are not positive to run their agriculture in the long term. While only 12 Per cent are strongly disagreed over the future land-use change at the same 28 Per cent are strongly agree to future change in land use and 36 agrees to the future land-use change. Both

answers validate the future land-use change in the study area is unquestionable.

**Parcels during the first registration and up to 2015**

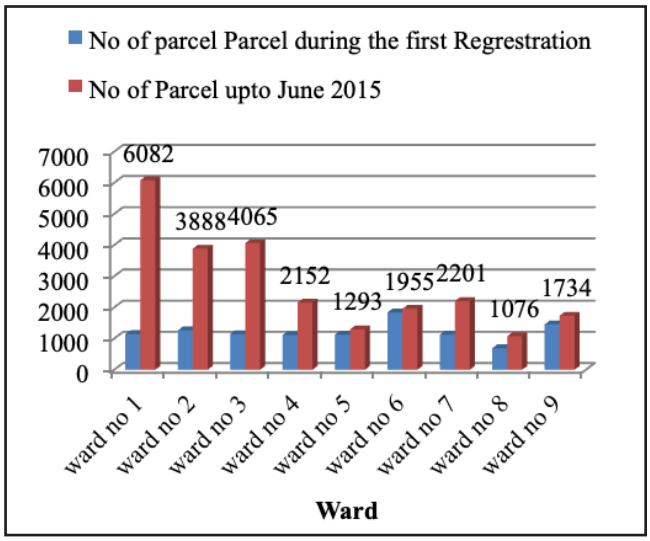



*Figure 9: Number of parcels during first registration and up to 2015*

(Source: Survey office waling)

The Figure displays the information about the number of parcels during the first registration and number of parcels up to study. The chart shows the ward wise number of parcels. Viewing the chart it can be observed that the number of the parcel are increased in all ward of the municipality but in ward number 1, 2 and 3 large number of the parcel are increased relating to the others since the major urban area of the municipality belong toward number 1, 2 and 3. The result advocates urban area is significantly increased in ward number 1, 2 and 3.

**Parcel fragmentation trend of ward number-1**

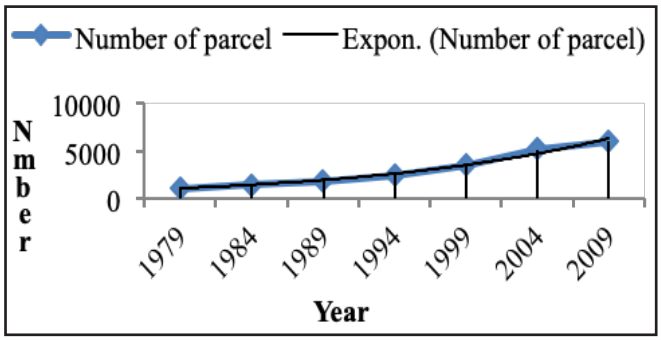



*Figure 10: Number of the parcel of Waling- 1*

Figure 10 expresses the rate of parcel fragmentation in the interval of five years. The year 1979 is the date of first registration and data is observed up to the study period. The diagram shows the continuously increasing the number of parcels. The best-fit trend line is exponential which indicate the number of the parcel is in still in increasing trend.

## 7. RESULTS AND DISCUSSION

In the study area majority of the house are made with the mud, stone and RCC. All most all household having the child used the private school for schooling. All household have the land ownership hence the security of the tenure can be considered as high. Irrigation facilities are available all *Khet* land in the study area. The irrigation system is not modern but they are using irrigation from past many years. All basic facilities road, telephone, drinking water etc are available in their house.

The population is increasing in the study area whereas the population of the district is decreasing. The caused behind such change in the population is the migration of the people from the nearby VDC of the same district and adjoining VDC of the surrounding district.

The foreign employment is high and increasing. Majority of the household had at least a member in foreign employment and receiving remittances. Among the migrated labour maximum are unskilled. Agriculture and foreign employment are the major livelihood strategy of the household and the happiness over the livelihood strategy is high. But who has not satisfied with their livelihood wants to go for foreign employment.

The land in the low altitude *(Khet)* of the study area is productive and three crops are possible in this area. Most of the household produce sufficient food for themselves. Amount of production per unit area, where they are still harvesting is increasing due to the new technology, hybrid seed and fertilizer but overall production is decreasing because of the labour unavailability and barrenization of the land. This area is converting to an urban area due to the migration of the people from the high altitude. But land in the upper part (particularly *Bari)* is less productive comparatively and specifically converting to barren. Plantation of *Kimbu* is integrating with livestock farming in *Bari* land.

Most of the household has at least a member outside the home and most of them are in foreign employment. Gulf countries are the major destination area of labour. Maximum households are changing the land use decision at a household level. The major cause behind such change is the unavailability of labour and changing the agriculture-based livelihood strategy to the foreign employment-based livelihood strategy. The caused labour unavailability is foreign employment and construction labour. They are facing the labour shortage from the past 5 to 10 years. The strategy they adopt after the labour shortage is to left land as barren or change in cropping pattern.

The respondents are not assured to run their agriculture up to twenty years and almost of them agree that land-use change in the future is obvious. With remittance, most households wanted to build a new house and buy land in an urban area. Most of them want to buy land in *Waling* municipality; furthermore, they want to buy land in the *Butwal, Pokhara and Kathmandu* city. The remittance is also invested in the home accessory, education and health etc which shows that overall life status is improving.

Remittance playing a major role on parcel fragmentation and due to unplanned fragmentation productive agriculture land is converting to urban. The price of the land in the urban area is high and still increasing. The Government does not have a clear policy to stop the barrenization of the land. Existing land use policy has not been implemented yet.

Young and educated unemployment do not want to involve in the agriculture sector. They want to go to foreign employment. Society is also encouraging foreign employment than doing agriculture. Most of them do not have information on the soft loan and subsides in the agriculture insurance. These programmes still not attracting young people to do agriculture in a better way. Some people are doing their best in agriculture after returning from foreign employment. They are involving in livestock farming.

The visual interpretation of the orthophoto of 1996 and remote sensing image 2014, studying the present land use map 2014 and *Biraha* of field book 1979 and field observation, shows the significant change in land use. The urban area is significantly increased; *Bari* land is converting to barren and barren is changing to bushes and forest. Parcel fragmentation in the urban area is increasing every year and building the new home is also increasing.

## 8. CONCLUSION

The trend of labour migration and land-use change is increasing. Labour are not easily available to agriculture farm. Migration is the main cause behind the labour insufficiency. Foreign employment is observed as the important livelihood strategy in addition to agriculture due to which agriculture practices have been found going down. Remittance is playing a vital role to enhance the overall life quality of migrated household. This impact on the land use decision at the parcel level. Received remittance is investing to build a new house, to buy land, home accessory, for education and health. Remittance invested in housing is consuming extra labour in the local market; also the wage of labour cost in construction is more than agriculture. The result of agriculture is facing the extra labour shortage and production cost going to be high. In result, people are changing the land use decision.

Cultivation area in high slope with high altitude i.e *Bari* land is getting changed to barren, forest area is increasing. The low sloppy area with low altitude i.e *Khet* land is converting to built-up area hence built-up area is expanding and cropping pattern and crops are also changing. This concludes that the cultivation area is mainly affected.

Some positive works were also observed in agriculture after returned from foreign employment; this shows the optimistic step in agriculture after migration. These conclude the labour migration is impacting on land use. The result indicates a strong positive correlation between land-use change and labour migration.

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# ULTRA-HIGH RESOLUTION UAV IMAGES FOR LAND POOLING

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## ABSTRACT

Land pooling is a development technique where a number of small holdings are pooled together and a part of the pooled land is utilized for developing physical & social infrastructure. The remaining land is returned to original land owners with development rights. One of the requirements of land pooling in that area is because of small and irregular shaped parcels. The other was to use systematic approach of sustainable development, help in planned and systematic urbanization, infrastructural developments and therefore increase the living standard of people. The main objective of our study was to perform land re-adjustment providing roads, open spaces, parks, drainages and other facilities; then returning corresponding proportion of adjusted regular shaped land to the owners in a systematic way and was located at Dhulikhel municipality at ward no 04, 200m due east of the Land Management Training Center. Existing cadastral and topographical map was used during the process. UAV was used for capturing the photographs, DGPS was used to determine the co-ordinates of the proposed stations and PIX4D mapper was used to stitch those images into one. GIS was used for further processing of data such as creation of contours, creation of slope map, water flow pattern. Similarly, AutoCAD was used for fragmentation of regular shaped parcels after separating developmental features. Not to mention that the old documents and existing laws are considered and followed during the whole process. After land pooling, we created systematic planned area and we can analyse that the development in this area will bloom in the near future.

## KEY WORDS

*Pooling, Consolidation, Sustainable, Game Changing Technique, Public Private Participation*

## 1. INTRODUCTION

### 1.1 Background

Urban resilience is a city's ability to withstand and recover from unexpected shocks associated with natural hazards (ADB, 2013). Densely populated urban core areas are understandably at greater risks to hazards such as earthquakes and fire. However, even the newly developed urban areas are falling prey to disorganized spatial pattern because of the fragmentation of land parcels into irregular shapes and sizes. As a result, efficiency in terms of mobility is being compromised. Functional open spaces are becoming rarer with each new building constructed with little or no harmony with the existing buildings or infrastructure in the neighbourhood. To correct this, the National Urban Development Strategy 2015 (draft) has aimed to get half of the new residential area developed through land readjustment (land pooling) process by 2031 A.D. Land readjustment is a land assembly process that is used for developing and redeveloping real estate. The process is also known as land pooling or land consolidation.

In the context of Nepal, Land Pooling mechanism was introduced in 1998 by the Town Development Act, with the goal to provide basic urban infrastructure through contribution and participation of the owners. The land pooling method is the only programme which will assist on sustainable urban development with appropriate infrastructures, and land consolidation without financial assistance of the government, most of land litigation will be solved and nobody will be evicted from their areas. The concept of land pooling can, therefore, be explained with the help of two key words – '**unification**' and '**partnership**'. Unification implies consolidation of separate land parcels, the unified design, infrastructure provision and subdivision of these parcels and a unified preparation and implementation of the scheme under a single management. 'Partnership' indicates the partnership between government, private and community for urban land development.

Land pooling, simply is a development technique where a number of small holdings are pooled together, a part of the pooled land is utilized for developing physical & social infrastructure, open spaces, parks and the remaining

portion is returned back to the owners. Land Pooling is simply an assembly of small rural lands being converted into large parcels through readjustment. The infrastructure development is planned on this large land with around more than half the land given back to the land owners which makes it a very fair practice. Simply put, in land pooling a number of small holdings are pooled together and a part of the pooled land is utilized for developing physical & social infrastructure. The remaining land is returned to original land owners with development rights. Basically, the parcels, being most of them irregular; is merged together as one and later systematically divided into regular patterns including services such as roads, drainages, open space, parks, hospitals etc. It can be further explained by this figure below:

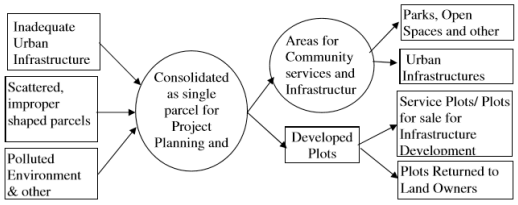


*Figure 1: P. P. Oli , 2010, Land Pooling / Readjustment Programmes in Nepal (4553)*

### 1.2 Objectives of Land Pooling:

Most of the semi-urban areas of Nepal are unplanned where housing and infrastructures situation are worst. The government does not have enough resources to develop these infrastructures. It is also striving to achieve minimum development goals (MDG). Similarly, irregular parcel shapes, fragmentation of land into smaller pieces, etc. are the major problems regarding land in semi-urban areas. Hence, we performed this project to address these problems, re-adjust parcels into regular shapes, perform planned urbanization while introducing roads, drainages, electricity, drinking water, parks, open spaces and other plots for development.

## 2. METHODOLOGY

*Table 1: Land Pooling Parameters*

| S. N | Land Pooling Parameters | Averaged of some recent land pooling programmes |
|---|---|---|
| 1. | Road<br>1st plot depth<br>2nd plot depth | Max. 8m, Min 6m<br>15%<br>25% |
| 2. | Sales Plot | 8.1% |
| 3. | Open Spaces | 4.8% |
| 4. | Drainage | 2% |
| 5. | Total land contribution | 29.9% - 39.9% |
| 6. | Total land returned back | 60.1% - 70.1 % |
| 7. | Minimum Plot Size | 80m$^2$ (0-2-2-0) |

The concept of land adjustment is to accumulate small sized rural parcels of land into a large-sized land parcel. It also includes providing the land with good set-up in a systematic way and give back the re-formed land to its owners after taking out the cost of provision of the setup and the public areas by sale of few serviced lands. During our project, UAV was used for capturing the images, DGPS was used for establishing control points, Pix4D was used for image processing, Trimble Business Center was used to process the DGPS data afterwards, GIS and AutoCAD were used to analyse and re-divide the parcels and different recent land pooling programmes in Nepal were studied and the land pooling parameters were categorized accordingly. The detailed information on each of them is shown below.

### 2.1 Specifications:

*Table 2: General Specifications*

| S.N. | Particulars | Description |
|---|---|---|
| **Instruments Used** | | |
| 1. DGPS | | 3 sets, to establish control points |
| 2.Drone | | 1 set, to capture aerial photographs |
| **Data Used** | | |
| 3. | Cadastral Map | Scanned Map (1:2500, 157-1366) |
| **Software used** | | |
| 4. | Pix4D Mapper | For processing images |
| 5. | GNSS Solution & Trimble Business Center | For computing co-ordinates |
| 6. | AutoCAD | For parcel sub-division |
| 7. | ArcGIS | Datum transformations, creating layers, layouts and templates |

*Table 3: DGPS specifications*

| S.N. | Particulars | Description |
|---|---|---|
| B. | **DGPS** | Trimble R8s |
| 1. | Observation Time | 30 – 60 minutes |
| 2. | Max PDOP value | 5 |
| 3. | Cut-off Angle | 15° |
| 4. | Epoch Time | 10 sec |
| 5. | **Datum transformation Parameters** | UTM to MUTM |
| | Translation x-axis | 124.3813 |
| | Translation y-axis | -521.6700 |
| | Translation z-axis | -764.5137 |
| | Rotation x-axis | -17.1488 |
| | Rotation y-axis | 8.11536 |
| | Rotation z-axis | -11.1842 |
| | Scale factor (ppm) | -2.1105 |

The parameters used in various land pooling projects varied in some extent. So, we studied various recent completed land pooling projects of Nepal and decided our parameters accordingly.

*Table 3: Land Pooling Parameters*

| S. N | Land Pooling Parameters | Averaged of some recent land pooling programmes |
|---|---|---|
| 1. | Road<br>1st plot depth<br>2nd plot depth | Max. 8m, Min 6m<br>15%<br>25% |
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| 3. | Open Spaces | 4.8% |
| 4. | Drainage | 2% |
| 5. | Total land contribution | 29.9% - 39.9% |
| 6. | Total land returned back | 60.1% - 70.1 % |
| 7. | Minimum Plot Size | 80m² (0-2-2-0) |

*Table 4: UAV specifications*

| S.No. | Particulars | Description |
|---|---|---|
| **Instruments** | | |
| **A.** | **Drone** | DJI PHANTOM |
| 1. | Camera Model | FC330_3_6_4000*3000(RCB) |
| 2. | Flying Height | 63.00m |
| 3. | Flight duration and speed | ~20 min, 5.51 m/s |
| 4. | Average ground sampling distance | 2.46 cm / 0.97 inch |
| 5. | Area covered | 0.163 km²/ 16.296 ha/ 0.06 sq. mi. |
| 6. | Image captured and Overlap | 227 images, 80% |
| 7. | Image Co-ordinate System | WGS84 (EGM 96 Geoid) |
| | Ground Co-ordinate System | WGS84/UTMZone45N (ECM96Geoid) |

### 2.2 Study Area

Dhulikhel is located at the Eastern rim of Kathmandu Valley, south of the Himalayas at 1550m above sea level and is situated 30 km southeast of Kathmandu and 74 km southwest of Kodari. This city lies on the intersection of the Araniko Highway to Tibet and B.P. highway to the Eastern Terai.

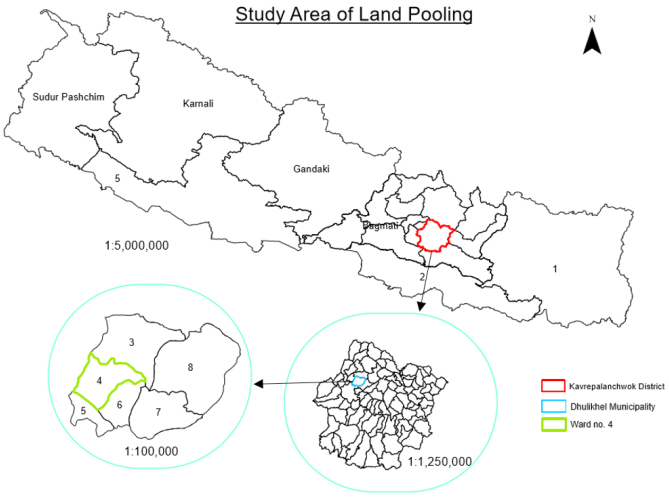



*Figure 2: Location map showing sudy area*

In our context, the study area was located at 28 kilo, Dhulikhel-04, Kavre. The area covered during land pooling was 0.163 km²/ 16.296 hectares. The study area was at altitude of around 1465m with geographic co-ordinates 27°37'10" N and 85°32'46" E. It is situated around 200m due east from the LMTC and around 500m southeast from the junction of Kathmandu University and the LMTC. We selected this area as we had very limited project time and it was very close to the LMTC (our working place). Also, the area was almost open so flying UAV was not a problem and surface was fairly levelled with uniform slopes and hence proper DTM will be extracted. The area where we performed land pooling consists not only plain areas but also have uniform slopes and the gradient can be clearly seen in the DEM produced.

## 3. PROCEDURE

Land pooling is a rural-to-urban development technique in which every newly created parcel is facilitated by basic infrastructures such as roads, drainages, water supply, electricity with hospitals, parks, playgrounds, parking and other re-creational areas in necessary areas. We completed our project going parallelly with office work and field work. The procedures we followed are briefly explained.

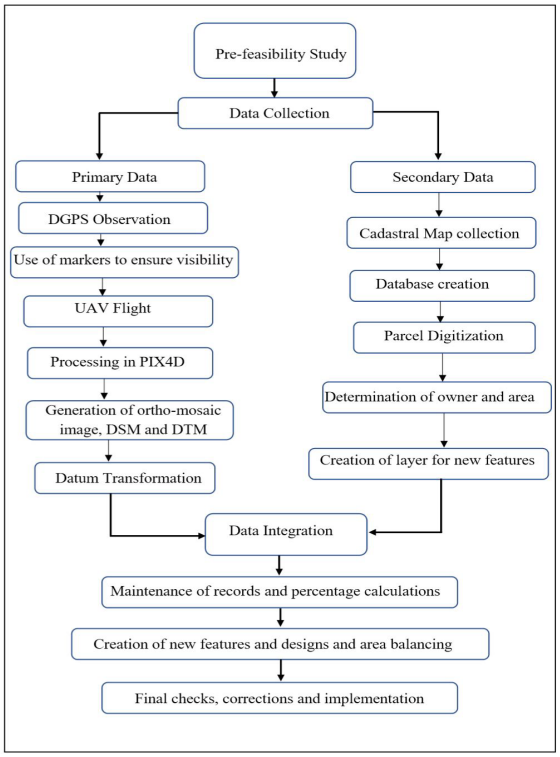



*Figure 3: Workflow*

### 3.1 Pre-feasibility Study:

A good planning is considered half-work done. Hence, we had selected the area for the project, various methods to be used, the instruments, hardware, software and created specifications in every process following the standards. Cadastral map was primarily collected for the visualization of study area. Topographical map was also collected for studying the terrain structure.

We went on field visit to select our study area and visualized various parameters such as existing roads, forest areas, drainages, buildings, electric poles etc. We took wooden pegs and created around 11 stations, well distributed in the area, where there was high visibility. They were established neither too close to the boundary of our study area nor too close within other stations. Wooden pegs were driven in the ground half visible with additional marks and pins in the top to precisely locate the point for later observation.

### 3.2 Field Work:

#### 3.2.1 DGPS Observation:

On those ground-driven pegs, DGPS (of Trimble brand) was set for observation for about 30-60 minutes in each station. A base was set inside LMTC and two rovers were used simultaneously. It was made sure that the base was operating until the very end until we finished our observation. Considerations such as visibility, uniform distribution and stability were strictly followed.

Altogether, 11 stations were studied, which tentatively covered the whole study area. The weather was clear and the location was very open, so the PDOP values were very low and stuck between 1 and 1.5 respectively. Co-ordinate system was set to WGS84 and at the end of the day, all the stations were successfully observed following the above-mentioned specifications.

#### 3.2.2 UAV Flight:

Markers of size 30*30cm were used to mark the stations in the ground exactly above the wooden pegs. Flying height was set at 63.00m and the flight duration was around 20 minutes. Performing UAV flight was easy as all we had to was to provide it with the flying path and its configurations. After the study area was covered, the drone itself came back to the starting position. The images were synced and data was stored in micro SD-card. We performed several test flights to check the clarity and quality of images. After determining all the required configurations, we selected a sunny day and successfully captured our strip at around noon and the number of pictures counted 280.

### 3.3 Office Work

#### 3.3.1 Data Processing:

For DGPS, first of all data download was performed from all devices using USB or Bluetooth and then was opened in Trimble Business Center in the presence of license. All the observed data was also imported in the TBC. The base data was sufficient so we didn't need the CORS data of KU. In the TBC, the base lines were processed, network adjustments were performed, reports were generated and co-ordinates were extracted.

For UAV, first of all, PIX4D was installed and a project was created. Steps to be followed during processing was easy. We provided the strips of images, imported the GCPs and addressed the GCPs in those images and the software did the rest. Ortho-mosaic image, DSM, DTM and contours were created automatically by the software. It took some time though.

After this, required portion of cadastral map was digitized after geo-referencing. The layer was converted into WGS84 through datum transformation. The digitized layer was overlayed with the ortho-mosaic image and was compared with the present ground structure. Slope and contours were generated from the DTM. On the other hand, database was created in Excel sheet regarding the land owner, its parcel number, its present area, various parameters for deduction in various attributes such as road, sales plot, drainages, open spaces etc. and the final deducted area with new parcel number was also included. Numerous land pooling projects were studied and the percentage calculations was performed based on them. Some of the provisions for land pooling were:

- The roads must touch each plot and the road must be parallel and perpendicular to each other if road is developed or run across.
- The plots side must be perpendicular to road touching on it.
- The area for the open space must be in such a place

that it should be accessible to every peoples of the area.

- The plots should be re-distributed at the same place as before as much as possible.
- The area covered by road, open space, greenery was as per the specification.
- The drainage should be created in such a way that the water doesn't gets stored in-between the plots and the flow of water directly goes to the drainage. First plot depth was considered 18.5 m from the existing road and 15% deduction was done to those area whereas 25% deduction was performed on remaining plots.
- Fair and transparent procedure with participatory approach and parallel provision of infrastructure.

We mostly used AutoCAD to design the new plots and developmental features. The procedure was lengthy and consumed a lot of time. Then, used GIS afterwards to create various layers and sub-types between each layer, performed topological checks, applied suitable colour, labelled new parcel numbers, created templates for various sizes, included scale, co-ordinate system, symbols, legends, and other marginal information and printed them.

## 4. RESULTS

After all the computations, calculations and analysis, we came up with similar output as planned. Most of the planning was performed in AutoCAD with iterative process. All the basic requirements we listed above were considered and fulfilled. Each of the parcels were connected through road and were modified into regular shapes, mostly rectangles and squares. The table shown here represents the details in each field, i.e. roads, drainages etc.

*Table 5: Outcomes in terms of area*

| SN | Particulars | Description | Percentage (%) |
|---|---|---|---|
| 1 | Total Project area | 99864.186 $m^2$ | 100 |
| 2 | Area covered by Road | 19825.561$m^2$ | 19.85 |
| 4 | Area covered by Open spaces | 6039.788$m^2$ | 6.04 |
| 5 | Area covered by Sales Plot | 8250.078$m^2$ | 8.26 |
| 6 | Area covered by Drainage | 4765.943 | 4.77 |
| 7 | Area of plot:<br>Smallest<br>Largest | 80$m^2$ (0-2-2-0)<br>1881.41$m^2$ (3-11-0-3) | 0.080<br>1.183 |
| 8 | Total no of developed plots | 148 | |
| 9 | No. of land owners | 121 | |
| 10 | Road length | 6361.037m | |
| 11 | Slope of area<br>Minimum<br>Maximum | <br>0.06 degree<br>31.84 degree | |

### 4.1 Output in terms of Perspective

#### 4.1.1 Land Owner's Perspective:

- Regular shaped of plots which can be useful for proper housing.
- Developed area so higher standard of living.
- Roads, drinking water, electricity and other facilities all around the area.
- Sky rocket in price of parcels after pooling, i.e. increase in land valuation.
- Higher motives of investment in banks and other financial institutions which promotes in more investment, that increases the life style and living standard of the locals.

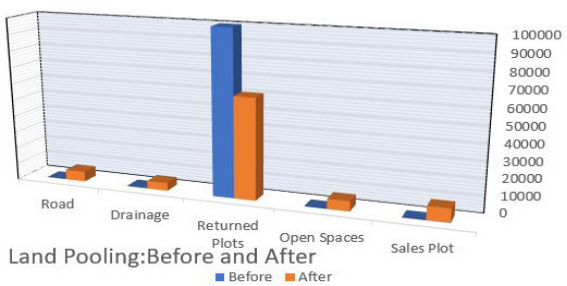
#### 4.1.2 Developmental Perspective:

- Sustainable development, a best approach for development.
- Establishment of basic infrastructures in very short period of time, which would have taken decades.
- Roads touches every parcel, so enormous possibility and higher rates of development.
- With analysis, natural disasters such as landslides, floods, can be minimized.
- A new perspective of development, which can be a game changer considering its unlimited possibilities and impact in the development of that place.

#### 4.1.3 Governmental Perspective:

- With the use of new technologies and analysis on various aspects such as drainages and slopes, this technique becomes a game changer.
- Roads reached in and around and agricultural land converted into residential and commercial area, so more revenue and more tax collection in a long run.
- With the creation of parks and open spaces, eco-friendly environment is created which enhances healthier life and hence promotes the living standard.

*Figure 4: Graphical view of output*



| | | | Open Space | | Sales Plot | | | Road | | | Drainage | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parcel_Numbe | Owners_Name | Area (square m | Percentage(% | rea (sq. m | Percentage(% | Area(m2 | Plot Depth | Area | Percentage | Reduced Area | PercentageArea | | Total Area Deducted | Total Returned | ew Parcel Numbe | Rema |
| | | | | | | | 1st depth | 80.439 | 15% | 12.066 | | | | | | |
| 85 | Roshan Khadka | 394.841 | 4.800 | 16.188 | 8.100 | 31.982 | 2nd depth | 314.402 | 25% | 47.160 | 2% | 7.897 | 115.294 | 279.547 | 326 | |
| | | | | | | | 1st depth | 1017.106 | 15% | 152.566 | | | | | | |
| 90 | Uddhav Khadka | 1077.000 | 4.800 | 44.157 | 8.100 | 87.237 | 2nd depth | 59.893 | 25% | 8.984 | 2% | 21.540 | 314.484 | 762.516 | 331 | |
| | | | | | | | 1st depth | 734.141 | 15% | 110.121 | | | | | | |
| 25 | Sisan Baniya | 1294.808 | 4.800 | 53.087 | 8.100 | 104.879 | 2nd depth | 560.667 | 25% | 84.100 | 2% | 25.896 | 378.084 | 916.724 | 332 | |
| | | | | | | | 1st depth | 954.745 | 15% | 143.212 | | | | | | |
| 7 | Krishal Manandha | 1788.898 | 4.800 | 73.345 | 8.100 | 144.901 | 2nd depth | 834.153 | 25% | 125.123 | 2% | 35.778 | 522.358 | 1266.540 | 317 | |
| | | | | | | | 1st depth | 4.743 | 15% | 0.711 | | | | | | |
| 2 | Anil Khatiwoda | 722.723 | 4.800 | 29.632 | 8.100 | 58.541 | 2nd depth | 717.979 | 25% | 107.697 | 2% | 14.454 | 211.035 | 511.688 | 323 | |
| | | | | | | | 1st depth | 504.536 | 15% | 75.680 | | | | | | |
| 98 | Sheetal Kc | 2083.225 | 4.800 | 85.412 | 8.100 | 168.741 | 2nd depth | 1578.689 | 25% | 236.803 | 2% | 41.665 | 608.302 | 1474.923 | 320 | |
| | | | | | | | 1st depth | 2.176 | 15% | 0.326 | | | | | | |
| 93 | Aadarsha Pote | 223.258 | 4.800 | 9.154 | 8.100 | 18.084 | 2nd depth | 221.082 | 25% | 33.162 | 2% | 4.465 | 65.191 | 158.067 | 338 | |
| | | | | | | | 1st depth | 883.725 | 15% | 132.559 | | | | | | |
| 110 | Pramod Dahal | 1274.735 | 4.800 | 52.264 | 8.100 | 103.254 | 2nd depth | 391.01 | 25% | 58.652 | 2% | 25.495 | 372.223 | 902.512 | 327 | |
| | | | | | | | 1st depth | 214.349 | 15% | 32.152 | | | | | | |
| 113 | Himal Subedi | 782.333 | 4.800 | 32.076 | 8.100 | 63.369 | 2nd depth | 567.984 | 25% | 85.198 | 2% | 15.647 | 228.441 | 553.892 | 329 | |
| | | | | | | | 1st depth | 172.149 | 15% | 25.822 | | | | | | |
| 92 | rinkhala Khatiwa | 194.572 | 4.800 | 7.977 | 8.100 | 15.760 | 2nd depth | 22.422 | 25% | 3.363 | 2% | 3.891 | 56.815 | 137.757 | 339 | |
| | | | | | | | 1st depth | 167.695 | 15% | 25.154 | | | | | | |
| 24 | Sundar Yadav | 430.080 | 4.800 | 17.633 | 8.100 | 34.836 | 2nd depth | 262.385 | 25% | 39.358 | 2% | 8.602 | 125.583 | 304.497 | 315 | |
| | | | | | | | | | | | | | | | | |
| 1 | | | | | | | | | | | 2% | | | | | |
| 3 | Abhishek Badal | 2224.974 | 4.800 | 91.224 | 8.100 | 180.223 | | | 25% | 556.244 | 2% | 44.499 | 872.190 | 1352.784 | 249 | |
| 4 | Aashman Basnet | 332.119 | 4.800 | 13.617 | 8.100 | 26.902 | | | 25% | 83.030 | 2% | 6.642 | 130.191 | 201.929 | 275 | |
| 5 | Aayush Regmi | 143.046 | 4.800 | 5.865 | 8.100 | 11.587 | | | 25% | 35.762 | 2% | 2.861 | 56.074 | 86.972 | 286 | |
| 6 | Roshan Khadka | 187.034 | 4.800 | 7.668 | 8.100 | 15.150 | | | 25% | 46.758 | 2% | 3.741 | 73.317 | 113.717 | 288 | |
| 8 | Kunjan Shrestha | 858.082 | 4.800 | 35.181 | 8.100 | 69.505 | | | 25% | 214.520 | 2% | 17.162 | 336.368 | 521.714 | 342 | |
| 9 | Ramesh Oli | 421.421 | 4.800 | 17.278 | 8.100 | 34.135 | | | 25% | 105.355 | 2% | 8.428 | 165.197 | 256.224 | 341 | |

*Table 6: Output summary in tabular form*

*Figure 5: Merged aerial photographs of study area with image resolution 24733 x 16975 (280 images merged)*

## 5. DISCUSSION

Hence, after the completion of this project we realized the potential of land pooling. Most of the semi-urban areas of Nepal are unplanned where housing and infrastructures situation are worst. The government does not have enough resources to develop these infrastructures. It is also striving to achieve minimum development goals (MDG). Similarly, irregular parcel shapes, fragmentation of land into smaller pieces, etc. are the major problems regarding land in semi-urban areas. On the other hand, land pooling provide infrastructure like road, water supply, sewerage and drainage facilities. The projects also provide open spaces for breathing, relaxation and recreation such as for playgrounds and children parks. In addition to that, the land pooling technique leads to an arrangement of irregular plots into regular plots which are suitable for housing and for accessibility. Because land pooling projects are designed as self-financing projects, the burden on government or local governments to provide infrastructure and services is lessened to a significant degree. Although landowners lose some portion of their lands, they get serviced plots in return which are more valuable than before. In short, a land pooling project is a win-win scheme for both people and government. The rapid infrastructural developments during the process and rapid planned urbanization after the land pooling makes it one of the best and a ***game changing development technique*** for country like Nepal. The only concern is the will of the owners to perform land pooling. If majority of owners agrees, then it can be a game changer. But, if the majority of owner dis-agrees, it can be a problem and conflicts may occur frequently. So, there should be enough amount of negotiations with the owners (>50%), agencies and stake-holders and forceful acquisition of land should be avoided as much as we can during this process. Hence, government can implement these kinds of game changing techniques with tri-partnership (between public-agencies-government) for the effective development of country in a systematic way.

## 6. CONCLUSION AND RECOMMENDATION

The land pooling is one of best solution of solving problems of provision of comfortable housing and infrastructure development without external funds. Despite the hardship during the implementation phase, generally residences are always happy after implementation. The land records are updated, tenancy secured and comfortable shelter developed. Land pooling is a tool that can support sustainable urban development by allowing for planned and managed urban extension and densification. For land readjustment to be successful, it is necessary to have favourable economic conditions, along with procedural and regulatory rules in place to guide the process. Land readjustment requires intensive voluntary participation and cooperation by the property owners. It must be obvious to the property owners that the final profits will be greater than they would receive otherwise, without land readjustment and is worth, negotiating time that will be devoted to the project implementation. We learned a lot about this technique of development and its procedure and theoretically fulfilled all our objectives and now consider ourselves able to handle these kinds of projects in real-life scenario.

As for the recommendations, these developmental procedures should be focused more as we all know its endless benefits. We performed land pooling in open area without any analysis with no houses within, but the urban growth rate should be determined and land pooling should be done in such areas so that the place can actually be benefited. Also, land pooling techniques should be linked with environment and climate change concerns (such as provision of green infrastructure, rainwater harvesting, sustainable designs, and energy efficiency), to frame a whole new mode of development.

## 7. ACKNOWLEDGEMENT

With great honour, I would like to thank Dr. Pradeep Sapkota, Er. Sanjeevan Shrestha, Er. Govinda Ghimire and Er. Bhuwan Ranjit for their valuable time and support during this project, without whom it would be incomplete.

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# IDENTIFYING SUITABLE RESETTLEMENT AREAS FOR SQUATTERS USING MULTI CRITERIA EVALUATION

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## ABSTRACT

The squatter population has been surging in Kathmandu since 1970s. Most of the squatter settlements are located along the river banks, which are highly polluted, and are the major source of water borne diseases. Lack of basic facilities and sanitation in these areas further endanger the squatters to water borne diseases. These areas are also prone to natural disasters such as floods, landslides and earthquakes. Apart from this, the settlements are always in threat of eviction for different activities. Therefore, there is an urgent need for resettling the squatters in a suitable area. However, since the number of squatter settlements are high, the present study intends to identify a suitable area for resettling the squatters of Shankhamul area of Kathmandu only.

Multi-criteria evaluation was used to identify suitable resettlement area. For this, different criteria (constraint and factor) were selected. Land use land cover and minimum area required for resettling the squatters were identified as the constraint, while slope, aspect, distance to water bodies, road and settlements were identified as factors. The criteria were subcategorized and weights (degree of suitability) were given to the sub categories of each factor based on literature review. Analytical Hierarchy Process was used to determine the weights of each factors and check the consistency of the weights. Weighted linear combination was used to combine the factors to identify the suitable sites for resettlement. Spatial analysis showed that around 395 $Km^2$ of land surfaces were suitable for resettlement, however only around 136 $Km^2$ of land surfaces were highly suitable. Most of the suitable areas were outside Kathmandu and Lalitpur Metropolitan City.

## KEY WORDS

*Multi-Criteria Evaluation, Weighted Linear Combination, Squatters, Resettlement, Analytical Hierarchy Process*

## 1. INTRODUCTION

Squatters are people who reside on land without legal rights (Brooks, 2016). The area where they settle without any legal right, neither as tenants nor owners, and have built houses without regard to survey boundaries, whether or not such boundaries have been established is known as squatter settlement (Khatiwada, 2013; Acharya, 2010). Taher and Ibrahim (2014) defined squatter settlement as "a residential area in an urban locality inhabited by the very poor who have no access to tenured land of their own, and hence "squat" on vacant land, either private or public." These settlements are characterized by limited access to basic services, substandard housing and vulnerability to natural disasters (Sengupta & Sharma, 2009).

Squatter settlements are proliferating in urban areas of least developing countries and now they have become a principle feature of urban areas and a global issue (Acharya, 2010). City oriented development, failure of Government to invest and provide affordable housing to low income people, inability to afford accommodation and freedom from rent and civic obligation are some of the reasons that force the people to live in squatter settlements (Acharaya, 2010; Taher &Ibrahim, 2014; Brooks, 2016).

In Nepal, like in other least developing countries, surging of squatter settlement is associated with political instability and economic stagnation (Sengupta & Sharma, 2009). People from various parts of the country have been migrating to Kathmandu for various purposes like employment, security, health care, education etc. (Toffin, 2010; Little, 2012). This has escalated housing demands and land prices, but expensive housing prices and rent have barred the low income people from proper housing and have resorted them to substandard houses in unauthorized lands, giving

rise to squatter settlements (Sharma, 2010).

In 1970, there were 17 squatter settlements in Kathmandu, Lalitpur and Bhaktapur districts, which rose to 40 in 2008, with 12,726 people living in 2,735 households (Lumanti, 2008). Majority of these settlements are located in ecologically sensitive and marginal areas such as river banks and forests (Sengupta & Sharma, 2009). Study by Subedi (2018) showed that squatter settlements are present in 73 places in Kathmandu and three places in Lalitpur and Bhaktapur.

Squatters in these settlements are living in dilapidated condition. The houses are made up of substandard materials, like corrugated iron sheets, tarpaulin, poor quality bricks, mud or bamboos. Most of the houses are deprived of basic facilities like private latrines, water supply and solid waste management. Only a third of households have private latrines. Most of the squatters depend on public tap and tube well for water (Sengupta & Sharma, 2009; Toffin, 2010).

The squatter settlements are also prone to natural disasters like floods, landslides and earthquakes. Every year, most of these settlements that are located along the river banks are flooded (KathmanduPost, 2020; Toffin, 2015). The river banks are also highly polluted, and the continuous exposure to these high level of pollutants (water pollutants, disposed wastes) make the squatters vulnerable to water borne diseases (CARE, 2008; Lumanti, 2008)

Apart from this, squatters are always in threat of eviction. The settlements are constantly evicted for development activities such as city beautification projects. During 2001 and 2002, there was sharp rise in eviction activities. Thirteen families were evicted from Bagmati river side without prior notice or any compensation in 2001 (Sengupta & Sharma, 2009). In 2002, 142 squatter houses along the Bishnumati river bank were demolished for Vishnumati Link Road project (Toffin, 2010). In 2012, Government demolished a squatter settlement in Thapathali, located along the bank of Bagmati River, which displaced 1,000 people living in 250 houses (KathmanduPost, 2020). Such activities not only make the squatters homeless, it also creates anxiety that can affect their daily life (Deshar, 2013).

Considering the dire situation of squatters, there is an urgent need to resettle the squatters in a suitable area. However, since the number of squatter settlements are high, the present study intends to identify suitable sites for resettling the squatters of Shankhamul squatter settlement in Kathmandu and Lalitpur districts. This study will help to meet the agenda of land related problem solving commission and National Land Policy, 2019, of securing the rights of every citizen to land, rehabilitation of landless, squatters by providing land (UNHABITAT, 2019)

This study has not considered land prices, type of proposed housing (apartment, single buildings for each household), willingness of land owners to sell land for resettlement area, willingness of squatters to move from their current settlements, impacts on local communities and landowners by the resettlement project.

## 2. DESCRIPTION OF STUDY AREA

Shankhamul squatter settlement is located along the bank of Bagmati river in Shankhamul, which is located in ward number 10 of Kathmandu Metropolitan City as illustrated in Figure 1. There are 503 (253 male, 250 female) squatters living in 105 houses (Sharma, 2010; Shrestha et al., 2017).

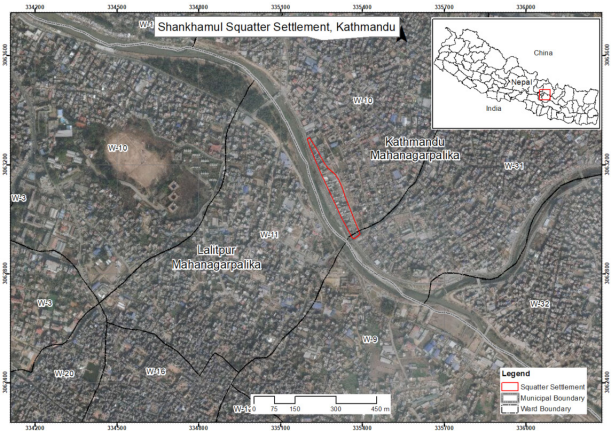


*Figure 1: Study Area*

All houses are of semi-permanent type and constructed with bricks, mud mortar and corrugated zinc. Most of the houses are single storied with narrow rooms that are aligned one behind the other (Sharma, 2010; Subedi, 2018). Most of the household depend on ground water for different purposes. Around 92 household get water from tube-well (Lumanti, 2008).

Squatters residing in the settlement are living in dilapidated conditions along the river bank. The river bank is highly polluted, and the continuous exposure to these high level of pollutants (water pollutants, disposed wastes) make the squatters vulnerable to water borne diseases (Lumanti, 2008). Absence of proper access to sewerage system, proper sanitation, drinking water, and solid waste management facilities further puts them in risk of epidemics of water borne diseases like Cholera (CARE, 2008; Subedi, 2018).

Further, the squatter settlement is also under threat of eviction by the Government for conducting different development and conservation activities (Shrestha, 2017). The settlement was almost bulldozed in 2003 for construction of park, but protest by lying down on the ground in front of the bulldozer prevented the settlement from being bulldozed.

Bagmati Action Plan (2009-2014) has proposed plantation along the river banks, and its surrounding area, including Shankhamul area, in order to protect river side land, aquatic biodiversity and aesthetic value of the river and its surrounding areas. (GoN/NTNC,2009). The action plan had also proposed to control encroachment, construct

embankments. Evicting the squatter settlements and resettling them in suitable land is also one of the major steps of the project to meet its objective (objective 6.3.2, Bagmati Action Plan 2009-2014) (GoN/NTNC, 2009).

Department of Urban Development and Building Construction (DUDBC) in collaboration with Lumanti, Support Group for Shelter, proposed Land sharing project during 2008 in the settlement for revitalizing the riverside, commercial development of the area and upgrading the living conditions of squatters of the area. But the project could not be implemented due to legal constraints, lack of working policy, and technical constraints (Sharma, 2010).

## 3. METHOD

Suitable resettlement areas were identified using Multi criteria evaluation. Data were generated using remote sensing and GIS, which were further categorized as factors and constraints. Factors were assigned weight using analytical hierarchy process. Then, weighted linear combination was used to identify the suitable areas.

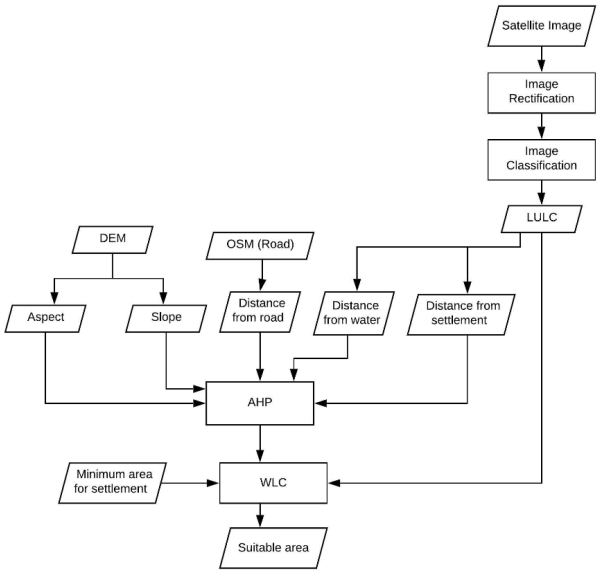


*Figure 2: Flow chart of method followed*

### 3.1 Data

Satellite imagery of 5 m resolution (resourcesat-2, Scene ID: RS2-LISS4-24-Jan-2015-104-52, acquired on January 24, 2015) obtained from India Space Research Organization (ISRO) was used for land use land cover classification. The imagery had 3 bands, green, red and Near Infrared (NIR).

Digital elevation model (DEM) of 30 m resolution (ID: SRTM1N27E085V3) was obtained from Shuttle Radar Topography Mission (SRTM) to generate slope and aspect. Road data was obtained from open street map (OSM, 2015) for performing different spatial analysis.

### 3.2 Image Processing

#### 3.2.1 Image Rectification

Resourcesat-II image was rectified using ground control points and rectified image. The ground control points were collected using well defined points such as intersection points of roads, intersection of rivers. First order polynomial was used as the transformation function, and nearest neighborhood was used as the resampling method. The accuracy of the rectified image was 6.005733 m.

#### 3.2.2 Image Classification

Nearest neighborhood classification was used to classify image into different land use land cover classes (Water bodies, settlement, forest, cultivated, grasslands and others). Nearest neighborhood classification uses set of samples of different class to assign membership values. Once samples are provided, nearest neighborhood classification searches for the closet sample object in the defined feature space for each image object. The closer an image object is located in the feature space to a sample of a class, the higher the membership degree is to the class. The membership value has a value of 1 if the image object is identical to the sample. If the image object differs from the sample, the feature space distance has a fuzzy dependency on the feature space distance to the nearest sample of a class(Trimble, 2014). Accuracy assessment showed that the overall accuracy of the classification was 81 %.

### 3.3 Multi Criteria Evaluation

Multi Criteria Evaluation (MCE) is “concerned with the allocation of land to suit a specific objective on the basis of a variety of attributes that the selected areas should possess” (Eastman, 1999). MCE was used to identify suitable resettlement areas as it is widely used method for studying suitable location for different purposes. It involves identifying criteria’s, assigning weights and combining factors using weighted linear combination to find out suitable location for specific purpose (Olgun and Yilmaz, 2019; Omar and Raheem, 2016; Gautam, 2015).

#### 3.3.1 Criteria

In order to identify suitable resettlement sites, different criteria were identified. Criteria were classified as constraints and factors. Constraints are “those Boolean criteria that constrain (i.e. limit) our analysis to particular geographic region”(Eastman, 1999 ). Constrain are always Boolean image, and does not provide space for degree of suitability(Eastman, 1999 ). In contrast, factors are “criteria that define some degree of suitability for all geographic region and define areas or alternatives in terms of continuous measure of suitability”(Eastman, 1999 ). In this study, two constrain and five different factors have been identified based on available data and literature review from Gautam (2015), Singh et al.(2014), Jain & Subbaih (2007) etc.

##### 3.3.1.1 Constraints

**Land Use Land Cover**

Land Use Land Cover was identified as constraint because

resettlement sites cannot be identified in particular areas like forest, water bodies and existing settlements. The suitable areas were given value of 1 and unsuitable area were given value of 0.

**Area**

For each household, it was assumed that a minimum area of 128 $m^2$ was required that included area for house construction, open space and road. Therefore, for 105 households, a total 13440 $m^2$ was required. Any area less than 13440 $m^2$ was excluded as it was not sufficient for resettlement. Land surface that had area equal to or more than 13,440 $m^2$ were given value of 1 and remaining areas were given value of 0

**3.3.1.2 Factors**

**Slope**

Slope is an important factor that determines the suitability of a relocation site as probability of occurrence of landslides and erosions are high in steep slopes, and strong engineering measures have to be taken to combat this, which can be costly (Dai et al., 2001; Singh et al., 2014). Therefore, flat areas are recommended for constructing infrastructures and housing projects (Singh et al., 2014; Gautam, 2015; Kumar &Biswas, 2013), and areas above 30 degree slope is not suitable for housing projects (GON, 2015; Singh et al., 2014; Xiaorui et al., 2013; Jagari & Zaredar, 2010). Following weights were assigned to different sub categories of slope.

*Table 1: Assigning weights to subcategories of slope*

| Slope (in degree) | Weight/value | Degree of suitability |
|---|---|---|
| < 10 | 9 | High |
| 10-20 | 6 | Moderate |
| 20-30 | 3 | Low |
| >30 | 0 | Unsuitable |

**Aspect**

Aspect is an important factor that determines the suitability of a relocation site, especially in hilly areas, where temperature is very low during winter. Southern aspect is highly suitable because it receives more sunlight than other aspects (Singh et al., 2014; Gautam, 2015). Western and Eastern aspects receive equal duration of sunlight, but less than that of South, therefore, it is moderately suitable. North aspect is least preferred as it does not receive sunlight, and is cold (Singh et al., 2014; Gautam, 2015). Following weights were assigned to different sub categories of aspect.

*Table 2: Assigning weights to subcategories of Aspect*

| Aspect | Weight/ value | Degree of suitability |
|---|---|---|
| Southern (135-225) | 9 | High |
| Flat (-1) | 9 | High |
| Eastern (90-135) | 6 | Moderate |
| Western (225-270) | 6 | Moderate |
| Northern (90-270) | 0 | Unsuitable |

**Distance from Water Bodies**

Areas within 100 m from water bodies are unsuitable for resettlement sites because areas within 100 m from water bodies are prone to flood hazard (MDEoP, 2008; Jain & Subbaiah, 2007). Further, structures constructed within 76.2 m of the shores of lakes, rivers and wetlands can cause soil erosion, decline water quality and destroy natural habitat (MDEoP, 2008). However, areas that are 500 m away from water bodies are highly suitable for resettlement site as they fall outside flood hazard zone(Jain and Subbaiah, 2007). Following weights were assigned to subcategories of distance from water bodies.

*Table 3: Assigning weights to subcategories of distance from water bodies*

| Distance from water bodies (meters) | Weight/ value | Degree of suitability |
|---|---|---|
| >500 | 9 | High |
| 250-500 | 6 | Moderate |
| 100-250 | 3 | Low |
| 0-100 | 0 | Unsuitable |

**Distance to Existing Roads**

Sites that are near to existing roads are highly suitable, whereas sites that are far from existing roads are unsuitable as traveling long distance incurs cost and time (Jain & Subbaih, 2007; Ekanayaka &Weerakoo, nd). Distance of 1000-1200 m from the existing road is acceptable distance as the walking time is around 15 to 20 minutes, however, shorter distance from existing road is better. Following weights were assigned to subcategories of distance to existing road.

*Table 4: Assigning weights to subcategories of distance to existing roads*

| Distance to existing road (meters) | Weight/ value | Degree of suitability |
|---|---|---|
| 0-400 | 9 | High |
| 400-800 | 6 | Moderate |
| 800-1200 | 3 | Low |
| >1200 | 0 | Unsuitable |

**Distance to Existing Settlement**

Sites that are near to existing settlement are highly suitable compared to sites that are far from existing settlement

(Ekanayaka &Weerakoo, nd ) because of the easy access to local markets for daily groceries and social bonding. Generally, in each settlement, there are markets for daily groceries, and squatters prefer to stay in areas that are at walking distance to existing settlements (Personal communication, Lumanti). Distance of 1000-1200 m from the existing settlement is acceptable distance (Ekanayaka &Weerakoo, nd) as walking time is around 15 to 20 minutes, however, shorter distance is better. Following weights were assigned to subcategories of distance to existing road.

*Table 5: Assigning weights to subcategories of distance to existing settlements*

| Distance to existing settlement (meters) | Weight/ value | Degree of suitability |
|---|---|---|
| 0-400 | 9 | High |
| 400-800 | 6 | Moderate |
| 800-1200 | 3 | Low |
| >1200 | 0 | Unsuitable |

**3.3.2 Weighing of Factors**

Analytical Hierarchy Process (AHP) method, introduced by T.L.Saaty (Saaty, 1987), was used to determine the weights of each factors and check the consistency of the weight. AHP is a "theory of measurement through pairwise comparisons and relies on the judgement of experts to derive priority scales" (Saaty, 2008). Comparisons are made using a scale of absolute judgement that represents how much one element dominates another with respect to a given attribute. There are possibilities for the judgement to be inconsistent. AHP helps to check such inconsistency and improve judgement (Saaty 2008). Pairwise matrix was created based on the importance of each factors over another.

*Table 6: Pairwise comparison matrix*

| | SL | WB | RO | SE | AS |
|---|---|---|---|---|---|
| SL | 1 | 3 | 5 | 7 | 9 |
| WB | 0.33 | 1 | 3 | 5 | 7 |
| RO | 0.2 | 0.33 | 1 | 3 | 5 |
| SE | 0.14 | 0.2 | 0.33 | 1 | 3 |
| AS | 0.11 | 0.14 | 0.2 | 0.33 | 1 |

Where SL= Slope, WB = Distance from water bodies, RO = Distance to existing roads, SE = Distance to existing settlements, AS = Aspect

To check the consistency of the judgement or comparison made, consistency ratio (CR) was calculated. If CR is greater than 10% i.e. > 0.10, then the weighted result indicates the presence of inconsistencies in the pairwise comparison matrix. If CR is less than 10%, then comparison is considered acceptable, and the eigenvector obtained for each factors can be used to assign weight to it.

Here, the CR was 0.054. This shows there was consistency in the judgement and the eigenvector obtained for each factors can be used to assign weights to each factors.

The eigenvector or weights of each factors are:

Slope: 0.502819496

Distance from water bodies: 0.260231588

Distance to existing roads: 0.134350441

Distance to existing settlements: 0.067777667

Aspect: 0.034820809

**3.3.3 Weighted Linear Combination**

Weighted linear combination (WLC) was used to combine the factors to identify the suitable sites for resettlement using following equation.

$$S = \Sigma (W_i X_i) * Cj \qquad (1)$$

Where, S= Suitability

$W_i$ = Weight of factor i

$X_i$ = Criterion score of factor i

$C_j$ = Criterion score of constraint j

Suitability = [([slope] * 0.502819496) + ([Aspect] * 0.034820809) + ([Distance from water bodies] * 0.260231588) + ([Distance to existing roads] * 0.134350441) + (Distance to existing settlements) * 0.067777667)] * (Land use land cover as Boolean image)

**3.4 Validation**

The output from MCE was checked in google earth to see if land is available or not for resettlement. Areas designated as public open space, areas of Nepal army, Police academy or areas allocated for specific purpose like waste water treatment plant were excluded.

## 4. RESULTS AND DISCUSSION

Around 551 km$^2$ of land surfaces had slopes below 30° and were suitable for the resettlement, while around 625 km$^2$ of land surfaces were moderately to highly suitable for resettlement based on the aspect. Around 724 km$^2$ of land surfaces were beyond 100 m from water bodies and were suitable. However, only 445 km$^2$ of land surfaces were beyond 500 m from water bodies and were highly suitable. Around 773 km$^2$ of land surfaces were within distance of 1200 m from existing roads and were suitable. However, around 650 km$^2$ of land surfaces were within distance of 400 m from existing roads and were highly suitable. Around 804 km$^2$ of and surfaces were within a distance of 1200 m from existing settlements and were suitable, however, around 746 km$^2$ of land surfaces were within 400 m and were highly suitable. The details are presented in Table 7 and Appendix (Figure 5 and 6).

*Table 7: Degree of suitability based on different factors*

| Factors | Suitability | Area (km²) |
|---|---|---|
| **Slope (degree)** | | |
| < 10 | High | 236.46 |
| 10-20 | Moderate | 148.70 |
| 20-30 | Low | 166.21 |
| >30 | Unsuitable | 256.68 |
| **Aspect** | | |
| Flat and Southern | High | 245.52 |
| Eastern and Western | Moderate | 379.71 |
| Northern | Unsuitable | 182.83 |
| **Distance from water bodies (meters)** | | |
| >500 | High | 445.33 |
| 250-500 | Moderate | 166.35 |
| 100-250 | Low | 112.68 |
| 0-100 | unsuitable | 83.70 |
| **Distance to existing road (meters)** | | |
| 0-400 | High | 650.85 |
| 400-800 | Moderate | 82.13 |
| 800-1200 | Low | 40.32 |
| >1200 | Unsuitable | 34.77 |
| **Distance to existing settlement (meters)** | | |
| 0-400 | High | 746.42 |
| 400-800 | Moderate | 49.61 |
| 800-1200 | Low | 8.92 |
| >1200 | Unsuitable | 3.16 |

The suitability analysis illustrated that around 395 Km² of land were suitable for resettlement, however only around 136 Km² of land were highly suitable. Around 410 Km² were unsuitable. The area of suitable areas based on the degree of suitability is provided in Table 8. The suitable map is provided in Figure 3 and Figure 4.

*Table 8: Area of suitable areas based on degree of suitability*

| Suitability | Area (km²) |
|---|---|
| High | 136.32 |
| Moderate | 216.49 |
| Low | 42.86 |
| Unsuitable | 410.98 |

Out of the total suitable areas, around 6 km² of land that were highly suitable were present within Kathmandu and Lalitpur Metropolitan City. Although suitable areas were identified within the metropolitan, most of the areas were public open space, areas of Nepal army, Police academy or areas allocated for specific purpose like waste water treatment plant. These spaces cannot be used for resettlement as they are allocated for specific purposes. Public open space has an important role during natural disaster like earthquake. During the earthquake of 2015 in Nepal, the public open space in Kathmandu and Lalitpur disticts provided refuge to the city dwellers.

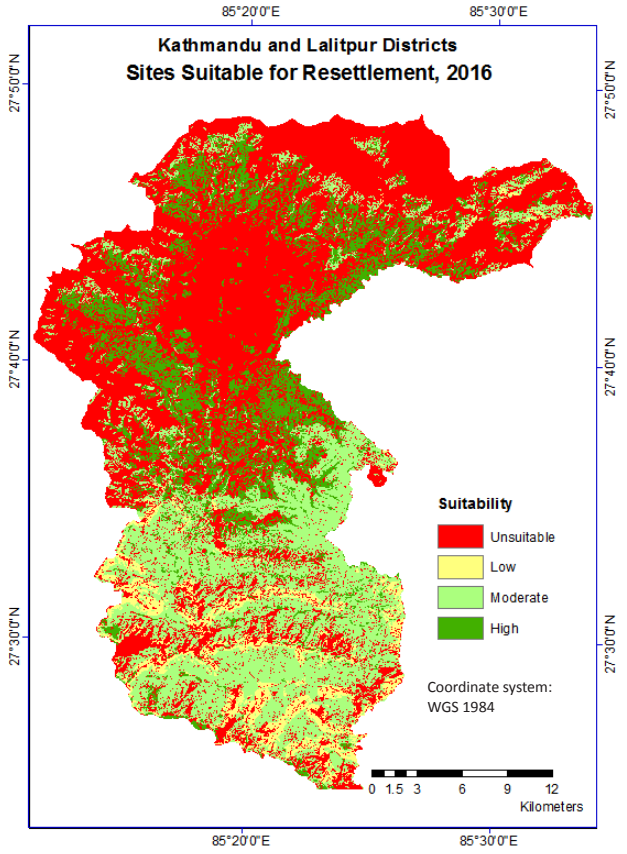


*Figure 3: Suitable resettlement sites*


*Figure 4: Suitable Location in Kathmandu and Lalitpur Metropolitan City*

## 5. CONCLUSIONS

Most of the highly suitable areas for resettlement were present outside Kathmandu and Lalitpur metropolitan city in different areas including, Kabresthali, near Jhor Mahankal and Kirtipur. Within the metropolitan city, most of the areas were public open space, areas of Nepal army, Police academy or areas allocated for specific purpose like waste water treatment plant. These spaces cannot be used for resettlement as they are allocated for specific purposes.

This study has not considered land prices, willingness of land owners to sell land for resettlement area, willingness of squatters to move from their current settlements, impacts on local communities and landowners by the resettlement project. And studies on these issues should be done.

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# GUIDELINES FOR AUTHORS PREPARING MANUSCRIPTS FOR PUBLICATION IN THE JOURNAL OF LAND MANAGEMENT AND GEOMATICS EDUCATION

Author Name,[1] Author Name[2]

[1]Author Affilation & Email Address
[2]Author Affilation & Email Address

## ABSTRACT

These guidelines are provided for preparation of papers for publications in the journal going to be prepared by Land Management Training Center. These guidelines are issued to ensure a uniform style throughout the journal. All papers that are accepted by the editorial board of this journal will be published provided they arrive by the due date and they correspond to these guidelines. Reproduction is made directly from author-prepared manuscripts, in electronic or hardcopy form, in A4 paper size 297 mm x 210 mm (11.69 x 8.27 inches). To assure timely and efficient production of the journal with a consistent and easy to read format, authors must submit their manuscripts in strict conformance with these guidelines. The editorial board may omit any paper that does not conform to the specified requirements.

## KEY WORDS

*Manuscripts, Journals, LMTC, Guidelines for Authors, StyleGuide*

## 1. MANUSCRIPT

### 1.1 General Instructions

The maximum paper length is restricted to 8 pages. The paper should have the following structure:

1. Title of the paper
2. Authors and affiliation
3. Keywords (6-8 words)
4. Abstract (100 – 250 words)
5. Introduction
6. Main body
7. Conclusions
8. Acknowledgements (if applicable)
9. References
10. Appendix (if applicable)

### 1.2 Page Layout, Spacing and Margins

The paper must be compiled in one column for the Title and Abstract and in two columns for all subsequent text. All text should be single-spaced, unless otherwise stated. Left and right justified typing is preferred.

### 1.3 Length and Font

All manuscripts are limited to a size of no more than eight (8) single-spaced pages (A4 size), including abstracts, figures, tables and references. ISPRS Invited Papers are limited to 12 pages. The font type Times New Roman with a size of nine (9) points is to be used.

**Table 1. Margin settings for A4 size paper**

| Setting | A4 size paper | |
|---|---|---|
| | mm | inches |
| Top | 25 | 1.0 |
| Bottom | 25 | 1.0 |
| Left | 20 | 0.8 |
| Right | 20 | 0.8 |
| Column Width | 82 | 3.2 |
| Column Spacing | 6 | 0.25 |

## 2. TITLE AND ABSTRACT BLOCK

### 2.1 Title

The title should appear centered in bold capital letters, at the top of the first page of the paper with a size of twelve (12) points and single-spacing. After one blank line, type the author(s) name(s), affiliation and mailing address (including e-mail) in upper and lower case letters, centerd under the title. In the case of multi-authorship, group them by firm or organization as shown in the title of these Guidelines.

### 2.2 Key Words

Leave two lines blank, then type “KEY WORDS:” in bold capital letters, followed by 5-8 key words. Note that ISPRS does not provide a set list of key words any longer. Therefore, include those key words which you would use to find a paper with content you are preparing.

### 2.3 Abstract

Leave two blank lines under the key words. Type “ABSTRACT:” flush left in bold Capitals followed by one blank

line. Start now with a concise Abstract (100 - 250 words) which presents briefly the content and very importantly, the news and results of the paper in words understandable also to non-specialists.

## 3. MAIN BODY OF TEXT

Type text single-spaced, with one blank line between paragraphs and following headings. Start paragraphs flush with left margin.

### 3.1 Headings

Major headings are to be centered, in bold capitals without underlining, after two blank lines and followed by a one blank line.

Type subheadings flush with the left margin in bold upper case and lowercase letters. Subheadings are on a separate line between two single blank lines.

Subsubheadings are to be typed in bold upper case and lower case letters after one blank line flush with the left margin of the page, with text following on the same line. Subsubheadings may be followed by a period or colon, they may also be the first word of the paragraph's sentence.

Use decimal numbering for headings and subheadings

### 3.2 Footnotes

Mark footnotes in the text with a number (1); use the same number for a second footnote of the paper and so on. Place footnotes at the bottom of the page, separated from the text above it by a horizontal line.

### 3.3 Illustrations and Tables

**3.3.1 Placement** Figures must be placed in the appropriate location in the document, as close as practicable to the reference of the figure in the text. While figures and tables are usually aligned horizontally on the page, large figures and tables some-

times need to be turned on their sides. If you must turn a figure or table sideways, please be sure that the top is always on the left-hand side of the page.

**3.3.2 Captions** All captions should be typed in upper and lower case letters, centered directly beneath the illustration. Use single spacing if they use more than one line. All captions are to be numbered consecutively, e.g. Figure 1, Table 2, Figure 3.

### 3.4 Equations, Symbols and Units

**3.4.1 Equations** Equations should be numbered consecutively throughout the paper. The equation number is enclosed in parentheses and placed flush right. Leave one blank lines before and after equations:

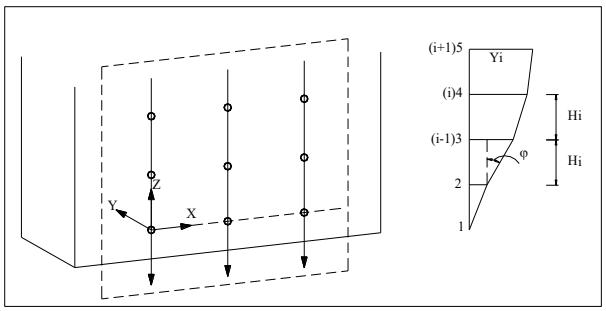


**Figure 3. Figure placement and numbering**

$$x=x_0 -c(X-X_0)/(Z-Z_0);\ y=y_0 -c(X-X_0)/(Z-Z_0) \quad (1)$$

where c = focal length

x, y = image coordinates

$X_0$, $Y_0$, $Z_0$ = coordinates of projection center

X, Y, Z = object coordinates

**3.4.2 Symbols and Units** Use the SI (Système Internationale) Units and Symbols. Unusual characters or symbols should be explained in a list of nomenclature.

### 3.5 References

References should be cited in the text, thus (Smith, 1987a), and listed in alphabetical order in the reference section. The following arrangements should be used:

**3.5.1 References from Journals** Journals should be cited like (Smith, 1987a). Names of journals can be abbreviated according to the "International List of Periodical Title Word Abbreviations". In case of doubt, write names in full.

**3.5.2 References from Books** Books should be cited like (Smith, 1989).

**3.5.3 References from Other** Literature Other literature should be cited like (Smith, 1987b) and (Smith, 2000).

**3.5.4 References from websites** References from the internet should be cited like (Maas et al. 2017). Use of persistent identifiers such as the Digital Object Identifier or (DOI) rather than a URLs is strongly advised. In this case last date of visiting the web site can be omitted, as the identifier will not change.

**3.5.5 References from Research Data** References from internet resources should be cited like (Dubaya et al., 2017).

**3.5.6 References from Software Projects** References to a software project as a high level container including multiple versions of the software should be cited like (GRASS Development Team, 2017).

**3.5.7 References from Software Versions** References to a specific software version should be cited like (GRASS Development Team, 2015).

**3.5.8 References from Software Project Add-ons** References to a specific software add-on to a software project should be cited like (Lennert and GRASS Development Team, 2017).

**3.5.9 References from Software Repository** References from internet resources should be cited like (Gago-Silva, 2016).

## 4. ACKNOWLEDGEMENTS (OPTIONAL)

Acknowledgements of support for the project/paper/ author are welcome.

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## APPENDIX (OPTIONAL)

Any additional supporting data may be appended, provided the paper does not exceed the limits given above.

*Note: The format for the journal is taken and modified from the format of ISPRS archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*

# THE INTERNATIONAL WORKSHOP ON CAPACITY BUILDING AND EDUCATION OUTREACH IN ADVANCED GEOSPATIAL TECHNOLOGIES AND LAND MANAGEMENT: SUMMARY REPORT

Bhuwan Ranjit, Ganesh Prasad Bhatta

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## 1. INTRODUCTION

Identifying the pressing need and opportunity to harness wealth of information on pivotal geospatial advances, especially for technological transformation, education outreach and capacity building in Nepal, Land Management Training Center (LMTC) organized an International event entitled 'Capacity building and Education Outreach in Advanced Geospatial Technologies and Land Management' with Special Session on 'BIM Technologies in urban land management and development' on 10-11 December 2019. It is the first ever-international event of this kind organized by LMTC in collaboration with the renounced national and international professional organizations devoted in the sector of Geo-information Science and Land Management. International Society for Remote Sensing and Photogrammetry (ISPRS) (Technical Commission V/ Working Group 7 (TC V / WG 7) and Technical Commission IV/ Working Group 6 (TC IV / WG 6)), Nepal Remote Sensing and Photogrammetric Society (NRSPS) and Nepal Institution of Chartered Surveyors (NICS) joined hands with LMTC in organizing the international workshop.

Geospatial domain has the characteristics of rapid development and adoption of newer technologies. This calls for a challenging task of harnessing recent scientific advances across multiple fields of education and research; then, accelerate and guide evolution of geospatial technology. To ensure this, this workshop incorporated a wide spectrum of themes, and provided a perfect global networking platform as it brought together renowned professionals from all over the world. The primary goal of this workshop was to cater exchange of recent research achievements and break-through ideas on cutting-edge geospatial technologies and latest trends in geospatial education amongst multi-disciplinary group of attendees. This international workshop also aimed to flourish collaborative relationship among national/international institutions, academicians and professionals for mutual benefit through knowledge sharing and technology transfer.

Particularities of the workshop were finalized by joint meeting with the co-organizers and several committees were formed and were allocated workshop duties sequentially presented in Annex 2.

LMTC envisioned the viability of organizing international workshop of such scale within the premises of LMTC with the intention of publicizing the organization. Even though seemed ambitious, LMTC team left no stone unturned and achieved the goals within the time line with collective hard work and dedication of the LMTC team, co-organizers and all involved in the workshop. The event was successfully held in the LMTC premises and the venue arrangement was well received. The crucial decision of the workshop venue paid off as LMTC demonstrated the potential of organizing event of such magnitude using its own resources especially the venue.

The LMTC international workshop saw 200 participants from 13 different countries from Nepal and foreign countries namely India, China, Australia, The Netherlands, Turkey, Czech Republic, Ukraine, Russia, Belgium, Israel, Afghanistan and Mongolia.

The first day of the workshop was structured in an inaugural session followed by keynote presentations, moving on to in-depth technical sessions. Similarly, the second day kicked off with a plenary session with brief summary of day I and plenary presentation followed by technical sessions and finally the closing ceremony. In total, there were 8 different technical sessions on 6 themes and a special session during which 54 papers were presentations. Among the 54acceptedpeer reviewed papers, 17 papers are published in ISPRS Annals, 23 papers are published in ISPRS Archives and remaining 14 papers are published in the workshop's digital proceeding.

## 2. INAUGURAL SESSION

The workshop commenced with the Inaugural session on the 10th of December, 2019. The Chief Guest of the event Hon'ble Minister Padma Kumari Aryal, MOLMCPA, inaugurated the

event. In her inaugural address, Hon'ble Minister extended warm welcome to all the international and national guests and participants, and congratulated LMTC for its exemplary work of organizing its first ever-international workshop at its own office premises. She praised LMTC of its important role for technology transformation through timely modification of its trainings, the capacity development of the trainers and cooperation with the universities. She expressed this workshop will play a vital role in the capacity building of the Center itself; and guide the training center in fulfilling the nation's expectations from the Center. She was most interested about the curriculum development of the center using the guidance received from intensive discussion with the invited scholars and International Cooperation with universities and related professional organizations.

Prof. Dr. Ram Kantha Makaju Shrestha, Vice-Chancellor, Kathmandu University, Dr. Sunil Babu Shrestha, Vice-Chancellor, Nepal Academy of Science and Technology, Mr. Ashok Byanju, Chief of Dhulikhel Municipality and Prof. Dr. Vladimir Seredovich, Chair of ISPRS TC V/WG 7deliberated their speeches. Chair of Organizing Committee, Mr. Ganesh Prasad Bhatta deliberated his welcome speech. The distinguished speakers expressed happiness on organizing such a useful event in line with LMTC's dedication in manpower production and capacity development in the sector of Surveying and Mapping, and Land Management.

There was the presence of high level Government officials in the inaugural session including Mr. Madhusudan Adhikari, Secretary, Ministry of Urban Development, the chairman and delegates of the co-organizers of this workshop, Joint Secretaries, Director Generals, Heads of several departments, dignitaries from different universities, professors, professionals, media persons and registered participants.

The chief guest of the session Hon'ble Minister Padma Kumari Aryal and high-level officials visited the exhibition stalls upon the conclusion of the inaugural session.

## 3. KEYNOTE SESSION

After the inaugural ceremony, the event moved to keynote session. Dr. Sunil Babu Shrestha, Vice Chancellor of Nepal Academy of Science and Technology (NAST), Prof. Dr. J. A. Zevenbergen, University of Twente, Dr. Sultan Kocaman, Hecettepe University and Prof. Dr. Ruizhi Chen, Wuhan University were keynote speakers. Former secretary of Government of Nepal, Mr. Baburam Acharya moderated this session.

Dr. Sunil Babu Shrestha deliberated on "GIS for Sustainable Urban Planning and Development of Nepal". He talked about the urban issues and challenges and exploring opportunities of GIS applications to address those issues and challenges. He also spoke about the activities of NAST in Geospatial sector with focus on the Nepali Sat-1: Nepal's first Nano-Satellite under BIRDS 3 Project launched on 18th April 2019 and Deployed on 17thJune 2019.

Prof. Dr. J. A. Zevenbergen during his presentation entitled "Responsible Land Administration: Geo-information and more" elaborated on people-to-land relationships—who, how, where and how much, land administration domain model, and managing right, restrictions and responsibilities on land. For this, he highlighted the modern technologies to capture the parcels and their dimension such as automatic extraction of parcel boundary from imageries using deep learning to timely map 3 billion parcels in the world yet to be mapped. According to him the true challenge today lies on huge geo-datasets to find data that shows reality. He specially focused on the application of smart land management that use social technologies, volunteered geographic information, and crowd sourcing in combination with technical drivers of intelligent information systems and big, linked, and open data to drive solutions for land related challenges. At the end, for innovative land administration, he stressed the need of change of mindset—interdisciplinary and cross agency thinking, goal and client orientation, not technocratic procedures, requirements and 'mandates', and appropriate (post) graduate training in new ideas, but especially in attitudes of land professionals.

Dr. Sultan Kocaman under her presentation on "Citizen Science and Geospatial Technologies in Modern Land Management" shared her knowledge on Citizen Science (CitSci) and related associations, obstacles on the participation, possibilities with Citizen Science projects, Open Data–Open Government and potential of CitSci in modern land management, disaster management and achieving Sustainable Development Goals 2030.Noticeably, she was invited to the workshop through ISPRS Keynote Speaker Programme, an ISPRS Initiative for the ISPRS Member hosting the ISPRS affiliated conferences.

Prof. Dr. Ruizhi Chen delivered enlightening presentation on "Beyond GNSS: sub-meter accuracy indoor positioning using smartphones". He highlighted the applications of Artificial Intelligence (AI) such as deep learning for indoor positioning using smartphones in underground parking, underground metro stations etc. During his presentation, the applications of AI based indoor positioning introduced were smart parking, precision marketing, human activity recognition, location based services and real-time location services. He talked about handling complications of indoor positioning with no open sky and complex topology such as corridor. He delivered on how Google uses visual positioning + wifi RTT and Apple uses iBeacon + UWD to achieve couple of centimeters indoor positioning accuracy. He also provided insights on use of Baidu for indoor positioning without facility installation as required by the aforementioned Google and Apple indoor positioning approaches. He discussed the challenges of using cellphones for positioning relating to measurement noise pertaining to cheaper sensors used in cellphones. He shaded light on hot topics on use of 5G, Bluetooth 5.1 and wifi6 to obtain sub-meter positioning accuracy and fascinating advances

positioning using speaker broadcasted song signals while listening music.

## 4. PLENARY SESSION

The second day of the workshop began with plenary session. Plenary speaker Professor Dr. Kevin McDougall, University of Southern Queensland, Australia presented on the future of authoritative geospatial data in the big data world—trends, opportunities and challenges.

## 5. TECHNICAL SESSIONS

Altogether six technical sessions and a special session were held. Each technical session were named and categorized as per their themes. The details of the sessions with their focus area, description of the papers presented, the number of papers per session and the chair of the technical sessions are illustrated in Table 1.

Additionally, the workshop saw of special session on *BIM Technologies in Urban land Management and development*. The Speakers for the BIM session were Prof Dr. Ing. Karel Pavelka, Czech Technical University, The Czech Republic and Prof. Dr. Roman Shults, Faculty of GIS and territories management, Kyiv National University of Civil Engineering and Architecture. Secretary of the Ministry of Urban Development, Government of Nepal, Mr. Madhusudan Adhikari moderated this special session. The focus area of this special session were Photogrammetry and Laser-scanning for BIM in Design, Construction and Operation of Transport Infrastructure, BIM Implementation from the Governmental, Organizational and Infrastructural Point of View, and Measurement and BIM in Construction and Facility Management

The technical sessions were filled to the rim with interesting papers on the latest research on the application of Geo-information and Land Management in agriculture, forestry, disaster, humanitarian relief operations, risk mapping and citizen science. Also, there were gripping papers dealing more specifically with education, outreach and capacity building Geo-information and Land Management. As these papers were within the realm of mandated duties of LMTC, the knowledge acquired from these researches surely will help LMTC become center-of-excellence in Surveying & Mapping, Geo-information and Land Administration Sector in Nepal through quality education, capacity, and collaboration with national and international partners.

**Table 1.Overview of the Technical Sessions and Special Session on BIM Technologies.**

| SN | Themes of Technical Sessions | Description | No. of Papers | Session Chair |
|---|---|---|---|---|
| 1 | Technical Session I (Advanced Geospatial Technologies: Urban Monitoring) | Papers presented included spatio-temporal analysis and modelling of urban growth, mapping of slums, multi-parameter optimal path analysis, surface temperature and landscape heterogeneity study, space-place based data integration and mapping for house numbering. | 6 | Chair: Dr. Sultan Kocaman |
| 2 | Technical Session II: Land Management | Papers presented included land management problems, web-based information service for land management, land use regulation impact assessment, land evaluation and urban expansion study in Nepal along with heat island intensity analysis. | 6 | Chair: Dr. Sagar Raj Sharma |
| 3 | Special BIM Session on | Papers presented included contribution of geomatics technologies to BIM, generation of 3d models for urban streets facades, low-cost photogrammetry for interior mapping, safety assessment in BIM for transportation, 3d scene technology for land management, and topology adjustment of wall geometry. | 8 | Chair: Dr.-Dipl. Ing. Karel Vach |
| 4 | Technical Session III: Remote Sensing and Space Education: Remote Sensing for Natural Disaster | Papers presented included estimation of volume of ice loss, landslide extraction, spotgalcier, temporal shift of rivers, spatio-temporal evaluation of long-term earthquake events, surface dynamics of glacier, temporal shift of river and relationship of land surface temperature with land indices. | 6 | Chair: Dr. Rijan Bhakta Kayastha |

| | | | | |
|---|---|---|---|---|
| 5 | Technical Session IV: Spatial Data Infrastructure and Internet of Things (IOT) | Papers presented included citizen science contribution to spatial decision support technology, smartphone based VGI for slum mapping, WPS enabled SDI, scidb based framework for remote sensing, and big data. | 6 | Chair: Dr. Dr. Devraj Paudyal |
| 6 | Technical Session V: Advanced Geospatial Technologies- Ecology and Geography | Papers presented included habitat modelling, climate change impact assessment on river hydrology, spatial biodiversity model, slope calculation algorithms on different terrains, and mapping urban trees using object-based CNN. | 6 | Chair: Prof. Roman Shults |
| 7 | Technical Session VI: Curriculum Development for GIS Education Outreach | Papers presented included capacity development in geoinformatics and land management in Nepal, gender balance capacity building in GIT, geospatial products and technologies throughout the world, knowledge transfer vehicle for capacity development, and syllabus preparation for geomatics engineering. | 5 | Chair: Dr. Purna Nepali |
| 8 | Technical Session VI: Remote Sensing and Space Education: Remote Sensing for Forest Management | Papers presented included ground forest biomass estimation, SAR-optical forest cover and greenness estimation, and estimating chlorophyll-A concentration in lake. | 5 | Chair: Dr. Him Lal Shrestha |

## 6. SIDE EVENTS

**a. Pre-conference Event**

As a workshop pre-event, LMTC and Paschimanchal Campus (WRC), Pokhara jointly organized a closed workshop on 9th December, 2019 aimed at gathering experts' suggestions on the Curriculum Development for the proposed MSc in Geomatics Engineering course at WRC under Institute of Engineering Studies, Tribhuvan University. LMTC supported event venue—LMTC main hall and expertize marking LMTC's continuation of cooperation with academia. About 20 professional experts participated in the event. Distinguished experts including Prof. Dr. Kevin McDougall, Dr. Dev Raj Paudyal, among others brought years of solid experience on curriculum development and teaching, and contributed invaluable suggestions and advices.

**b. Business Exposition and Exhibition**

A business exposition was organized during the event. In the plenary session of the second day of the workshop, ***Gold sponsor***—Trimble presented about their products elaborating applications of their products in geospatial domain. All the participants including representatives from the Government of Nepal attended the exposition.

Similarly, the ***Gold sponsor***—Trimble, ***local supporters***—ADMC Engineering Private Limited, GeoSpatial Systems Private Limited and NAXA Private Limited, ***academic partner***—Kathmandu university, exhibited their products and services parallel throughout the event. Several local companies sponsored this event in both monetary and non-monetary terms. NAXA developed Anroid app of the workshop. The investment of all the supporters is truly appreciable. ***Media partner***—Cooordinates publicized the workshop to greater mass. In fact, their support ensured the feasibility and success of this workshop. In addition, Nepal Geomatics Engineering Society and Nepal Surveyors Association supported as ***Professional Partners***.

**c. ISPRS Closed Meeting**

The Working Group Officers of the ISPRS TC V/WG 7 organized a close meeting among its officers that included Chair Prof Vladimir A. Seredovich, Co-chair Karel Vach, Secretary Argina Novitskaya, Regional Coordinators Roman Shults, Laxmi Thapa and invited guests—Prof Dr. Ing. Karel Pavelka, Adam Dlesk and Zdenek Svaty. There was discussion about the workshop success and weakness and assessed the special BIM Session organized by the WG. The BIM Session organized for the first time in Nepal was one of the interesting sessions of the workshop and participants were keen to organize lecture/training session in the future. Also, the meeting conversed about the participation of WG in the coming ISPRS Congress Nice 2020 and dialogued about the future activities of the group in ISPRS events.

## 7. LMTC CLOSED SESSION

During the International Workshop, keynote speakers and professors had discussion with senior management team of LMTC in a closed session to explore the possibility of collaboration. Ganesh Prasad Bhatta, Executive Director

of LMTC, moderated the closed session and presented introduction of LMTC, courses offered at LMTC, challenges and future plans of LMTC. The major points raised during the closed meeting conducted on 11 Dec 2019 are mentioned here:

Prof. Dr. J.A. Zevenbergen, Faculty ITC, University of Twente, The Netherlands, highlighted the need of collaboration with private sector as well as national and international forum, build strong International Network as well as regional network, need of Training of Trainers (TOT) for effective training, explore the possibility of Tailor Made Training (TMT) support from abroad, scholarship at Faculty ITC through Joint agreement and Internship at national and international organizations, get exposed with international activities, need to be trained with new tools and translate the tools in the context of the country, should introduce e-learning, and the idea of impact assessment of government policies by LMTC is good and should be continued.

Prof. Dr. Ruizhi CHEN, Wuhan University, China appreciated the identification of challenges by the LMTC. He emphasized the need of high level academicians at LMTC to conduct policy research and PhD people in this sector of Geo-information, mobilization of local resources for training, updating Curriculum incorporating the technological change, provisioning Survey License and course for upgrade at least in 3 years, use Exchange opportunity to acquire knowledge of new technology from abroad, collaboration with National and International Society, collaborate in Citizen Science, using China scholarship program at Wuhan University and other Universities, participating, for example, in 2 weeks long international summer school held in July at Wuhan University related to positioning, GIS and remote sensing and tourist courses may be useful as refreshment courses.

Dr. Sultan Kocaman, Department of Geomatics Engineering, Hacettepe University, Ankara, Turkey brought light on the need of research in Geospatial domain, concentrating on issues of own countries for research, grab the free education opportunities in Turkey for undergraduate, graduate and PhD studies, possibility to collaborate in land management sector with Turkish University, academic collaboration with the Hacettepe University, possibility of getting funds for research Turkish National Science Foundation. She further highlighted trainees from Government employees should bring in domain knowledge and University adds technological knowledge, focus on curriculum development and revision continuously by analyzing with regards to country specific needs, and focus should be on remote sensing and UAV photogrammetry looking at the topography of Nepal.

Prof. Candan Gokceoglu, Dean Hecceppte University, Ankara, Turkey suggested to focus on Research and Development in technology transfer as the technologies are changing very fast, use e-learning and remote education as they are cheap to learn and great means for technology transfer by development of competent human resources and to collaborate with Hacettepe University.

Prof. Dr. Kevin McDougall, University of Southern Queensland, Australia recommended LMTC, together with the government and partnership with universities, should look at its new vision on where it wants to be in future and set its priorities. Then, refocus and review roles of each of them. He emphasized professional practice year after degree for obtaining real world professional experiences, prioritize research area in line with government's vision that can be collaborated, revise Land Management training and academic courses, necessary to search for PhD support from national and international universities, pointed University of Southern Queensland can collaborate in research with LMTC in areas that benefit Nepal, launch integrated course of University and Training Center useful for capacity development, and staffs and students from Australia can work with staffs and students of LMTC in projects such that they can gain skills from each other and develop better understanding if issues and challenges.

Dr. Dev Raj Paudyal, University of Southern Queensland, Australia appreciated LMTC's strong collaboration with Kathmandu university and backed its continuation. Bringing in light that University of Southern Queensland is number Online Education provider in Australia, he advised LMTC staff and students to explore and enroll in those courses. Further, he suggested the possibility of PhD in Queensland University, development curriculum that matches the international standards like of Australian universities such that the courses provided here is easily accredited, graduates get recruited and obtain graduate studies opportunities in Australia, possibilities of opportunities like Colombo plan for further studies, joint supervision of PhD research with LMTC/KU, and developing projects on urgent issues that are to be solved in Nepal that can be worked on together at University of Southern Queensland.

Dr. Subash Ghimire, Department of Geomatics Engineering, Kathmandu University, Nepal shared the willingness to support in research, students and Faculty exchange is major tool for knowledge sharing and work together in common area with national and international organization.

Janak Raj Joshi, Joint Secretary, Ministry of Land Management, Cooperatives and Poverty Alleviation thanked the eagerness of renowned and reputed International Universities to support LMTC for its capacity building and collaboration. He mentioned that the Government of Nepal is in verse of transfer of technology and new initiatives are adopted by Government of Nepal to harness modern Geo-information Technologies demanding quite large number of trainings. He elaborated the professionals of the Survey Department and the Department of Land Management and Archive (DoLMA) require some sort of in-service and skill upgrade trainings, refresher courses and tailor made trainings on modern geo-information technologies and adopt them for service delivery. Also, he added LMTC has to take necessary actions to build the capacity of provincial as

well as local government.

Based on the aforementioned summary, LMTC will carry out the further processing for possible collaboration with National and International Universities in the areas of Geo-information science, and Land Administration and Management.

## 8. CLOSING SESSION

The event ended with the closing ceremony held on 11th of December 2019. Prof. Dr. Bhola Thapa, Kathmandu University was the Special Guest of the Ceremony. He congratulated the organizers on the success of the event and extended sincere thanks to all the distinguished presenters and participants of the event. Joint Secretary Mr. Janak Raj Joshi, MOLMCPA, also congratulated LMTC for grand success of the event. Chair of Technical Committee Professor Dr. Kevin McDougall presented the technical report with major highlights of the event, Co-chair of the Organizing committee Mr. Rabin Sharma recited the Resolution of the Workshop (as in Annex 1) and the other Co-chair of the Organizing committee Mr. Punya Prasad Oli extended vote of thanks to all the supporters and participants.

Before declaring the closing of the event, Mr. Ganesh Prasad Bhatta, the Chair of Organizing Committee, expressed immense happiness on successful completion of the event and acknowledged all the co-organizers, presenters, reviewers, keynote speakers, chairs of different committees, international and national participants, sponsors and contributors. More specifically, Mr. Bhatta acknowledged the Joint Secretary of MOLMCPA, Mr. Janak Raj Joshi, Directors-trio of LMTC, Mr. Rajendra Raut, Mr, Tanka Prasad Dahal and Mr. Lekhnath Dahal, Chief Survey Officer of Survey Department Mr. Susheel Dangol for their outstanding contribution in its success. He further acknowledged Survey Officer and Regional Coordinator of ISPRS TC V /WG 7 Er. Laxmi Thapa, and Instructors Er. Bhuwan Ranjit and Er. Sanjeevan Shrestha, for their hard work to make the event a grand success, who worked consistently from beginning until the end of the workshop. Mr. Bhatta expressed thankfulness to Instructor Dr. Pradeep Sapkota Upadhyay and Assistant Instructor Mr. Laxman Banjara, who worked very hard to timel manage the logistics of the workshop. He also thanked Instructors Mr. Sanjaya Manandhar, Er. Sudarshan Gautam, Er. Shivajee K.C., Er. Lava Prasad Kuinkel, Er. Rubina Shahi, Mr. Govinda Ghimire, Er. Maheswhar Karkee, Er. Binod Humagain, and Er. Promod Guragain, Section Officer Ms. Arati Adhikari, and all other staffs of the Center for their invaluable contribution in making the event a grand success. He equally, acknowledged the Co-chairs Mr. Punya Prasad Oli, President of NICS, and Mr. Rabin K. Sharma, President of NRSPS for their constant support and encouragement to organize the event.

Last but not the least, Mr. Bhatta, thanked all the international guests and participants for their willingness to attend the event and wished for safe journey back home. With all the acknowledgements, Mr. Bhatta concluded the event at 04:30 PM of the 11th December, 2020.

## 9. CONCLUSION

In context of "Competent Civil Administration: Prosperity, Development and Good Governance" being this year's main slogan of Public Service, Good Governance being the highest expectation of the public, and Surveying and Mapping and Land Management being the backbone of infrastructure development; capacity building is indispensable and challenging to enhance the contribution of Surveying and Mapping, and Land Management towards nation building. It was highly relevant to organize such an International Workshop in such an important and challenging topic.

Dedicated in manpower production and capacity development in the sector of Geo-information and Land Management, LMTC organized this international workshop expecting to harness information about latest technologies to completely transform the traditional technology based trainings into the latest technology based trainings. The presentations made were very useful for the targeted professionals. In one hand, all participants greatly benefited from the workshop through the exchange of experiences gained from the study, research, use and implementation of the latest technologies and concepts developed in the field of Surveying and Mapping, and Land Management. In the other hand, this workshop played a vital role in the capacity building of the Center, specifically encouraged technology transformation.

The organizers and organizing committee worked tirelessly to make the workshop a success. The participation was encouraging not only from the country but also from abroad. The remarks from the international guests as well as national dignitaries were highly motivational. The details about the workshop along with the proceedings are available at https://lmtc.gov.np/workshop/.

The successful conduction of this workshop in LMTC premises has clearly proven LMTC's capabilities of conducting international events of such magnitude. In nut shell, this workshop was successful in achieving its objectives and paved LMTC's way for organizing international events of similar and even greater impact in scientific arena!

## ANNEX 1: RESOLUTIONS OF THE WORKSHOP

We, The participants of, The International Workshop on 'Capacity building and Education Outreach in Advanced Geospatial Technologies and Land Management'; organized by, Land Management Training Center, Ministry of Land Management, Cooperatives and Poverty Alleviation (Government of Nepal); and co-organized by, International Society for Photogrammetry and Remote Sensing (ISPRS) Technical Commission V: Education and Outreach /Working

Group 7 Innovative Technologies in Training Civil Engineers and Architects and Technical Commission IV: Spatial Information Science /Working Group 6 SDI: Internet of Things and Spatial Decision Support (TC V/WG 7 and TC IV/ WG 6), Nepal Remote Sensing and Photogrammetry Society, Nepal Institution of Chartered Surveyors,

**Realizing** the need of qualified human resources in the field of geo-information and land management to support spatial planning and decision-making, infrastructure development and deliver people-centric services in line with the recently introduced federal structure of Nepal and ultimately play a vital role in achieving sustainable development goals,

**Bearing in mind** the provision made by the Public Service Act; according to which every public servant is entitled to attend training, at least once in three years,

**Emphasizing** the importance of new skills, knowledge and innovations for continuous professional development of professionals in land and geo-information domain,

**Believing** that utmost level of cooperation and support is essential to develop a center of excellence and a knowledge hub in the field of geo-information and land management,

1. Suggest conducting wide range of short and midterm trainings to fulfill the demand of skilled human resources and broaden the scope of Surveying, Mapping and Land Management professionals in local, provincial and federal levels.
2. Recommend expanding the opportunities of in-service and refresher courses, especially for newly recruited employees from varying domains and mid-career professionals to enhance and polish their skills in tandem with emerging technologies to ensure efficient and effective service delivery.
3. Encourage to exploit the opportunities created by rapidly growing information and communication technologies, embed it in the courses as required, amend the curriculum to synchronize with the evolving technologies, adopt and integrate the best practices, support innovative ideas and initiate research and development activities in this domain.
4. Request to develop communication mechanism for partnership and collaboration in national and global arena among professional organizations, academic institutions, private sector and development partners to enhance institutional capacity, develop LMTC as a knowledge hub and center of excellence in the field of Geo-information and Land Management.

## LAND MANAGEMENT TRAINING CENTER

**Dhulikhel, Kavrepalanchok, Nepal, December 11, 2019**

### ANNEX 2: DETAILS OF THE COMMITTEES

| SN | Name of the committee | Chair | Members |
|---|---|---|---|
| 1. | Advisory Committee | Mr. Surya Prasad Gautam, Former Secretary, MOLMCPA | Christian Heipke, President, ISPRS; Lena Halounova, Secretary General, ISPRS; Dr. Senthil A Kumar, TCV President, ISPRS; Mr. Janak Raj Joshi, Joint Secretary, MOLMCPA; Mr. Prakash Joshi, Director General, Survey Department; Mr. Krishna Prasad Gyawali, Director General, DOLMA<br><br>**Member Secretary**: Mr. Ganesh Prasad Bhatta, Executive Director, LMTC |
| 2. | Organizing Committee | Mr. Ganesh Prasad Bhatta, Executive Director, LMTC | Mr. Rabin Kaji Sharma, President, NRSPS; Mr. Punya Prasad Oli, President, NICS; Mr. Susheel Dangol, Chief Survey Officer, SD; Dr. Devraj Paudyal, ISPRS TC IV / WG 6; Mr. Lekha Nath Dahal, Director, LMTC; Er. LaxmiThapa, ISPRS TC V /WG 7<br><br>**Member Secretary**: Mr. Tanka Prasad Dahal, Director, LMTC |
| 3. | Event Management Committee | Mr. Rajendra Raut Director, LMTC | Dr. Pradeep Sapkota Upadhyaya, Mr. Hari Prasad Lawaju, Er. Sanjeevan Shrestha, Mr. Sanjaya Manadhar, Er. Shivaji K.C., Er. Sudarsan Gautam, Mr. Gobinda Ghimire, Ms. Arati Adhikari, Er. Binod Humagain, Er. Maheshwor Karki, Er. Lava Prasad Kuinkel, Er. Pramod Guragain, Er. Rubina Shahi, Mr. Laxman Banjara, LMTC<br><br>**Member Secretary**: Er. Bhuwan Ranjit, LMTC |

| | | | |
|---|---|---|---|
| 4. | International Program Committee | Dr. Senthil A Kumar, TC V President | Vladimir Seredovich, Gottfried Konecny, Karel Vach, Karel Pavelka, Radovan Haloun, **Markéta Potůčková,** Argina Novitskaya, Roman Shults, Eugene, Jurate Visockiene, Egle Tumeliene, ISPRS TC V / WG 7; Sisi Zlatanova, ISPRS TC IV President; Marguerite Madden, Giuseppina Vacca, Mingshu Wang, Reiner Jaeger TC V / WG 7; Dr. Devraj Paudyal, ISPRS TC IV/WG 6<br>**Member Secretary**: Er. Laxmi Thapa, ISPRS TC V /WG 7 |
| 5. | Technical Committee | Prof. Dr. Kevin McDougall, University of Southern, Australia | Dr. Pradeep Sapkota Upadhyaya, LMTC; Dr. Reshma Shrestha, Kathmandu University; Dr. Jagannath Aryal, University of Tasmania; Dr. Arun Pratihast, Wageningen University |
| 6. | Workshop Secretariat | Mr. Tanka Prasad Dahal, LMTC | Er. Bhuwan Ranjit, LMTC; Er. Sanjeevan Shrestha, LMTC<br>**Member Secretary**: Er. Laxmi Thapa, ISPRS TC V /WG 7 |

## ANNEX 2: LIST OF REVIEWERS

**Dr. Jagannath Aryal,** Senior Lecturer of Geomatics Engineering, University of Melbourne, Australia

**Dr. Bhogendra Mishra**, Remote Sensing and GIS Expert, Oxford Policy Management

**Dr. Dev Raj Paudyal**, Lecturer, School of Civil Engineering and Surveying, University of Southern Queensland

**Dr. Rehana Shrestha**, Postdoctoral Researcher at Leibniz Science Campus, Digital Public Health, IPP, Bremen University

**Dr. Himlal Shrestha**, Remote Sensing Analyst, ICIMOD

**Dr. Subash Ghimire**, Assistant Professor, Department of Geomatics Engineering, Kathmandu University

**Dr. Shova Poudel**, Early Career Fellow, Organization for Women in Science for the Developing World (OWSD), TWAS, UNESCO

**Dr. Pradeep Sapkota Upadhyay**, Instructor, Land Management Training Center

**Dr. Reshma Shrestha**, Assistant Professor, Department of Geomatics Engineering, Kathmandu University

**Dr. Chandra Prasad Ghimire**, Researcher, AgResearch, Lincoln Research Center, Christchurch, New Zealand

**Dr. Chudamani Joshi**, Special Advisor, Embassy of Finland, Kathmandu

**Dr. Rajesh Thapa**, Remote Sensing and Geoinformation Specialist, ICIMOD

**Dr. Arun Pratihast**, Senior Data scientist, Earth Informatics, Wageningen Environmental Research, Wageningen, The Netherlands

**Dr. Rijan Bhakta Kayastha**, Associate Professor, Department of Environmental Science and Engineering School of Science, Kathmandu University

**Dr. Laxmi Dutta Bhatta**, Manager at Reallocation and Development of Unused Concession Land Programme (REAL DEV) Myanmar Visiting Faculty and Sr Researcher at Tribhuwan University Institute of Forestry

**Dr. Rishi Raj Dutta**, Capacity Development Lead/Senior Project Manager, Asian Disaster Preparedness Center

**Prof. Dr. Roman Shults**, Faculty of GIS and territories management, Kyiv National University of Civil Engineering and Architecture

**Dr. P.L.N. Raju**, Scientist, Indian Institute of Remote Sensing, Dehradun, India

**Dr. Tri Dev Acharya**, Postdoctoral Researcher, The Institute of Transportation Studies at University of California, Davis

**Dr. Argina Novitskaya**, ISPRS TC V / WG 7

**Prof. Dr. Ing. Karel Pavelka**, Czech Technical University, The Czech Republic

**Mr. Janak Raj Joshi**, Joint Secretary, Ministry of Land Management, Cooperatives and Poverty Alleviation

**Mr. Uma Shankar Panday**, Assistant Professor, Department of Geomatics Engineering, Kathmandu University

GOVERNMENT OF NEPAL
MINISTRY OF LAND MANAGEMENT, COOPERATIVES AND POVERTY ALLEVIATION

# LAND MANAGEMENT TRAINING CENTER

Dhulikhel, Kavrepalanchok

## INTRODUCTION

Land Management Training Center (LMTC), under the Ministry of Land Management, Cooperatives and Poverty Alleviation, Government of Nepal was established in 1968. LMTC is the oldest and the only governmental institution continually and significantly producing human resources and enhancing capacity of the government personnel in the field of Surveying and Mapping, and Land Management since its establishments. The center has already produced more than 7,000 land professionals at different levels through various types of training courses.

LMTC has been conducting wide range of long and short term training incorporating state-of-art modern technologies. Moreover, LMTC has been collaborating to run academic courses with Kathmandu University (KU) and Council for Technical Education and Vocational Training (CTEVT).

## VISION

To be the Center of Excellence in Land Management and Geomatics Education.

## MISSION

To conduct academic courses, professional trainings, refresher courses and research in Land Management and Geomatics sector for the production of qualified and skilled human resources.

## OBJECTIVES

- To produce qualified and skilled human resources in the field of Surveying, Mapping, Geo-information and Land Management.
- To conduct and promote research and development activities in the field of Surveying and Mapping, Geo-information and Land Management.
- To establish collaborative relationship with national and international institutions for mutual benefit by knowledge sharing, professional trainings and technology transfer.

## OUR FACULTIES/TRAINERS

Our courses are delivered by passionate and dedicated faculties/trainers who possess wealth of national and international experiences, and high qualification obtained from renowned national and international universities.

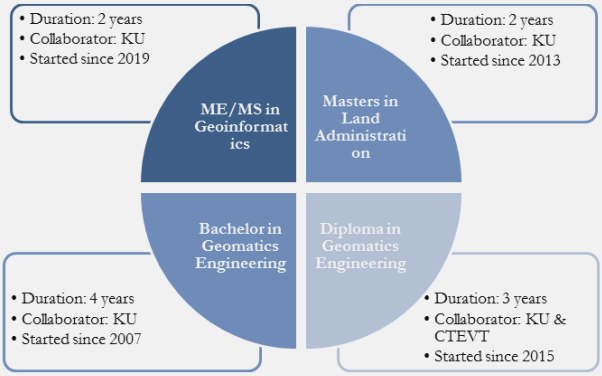
## ANNUAL PUBLICATION

JOURNAL OF LAND MANAGEMENT AND GEOMATICS EDUCATION

## OFFICIAL WEBSITE

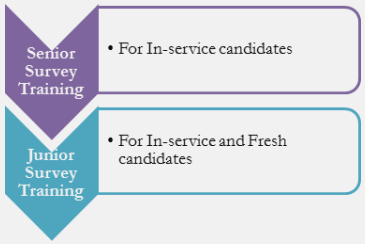
**www.lmtc.gov.np**

## ACADEMIC COURSES (In Collaboration)




## TRAINING COURSES

### LONG TERM TRAININGS




### SHORT TERM TRAININGS


## FUTURE PLANS

- To contribute in Policy Research in the sector of Geomatics and Land Management
- To contribute to capacity Building of Local Governments in the sector of Geomatics and Land Management
- To extend collaboration with academia and regional training institutions

Government of Nepal
Ministry of Land Management, Cooperatives and Poverty Alleviation

# LAND MANAGEMENT TRAINING CENTER

Dhulikhel, Kavre

## ACHIEVEMENTS OF FY 2076/77

### NOVEL SUCCESSES

- International workshop on 'Capacity Building & Education Outreach in advanced Geospatial Technologies & Land Management' on 10-11 Dec 2019
- Launched Journal of Land Management & Geomatics Education
- Residential Training of Trainers (TOT) for capacity building of LMTC staff
- Refresher Course for High Level Officials in land related issues
- Begun conducting trainings for local level

### COPING WITH COVID-19

Adopted Online method for teaching of Senior Survey Training and Junior Survey Training courses such that trainees graduate in scheduled dates

Successful Conduction of 2 weeks Training on GIS adopting 100% online mode and open source software; Orientation Training of newly appointed Survey Officers

### TRAININGS LAUNCHED THIS FISCAL YEAR

| | |
|---|---|
| Open Source (QGIS) | 15 |
| 47 Local Level Land Management | |
| Instrument Handling & Orientation | 23 |
| 12 Astronomical Observation | |
| GNSS + UAV | 11 |

### ADDITIONAL CAPACITY BUILDING SHORT TRAININGS

- Digital Cadastre Baglung (14), Palpa (14), Chitawan (22)
- Basic GIS Training Sankhuwasabha (11)
- Remote Sensing (15)
- Land Administration & Management Gazette Class III (15)
- Land Administration & Management Non Gazette (14)

### LONG TERM TRAININGS

- Senior Survey Training Inservice (24)
- Junior Survey Training Inservice (24)
- Junior Survey Training Inservice (24)
- Diploma in Geomatics Engineering (3rd year:46 2nd year 45)

### INSERVICE TRAINING GRANTING 2 POINTS

| | |
|---|---|
| Professional Course on Geomatics & Land Administration (Gazette Class III) | 15 |
| Digital Cadastre & Office Management Training (Non Gazette Class I) | 11 |
| Digital Cadastre & Office Management Training (Non Gazette Class II) | 21 |

### SALIENT FEATURES

Extended MoU with Kathmandu University in 2019 and launched ME/MS in Geoinformatics in addition to previously running MS in Land Administration and Bachelors in Geomatics Engineering courses

The figures in the parenthesis are the numbers of trainees


LMTC Family
International Workshop
10-11 December, 2019
Land Management Training Center, Dhulikhel, Nepal
International Workshop on 'Capacity building and Education Outreach in Advanced Geospatial Technologies and Land Management'

Senior Management Team, Land Management Training Center


Outgoing Senior Survey Training In-service Group, Batch 2075/76


Journal Release Ceremony of "Journal of Land Management and Geomatics Education, Volume I", 2076-03-30


51th Anniversary Ceremony of Land Management Training Center, 2076-03-30


Opening Ceremony of International Workshop

Lakhe Dance at International Workshop

Swastibachan at Opening Ceremony of International Workshop


Cultural Performance by Students at International Workshop

Participants at International Workshop

Participants Presenting paper at International Workshop


Closed Discussion session on Possible International Collaboration during International Workshop


Reciting resolution of International Workshop

Field Survey Camp, Lele, Lalitpur, 2076

Trainees at Field, Junior Fresh, 2076

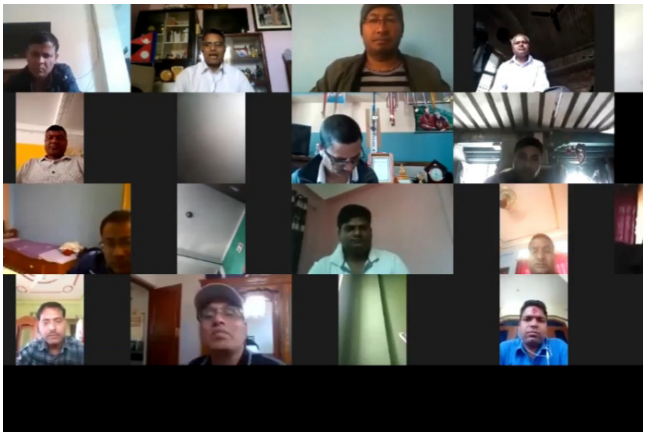
Theoritical Class Session at Field Camp, Lele, 2076

Students at Field, Diploma 3rd Year, 2076

Plotting Session at Field Camp, Lele, 2076

Students at Field, Diploma 3rd Year, 2076

Plantation Program in Land Management Training Center



Online Class, Senior Survey Training, 2076