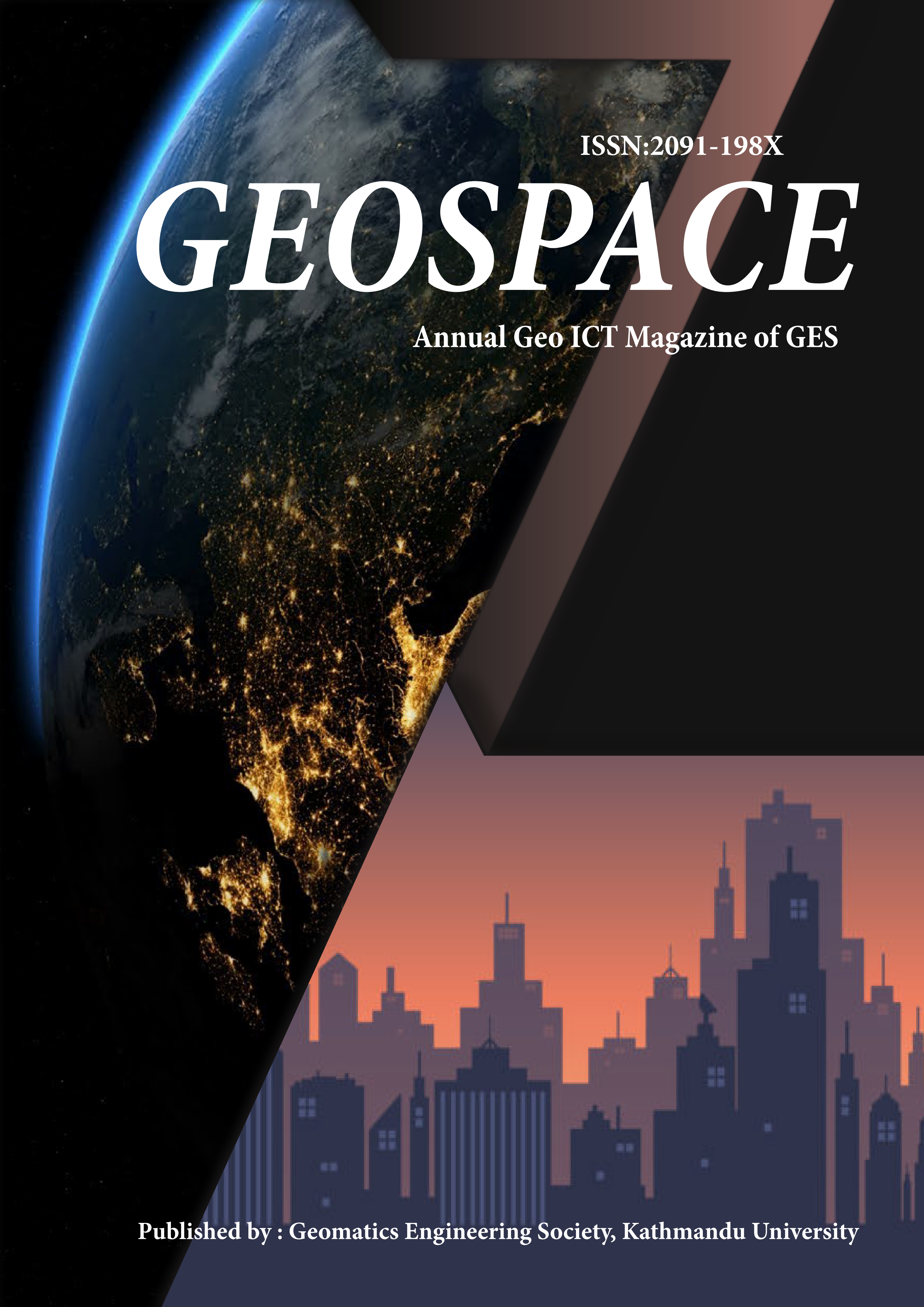

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GEOSPACE

Annual Geo ICT Magazine of GES

Published by : Geomatics Engineering Society, Kathmandu University

45 days Industrial Internship

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Land Management Training Center
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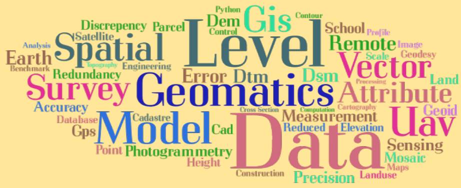
Bachelor of Engineering in Geomatics Engineering



Department of Geomatics Engineering
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Geospace

Volume 7

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Dhulikhel, Kavre
Email: ges@ku.edu.np

ISSN: 2091-198X

Editorial

We are very delighted to publish the seventh volume of GeoSpace magazine and honored to have got the chance to preserve the legacy of annual Geo-ICT magazine of GES "GeoSpace". Undoubtedly, Geospace has bridged the gap between educators, professionals, students, newbies with all the achievements, researches, findings in geo-informatics field since its inception. And that legacy continues with the seventh edition.

I take the opportunity to thank all the authors for their valuable submission on the magazine as it is their work that has made our magazine insightful.

Like Helen Keller said "Alone we can do so little; together we can do so much". This tremendous effort of preparing a magazine would have been impossible without the joint collaboration and effort of my entire team. I would like to extend by my warm appreciation to my teammates Mr. Saurav Raj Khanal, Mr. Siddhant Chaudary.

I would like to like to express my sincere appreciation to Dr. Subash Ghimire, Dr. Reshma Shrestha and Assist. Prof. Uma Shankar Panday for their valuable suggestions and guidance in this matter. I would also like to extend my deepest gratitude towards my colleagues Mr. Sarjun Khatri, Mr. Jenish Chauhan, Mr. Aadarsha Dhakal,Mr. Purna Bahadur Saud for their contribution in the magazine. I also extend my thanks to my seniors Mr. Abinash Silwal, Mr. Rabi Shrestha and Mr. Sandesh Sharma for their guidance. Last but not the least, I place on record our gratitude and heartfelt thanks to all the authors, students, faculties, seniors, former editioral board, financial contributors and all seen and unseen helping hands for making this magazine a reality.

Cecil Ghimire,
Editor in chief, GeoSpace Volume 7

Kathmandu University
Office of the Vice Chancellor

January 7, 2022

Message from Vice Chancellor

I am delighted to see the seventh issue of annual Geo- ICT magazine **Geo-Space** published by Geomatics Engineering Society (GES), Departmental club of Geomatics Engineering of Kathmandu University. This magazine adds to the literature of Geomatics Engineering in Nepal by creating and sharing new knowledge. Furthermore, it complements the initiatives of our University in advancing our institutional identity and in creating impact in the communities.

As our country moves in the era of decentralization that fuels development, the demand of expertise in Geomatics Engineering is increasing. I am hopeful that our team of Geomatics Engineering will help to fulfill this by providing locally suitable, applied skill and knowledge. Together, we will open new avenues growth and progress in our society.

I am confident that in coming days, GES will take our institution to newer heights and will act like a bridge to connect the world of academia directly with people and the communities.

I congratulate GES, Department of Geomatics Engineering and the Geo Space team for this publication and extend my best wishes and full support for your whole novel endeavors for future.

....
Prof. Dr. Bhola Thapa
Vice Chancellor

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Message from the HOD

Department of Geomatics Engineering
School Of Engineering,
Kathmandu University, Dhulikhel, Kavre

Dr. Subash Ghimire
Assistant Professor and Head of Department
Department of Geomatics engineering
Kathmandu University
subash_ghimire@ku.edu.np

I am delighted to write a few words on the Seventh issue of annual Geo-ITC magazine "Geo Space" published by Departmental club, Geomatics Engineering Society (GES). First of all, I personally and on behalf of Department of Geomatics Engineering, would congratulate entire students, faculties and staff of the Department to bring out "Geo-Space-VII". I am confident that this magazine is proficient not only to the surveying and mapping professionals, but also to others scientific community and researchers as well. I hope Geoinformation community will be benefitted at large by sharing scientific and professional articles.

It is also my pleasure to mention that Department of Geomatics Engineering, Youngest Department in School of Engineering, Kathmandu University, has been continuously contributing in the capacity building of Surveying, Mapping, Geoinformation Science and Earth Observation and Land Management. The Department has Undergraduate, Graduate and PhD programs. It has Geospatial, Photogrammetry and Surveying lab and in the future Cartography lab will be established at the Department. The Department is working in line with silver Jubilee initiatives such as Quality, Identity, Equality, Impact, Innovation and Global Engagement to achieve its vision. Finally, let me express my sincere appreciation to fellow colleagues, entire team of the editorial board to their invaluable contribution in "GeoSpace-VII". I would except such kind of support and professional contribution in the upcoming issues too. I believe that this effort will boost networking among the students, faculties and professionals.

Thanking You!

Message from LMTC

Government of Nepal
Ministry of Land Management, Cooperatives and Poverty Alleviation
LAND MANAGEMENT TRAINING CENTER
Dhulikhel, Kavre Nepal

Ganesh Prasad Bhatta
Executive Director
Land Management Training Center
Ministry of Land Management, Cooperatives and Poverty Alleviation
Government of Nepal

Let me express my happiness, one more time, for having the privilege of conveying my message in this issue of GeoSpace as well. I thank the Geomatics Engineering Society (GES) and its Editorial Team for this opportunity and congratulate the team on bringing one more brilliant issue

Maturity seems fostering in every successive issue with the reflection of encouraging professional dedication and enthusiasm of our future professional stars 'Geomatics Engineers-to-be'. I trust that dedication towards profession since its conception will certainly lead to the successful professional career, and I believe the same for such an energetic group of future geo-stars.

For the first time reader of the GeoSpace, let me briefly introduce Land Management Training Center (LMTC), the organisation that I belong to. LMTC is the only government training center that is responsible for producing human resources and developing capacity of the government officials working in the field of surveying, mapping and land management. LMTC played crucial role in laying the foundation of Geomatics Engineering (GE) courses at Kathmandu University (KU). LMTC-KU collaboration that began back in 2007 is getting stronger year by year. LMTC's efforts and concern are always focused on the quality that has to be injected in the profession through new graduates, and will remain over the years to come.

I thank the editorial team and entire GES community for their devotion, dedication and enthusiasm in publishing such a quality magazine that seems greatly contributing in the professional development of the students and practitioners. With this impression, finally, let me reiterate my statement from the previous edition's message "GeoSpace is a digest for the beginners, informant for the professionals, and publishing platform for the researchers. Reading GeoSpace is refreshing yourself. Enjoy reading GeoSpace!"

Thank you!

Message from GES

Geomatics Engineering Society
Department of Geomatics Engineering

Manisha K.C.
President, Geomatics Engineering Society
Department Of Geomatics Engineering
Kathmandu University, Dhulikhel
kc.manisha02@gmail.com

Geomatics Engineering Society (GES), recognized as a departmental club of Geomatics Engineering, has come a long way since its inception in 2007. Meanwhile, it has matured and expanded in conformity with time's growing demands and circumstantial challenges. It has been a beautiful platform to serve, guide, and motivate students to expose their talents, promotes shaping students' skills, and make them genuinely determined for the future. GES plays a crucial role in determining and channelizing students' passion and interest, offering limitless opportunities for student leadership and participation much beyond their academic pursuit. The extracurricular activities, talk shows, map literacy programs, webinars, training, guest lectures are routinely organized. Further, new research brainwashes the students' practical lessons of life, making them job-ready and ready to face the bumpy path of survival in this world of cutthroat competition. The programs thus organized are not only confined within the university but also with other associated clubs/organizations working in the geospatial domain.

As Coco Chanel once said, "Success is often achieved by those who do not know failure is inevitable" is an excellent saying for people who give it their all, especially Geospace Publishing Team for working hard for the publication of the magazine despite the global pandemic. I am in awe of all the hard work they have been doing helping the GES in a time of need and in the publication of this magazine. I commend the teamwork displayed by the publication team.

Lastly, I would like to extend a warm note of thanks to the "Geospace Publishing Team" for giving me this wonderful opportunity to pen my thoughts and share and communicate to our spectrum of readers, whom I consider, the source of our inspiration and support. I wish to sincerely appreciate the incomparable painstaking endeavors put forth by the editorial committee to bring out this popular and much-awaited "Annual Geo-ICT Magazine of GES, vol. VII" to a sea of eagerly waiting audience.

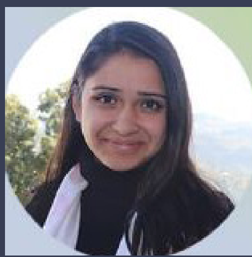
Happy Reading!!

Editorial Board

Cecil Ghimire (Editor in Chief)

Siddhant Chaudary

Pragya Joshi



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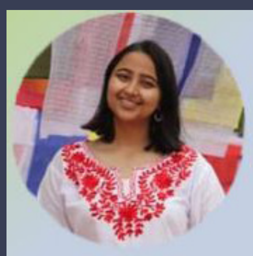

Pragati Dhakal

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Sharing Vision of the Department

-Dr. Subash Ghimire

Dr. Subash Ghimire joined Kathmandu University as a Teaching Assistant in Geomatics Engineering program in 2007. Currently, he is an Assistant Professor at the Department since December 2011 and also is serving as an Acting Head of Department of Geomatics Engineering from July 2019. He completed Master of Science in Geoinformation Science and Earth Observation: Land Administration from University of twente, Faculty of Geoinformation Science and Earth Observation, ITC. The Netherlands and PhD in Geomatics Engineering in Land Administration from Kathmandu University in collaboration with University of twente, Faculty of Geoinformation Science and Earth Observation, ITC. The Netherlands, University of Salzburg, Austria and Yildz technical University, Turkey in 2019. He is frequently involved in teaching and research activities at the department.

What is the vision of Department of Geomatics Engineering?

Department of Geomatics Engineering at Kathmandu University is officially established on B.S. 2075/12/12 (March 26, 2019). It is running its program within the umbrella of the vision and mission of School of Engineering, Kathmandu University. It is the youngest Department of School of Engineering at Kathmandu University. All programs running in the Department of Geomatics Engineering is in collaboration with Land Management Training Center (LMTC), Government of Nepal under the framework of Memorandum of Understanding (MoU).
Department of Geomatics Engineering has vision "To become center of excellence by providing quality education and research for leadership in Surveying, Mapping, Land Management and Geoinformation sector in collaboration with Government and other national and international organizations."

What are the strengths of Department of Geomatics Engineering?

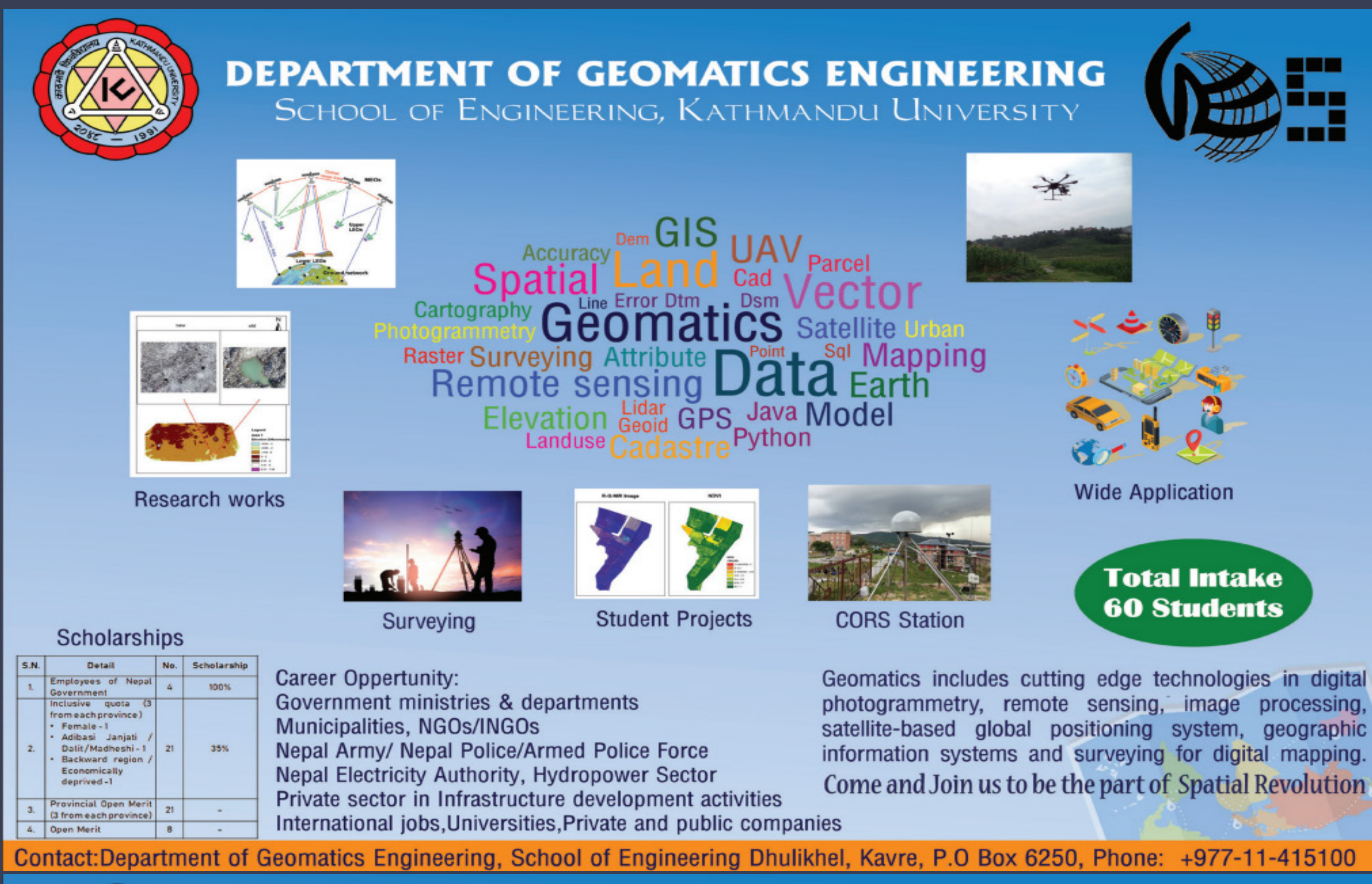
Most of the faculties at department have strong networks with international academic community. Faculties having PhD are increasing in the Department. Department has strong collaboration with LMTC, Government of Nepal and other reputed international Universities/organizations. Department has all level of Geomatics Engineering courses i.e. Diploma in Geomatics Engineering, Bachelor in geomatics Engineering, Master in Land Administration and Master of Engineering/Master of Science in Geoinformatics and PhD. Department has Geospatial, Surveying and Photogrammetry labs. We focused on problem, project and professional based learning in undergraduate and graduate level.

What are the challenges of the Department of Geomatics Engineering?

The major challenges at Department of Geomatics Engineering is infrastructure development for Lab expansion, office of the GES/ Alumni Association). Engineering education is normally considered as terminal program. Hence, it might be difficult to get students in Master and PhD level who can pay for their studies by themselves. Availability of hardware and software as per the student's expectation is also challenging issue at the department.

In your opinion, what are the opportunities for Department of Geomatics Engineering?

We can lead as Geoinformation and Land management knowledge / Data hub in the country and become centre of excellence in Surveying and Mapping, Land Management and Geoinformation sector. Geomatics Engineering will be highly demanded course in federal structure of the country. We can also contribute to UN Sustainable Development Goals and National Goal of the country. Due to COVID 19, we have to shape our Geomatics Engineering Education in new normal situation by using frontier technologies.



Women In Geomatics

-Dr. Reshma Shrestha

Dr. Reshma Shrestha is an assistant professor in Department of Geomatics Engineering; Kathmandu University .She has experience of over two decades in the applications of geoinformation in land management and planning and is actively involved in research and teaching. She is one of the foremost scholar in geospatial domain in Nepal.
Dr. Reshma has published more than 25 papers. She has also contributed in FIG within the theme of "Women in Surveying" and published a paper titled *"Looking from the lens of gender mainstreaming: the inclusiveness of women in surveying and Geo-information Technology (GIT) in Nepal"*. The paper can be accessed here: *https://research.utwente.nl/en/publications/looking-from-the-lens-of-gender-mainstreaming-the-inclusiveness-o*

How is the flow of women student in Geomatics and how is it changing these days?

Earth observation (EO) and geospatial information technology (GIT) predominantly outnumbered by males in academia as well as in the workforce. Often, EO and GIT including traditional surveying have tended to be perceives as masculine field. So it was normal for girls to be hesitant to take this field as career choice. Therefore, this gender imbalances leads to the great loss of skills, perspectives and innovations, which are immeasurable.
I still remember the first batch, at the time, when I was coordinator for undergraduate program in Geomatics Engineering. As that time there was only one female student in the batch 2007. Further we've had intakes when where the number of female student was zero as well. However, looking at present, the number is on steady incline, particularly from the batch 2019 when the intake criteria for the Geomatics Engineering has been made inclusive.

What do you thinks need to be done to increase this number?

Firstly, we need to think about why we need to increase the number of female students. I believe, in every field, gender equity and balance is required. In addition, there has been a global initiative. For instance, in order to achieve full and equal access to and participation in science for women and girls, and further achieve gender equality and the empowerment of women and girls, the United Nations General Assembly declared 11 February as the International Day of Women and Girls in Science in 2015.
Taking about specific sector like Geoinformatics, it is indeed necessity to balance the gender and introduce gender diversity. In this regards there is already a scientific argument and already scientific claim, that it is important to minimize gender gaps in order to mitigate internal biases while analyzing the data sets in general and geo datasets in particular. Therefore, to understand the women related issues spatially, there is important role of women geo

data analyst.
To bridge the gender gap in Geoinformatics, some interventions are required because cultural belief about gender plays a big role in encouraging or discouraging girls to choose the sectors like geoinformatics and surveying, which basically consists more field based subjects. My study shows that, inclusive criteria set by government for females is also playing some significant role in increasing female participation. Civil Service Act 1993 has the provision of the inclusiveness of women in a government job. Moreover, the inclusive criteria set by ensuring a seat for female student from each province, during the intake process of Geomatics Engineering at Kathmandu University, has in fact played key role in increasing the number female students.
Another important thing that is making the impact in the selection of this field by women is availability of Role models. In fact, the female role model triggers the mindset of female students. When there is successful female professionals in the Geomatics field, more females are going to be attracted to pursue this field as a career. Moreover, we need to realize that this is a gradual and cumulative process that is going to make more and more impact in female participation.

What are the challenges women face in field works and what should be done to encourage them to be involved more in it?

From a gender mainstreaming perspective, society, family and cultural belief has a huge impact on what kind of work women choose and these are the most important factor affecting their choice. Firstly, the kind of work women chooses, is directly related to the family life. Specifically, those who are already in the marital state as the female professional need to play a vital role in balancing career and family. However, the modern technology in geospatial domain has decreased the massive time that is needed to collect ground data by traditional technology of surveying and mapping. The modern technologies in capturing ground data like satellite images, UAVs, LiDAR, and various mobile based applications has created opportunity for women to choose this career because less time needed to be spent in field and also there is opportunities to choose desk based analysis as a career choice.

Despite of this advancement in geospatial technology, the field based knowledge is required. One thing that I would like to mention is that, data we've collected for our work show that female students are less interested in field work. Hence, we can encourage female student to take part in ground based field activities. There is no doubt that female student are equally capable in academic setting for their courses. In fact, we've had female that have outperformed their batch in our courses.In real world field a female surveyor may not be physically capable of carrying heavy equipment, that is a natural fact and we cannot argue it. In this regards the academic field work need to be designed by considering gender based components making it a gender friendly and gender sensitive. It should be ensured with security in lodging facilities, wash room facilities and so on.

What kind of effort are being made for this internationally?

There are many initiatives from international organizations to empower women in geospatial domain. For instance, UNOSAT in collaboration with the United Nations Economic and Social Commission for Asia and the Pacific, UNESCAP, have conducted a training with the theme Disaster Risk Reduction within Geospatial Information Technologies for Disaster Risk Reduction: A Gender-Responsive Approach to Disaster Reduction in December 2019.
Similarly, International Centre for Integrated Mountain Development (ICIMOD) has been organizing the "Empowering women in geospatial information technology" training

under its SERVIR Hindu Kush Himalaya (SERVIR-HKH) Initiative.
The international Federation of Surveyors (FIG) Commission 1 has established a working group 1.2 as "Women in surveying" with an objectives of actively promote women in the industry, address the hidden bias towards women, and address the lack of gender diversity. Besides, there are many more initiatives.

At the end my key messages:

It is oblivious that when women (or men) don't hear about many other women (or men) doing a certain type of work, it can be harder for a student to visualize how they could succeed in the particular field, and would make them less likely to decide that it is a path that would suit them.
Hence, I would like to say there are female role model in the geoinfomatics field, even within our country. So, female do not need to think "twice", when choosing the geoinformatics and its application domain as a career choice.

Tech In Geomatics

-Assistant prof. Uma Shankar Panday

Mr. Uma Shankar Panday is an Assistant professor in Department of Geomatics Engineering; Kathmandu University. He has experience of more than a decade in Geomatics Engineering Domain and is actively involved in research and teaching. He has the interests in Remote Sensing, GIS, Photogrammetry, Laser scanning, C, C++ and Python Programming. We sit down with Mr Panday to assess the current state of technology, challanges for implementation of such high tech instruments and alternatives in our context. Moreover, we also talk to him about his personal experience in the Geomatics engineering Domain.

What made you pursue a career in Geomatics coming from a Computer engineering background?

In Geomatics engineering, there are two main domains surveying and Geo Information i.e. processing of information related to Geo-Spatial fields. Surveying and computer Science/Engineering are the two pillars of Geomatics Engineering. Coming from computer engineering, Geo information is one of the applications of computer in geo spatial field. There is large amount of data to be processed in geo spatial field and there comes the application of computer Science/Engineering. There is vast amount of data used in geo spatial field and to process all these data computer applications are needed.

How is technology changing the Nepali Geomatics scene? Do you think it is possible to adopt advance tools in the context of Nepal in Geomatics as cost is usually a major driving factor?

In context of Nepal, new technologies are gradually evolving but it will take time to be adopted in a large scale. In current scenario, Nepal is slowly adopting modern and expensive technologies like LIDAR. The government of Nepal has adopted different modern technologies. But due to its higher cost, it was not started in academic arena. As an alternative to LiDAR surveying, UAV/ Drones are being used which in many cases can provide comparable results in cheaper costs. Aerial LiDAR is still very expensive for developing countries like Nepal to adapt at scale.

How would you describe your experience in the academic field as an instructor?

During the student life, I was my batch topper in the college so I used to guide my classmates and juniors. Since then interest towards teaching was developed. Due to some social circumstances I started teaching after my bachelor. Beside academic field, other professional works is also going on and it's been almost 15 years in academic field. Being an academic instructor, I have felt that students in the past students were hardworking. Learning materials have now become available at their finger-tips. In context of Nepal, the courses should now be updated according to the international standards.

What suggestions or advices you would like to give to students who want career in Geomatics?

In my view, Geomatics has very good scope in present and coming days since it is a multi-disciplinary field. For any development, Geomatics comes first and in Nepal many more development works are being carried out or are in the pipeline. Hydropower is on the most developing state and other infrastructures such as roads, highway and railroads are also there. Like on local level, development works are being carried out on very fast manner and for any development geomatics comes first. So, other fields like land surveying, data processing, web designing, mapping, etc. are also done by geomatics engineers. There are not only government jobs or land surveying jobs are available but also there is big opportunities

FOSS4G-Asia 2021 conference

A group photo during the conference on October 1, 2021 and the FOSS4G ASIA 2021 logo.

FOSS4G-Asia 2021 conference is an international conference for Free and Open Source Software for Geospatial Community. FOSS4G-Asia 2021 aims to support the global agenda of sustainable development goals including land management and contribute to Artificial Intelligence and IOT by bringing researchers, professionals, private developers, students, and all the stakeholders from worldwide in general and Asia in specific together in one platform. "FOSS4G-Asia 2021" was hosted at Kathmandu University by the Department of Geomatics Engineering with support from the Department of Computer Science and Engineering and Land Management Training Centre. The conference was held on 1-2 October 2021. It gave an impression that there is a wider interest in the domain of Free and Open Source Software for Geoinformatics and Land Management. The conference also had involvement from government, national and international private and public stake holders including organizations such as **National Academy of Science and Technology (NAST), Land Management Training Centre (LMTC), International Centre for Integrated Mountain Development (ICIMOD).** Gaia3D and ICIMOD are Platinum Sponsors and OSGeo-Japan, OSGeo-Korea, OSGeo-Thailand and FOSS4G-Asia 2018 are Gold Sponsors. Similarly, international and national private organizations have sponsored this conference. Aviyaan Consulting (P) Ltd., VidaGIS, CERG, GENESIS Consultancy (P) Ltd., NEST Consultancy Pvt. Ltd, Rajdevi Engineering Consultant Pvt., OSGeo India Chapter are contributors. Dr. Reshma Shrestha, Assistant professor of Department of Geomatics Engineering co-ordinated the event on behalf of the organizing committee and Department of Geomatics Engineering. The conference aimed to support the UN sustainable development goals agenda by bringing together academics, researchers, professionals, private developers, students from across the Asian region and the world to discuss on deliberate on the use of FOSS4G in the areas related to land management and use of IoT and Artificial Intelligence towards sustainable development. Considering the situation brought about by the Covid-19 pandemic at a global scale, the conference was the first hybrid model or online-physical mode conference held in Kathmandu University. This conference gave students excellent opportunities for awareness and exposure. Moreover graduate students also got a chance to make academic contributions. The conference set the tone for future developments in Free and opensource software for Geo informatics community in Nepal and in the world. The overarching theme for the conference was '**FOSS4G in the era of Artificial Intelligence, IoT for Land Management and Sustainable Development**'. There were 230 participants and delegates including both national and international. The international participants are from India, Sri Lanka, Thailand, Korea, Japan, China, Germany, France, and Canada. The dignitaries have highlighted the importance of Free and open sources for the geospatial community for societal benefits. This event has remained successful in enhancing the awareness of the importance of FOS4G in the wider community in Nepal including private organizations and academic sectors.

AGSE 2021 Conference

Vice Chancellor, Dr Bhola Thapa ,inaugurating the conference and giving an opening speech

Department of Geomatics Engineering, Kathmandu University organized International conference and workshops on Applied Geoinformatics .For Society and Environment (AGSE) 2021 from Nov 24- 26, 2021 at Kathmandu University in collaboration with the Geospatial Department of Stuttgart University of Applied Sciences, Germany, co-organized by the laboratory for interoperable and open source Geospatial software data and standards (HFT ICA-OSGeo-Lab). AGSE is an annual conference and workshop on Geospatial topics that was organized since 2009. The theme of the AGSE 2021 conference was Geospatial Technology in Times of Global Challenges. The AGSE 2021 conference was organized in hybrid mode. In this conference, we had opening ceremony followed by cultural program performed by Department of Music, Kathmandu University in a category of Newar Drum Ensemble, Nepali Folk Tunes and Classical Vocal Music and closing ceremony. Similarly, there were six keynote sessions, two parallel technical sessions with thirty six presentations in a category of National mapping and infrastructure, Sustainability and natural resources, UAV, photogrammetry and Remote sensing, Sustainability, Environment and disaster management, open source, land use and management, four different workshops, young scientists session, and alumni session and professional development. In the Alumni Session(s) international alumni shared their experiences after leaving their German University. The funding agency of the conference was German Academic Exchange Service (DAAD). Dr. Subash Ghimire, Acting Head of Department of Geomatics Engineering co-ordinated the AGSE 2021 on behalf of the organizing committee and Department of Geomatics Engineering.

Dr. Subash Ghimire, Acting HoD, Geomatics Engineering deliverying welcome speech and a group photo after opening ceremony

Continuous Professional Development in Surveying Profession in Nepal

Ganesh Prasad Bhatta,

Land Management Training Center, Executive Director
Ministry of Land Management, Cooperatives and Poverty Alleviation,
Government of Nepal, Dhulikhel, Kavre

gpbhatta@gmail.com

This article aims to highlight the importance and challenges of continuous professional development (CPD) in surveying profession, its state in Nepal, and highlights its challenges and role to be played by professional organizations. Please, note that, this is an informative article and may lack academic standard. The references are listed at the end.

Human beings for their survival and psychological fulfillment need association with some form of work. The kind of work that a person undertakes is called his or her profession. Principally, a profession is a certain discipline of work that needs special knowledge and skills, acquired from education, training, research and other different means.

In the literal sense of the term, a person following a certain profession is termed as a professional. A true professional is characterized by his or her mastery of a particular intellectual skill, acquired through education and training; acceptance of duties to society in addition to duties to clients and employers; an outlook that is essentially objective; and the rendering of personal service to a high standard of conduct and performance. (The International Federation of Surveyors (FIG), 1998)

Surveying as a profession primarily consists of activities related to determination, measurement and representation of land, three dimensional objects, point fields and trajectories; assembling and interpretation of the land and geographically related information; use of this information for the planning and efficient administration of land and land related features; and conducting research and development activities into these practices. Surveyor is someone who possesses academic qualification and technical expertise to conduct one or more of above-mentioned activities of the profession. Furthermore, a surveying professional should have professional competencies like knowledge competence (the possession of appropriate technical and/or business knowledge and the ability to apply this in practice); cognitive competence (the abilities to solve using high level thinking skills technical and/or business-related problems effectively to produce specific outcomes); business competence (the abilities to understand the wider business context within which the candidate is practicing and to manage client expectations in a pro-active manner); and ethical and/or personal behavioral competence (the possession of appropriate personal and professional values and behaviors and the ability to make sound judgments when confronted with ethical dilemmas in a professional context). (The International Federation of Surveyors (FIG), 1998)

Like every other professionals, a Surveyor needs to have keen sense of awareness about the evolution in the field. He/she should strive to adapt to the changing dynamics in the field and be conscious about his or her professional development. In this context, the professional development means a surveyor needs to explore the opportunity of continually improving his or her skills and competencies to enhance workplace performance and future career prospects. In the following paragraphs an attempt has been made to shed some light on how that can be done.

Professional development entails looking forward and identifying opportunities to learn something new, refresh professionals' knowledge and skills, or keep track of the latest developments within the profession. It results in gradual self-improvement; awareness of latest developments.; retention of personal capabilities that ensure similar standards with the peers in the same field; presence of the knowledge and skills that is needed to deliver a professional service to the customers, clients and the community; and most importantly strengthening one's the curriculum vitae.

Rapid pace of technological advancement in the field of Surveying has necessitated professional development for its professionals. Most of the surveyors are largely affected by the rapid pace of technological change and need to adapt swiftly to the changing conditions to maintain competency. According to FIG Statement 15, it has been estimated that the knowledge gained in a vocational degree course has an average useful life span of about four years. This fact highlights the increasing need to maintain an active interest in keeping up to date with changing technology, legislation and operational procedures. Furthermore, the scenario has come up such that a 'keeping up to date' is not an option for a surveyor; it is a necessity. The changing scenario has not only necessitated a surveyor to prioritize the professional development but also keep it continuing. Such a necessity of keeping perpetual professional development is called Continuous Professional Development (CPD).

CPD is the process of ‘keeping up to date’ or it is ‘the systematic maintenance, improvement and broadening of knowledge and skills and the development of personal qualities necessary for the execution of professional and technical duties throughout the practitioner’s working life’. Likewise, as per the definition of the Institutions of Surveyors, Australia, CPD is ‘the process by which a professional person maintains the quality and relevance of professional services throughout his/her working life’. (The International Federation of Surveyors (FIG), 1996)

The ultimate goal of CPD is to ensure that professionals remain competent throughout their career journey by keeping up to date with relevant information, knowledge, skills and training. CPD is important because it helps in enhancing the professional competence at every step of the professional career; coping with the expectations of higher level of services by the consumers; consciousness in professional responsibility so that there are less cases of disputes, ensuring that professionals are well aware of the standards to be followed in their professional work, ensuring quality assurance in their professional work; and professionals possess competitiveness in their career.

CPD is not only advantageous for an individual professional but also the organization he or she is associated with. From CPD, an employee can increase confidence in abilities and credibility, exemplify commitment to growth, increase ability to reach career goals, and cope with the changes brought by the advancement in the technologies by demonstrating enough competency and fulfilling the gaps; whereas an organization can maximize staff potential, promote staff development, enhance staff morale and motivation to work, set objective organizational goals, and ultimately improve the overall performance of the organization. (https://www.findcourses.co.uk/cpd/benefits-of-cpd-8541)

Effected CPD is possible only if it is continuous (throughout the professionals’ working life); professionally or organizationally focused; broad based (including the knowledge and skills and development of personal qualities) and structured (systematic maintenance, improvement and broadening) (FIG Publication No.15). Furthermore, to be an effective CPD, it should be a part of planned process along with clear perspective on the improvement required, and tailored individually to each professional and mentored by a person having necessary expertise, experience and skills.
CPD can be achieved mainly in two forms; formal and informal. Formal forms of CPD may include; formal education, trainings, lectures, workshops, conferences, research, structured reading, interactive learning, e-learning, among others. Similarly, informal forms of CPD may include; transfer to new department, secondment or sabbatical to other organization, exchange of staff or experience, study visits, observations of colleagues’ work, chairing a task force or working group, among others.

The CPD Certification Service of the United Kingdome (https://cpduk.co.uk) has proposed a CPD Cycle that can help making a worthwhile CPD. The CPD cycle stages include; need identification or assessing the knowledge gap (stage 1), planning (stage 2), acting/doing (stage 3), reflecting on the learning (stage 4), and implementing the new learning (stage 5). This CPD cycle is a practical tool that helps making regular and measurable improvements to CPD endeavors.

The International Federation of Surveyors (FIG), a leading international professional organization representing the interests of surveyors worldwide and providing international forum for discussion and development aiming to promote professional practice and standards, has developed policy of CPD. The FIG believes that a commitment to CPD is essential to the work of the professional surveyor, throughout his/her working life. The FIG endorses the concept of lifelong learning which is implicit in CPD and in particular encourages professional surveyors to: produce personal CPD work plans (personal development plans) which highlight future learning goals, view CPD as a continuous development process which can be satisfied by a balanced and flexible range of formal and informal learning activities, and ensure CPD activities are concerned primarily with the production of enhanced performance (output) rather than being predominantly concerned with the level of CPD input.

Talking about the context of Nepal with respect to Surveying, it is fair to state that the profession in Nepal is evolving as a competent profession both in government as well as private sector. However, compared to rest of the developed world, it is quite new for Nepal. It began to take wider scope only since late 1970s. In the past, cadastral surveying was the main area of professional concern for the surveyors in Nepal, but today the sphere has multiplied. There is no any area left that is untouched by in recent years. It is quite encouraging that private sector is growing quite competently. Despite this robust growth, both the government as well as the private sector has plenty of challenges to maintain the professional competency as required by the consumers, and that is where numerous efforts of CPD are necessary.

Surveying profession has not yet gained the value it deserves in the country, despite the serious role and responsibilities it has in several aspects of the country’s development. There is a huge gap in the awareness regarding the importance of surveying profession and geo-literacy among the high level policy makers. Quite a few efforts are seen in the sector of CPD. Land Management Training Center is the only organization that is conducting some refresher course but only some government staff and no any other alternative is seen for undertaking formal courses of professional development. Most of the professionals have been following the principle of ‘learning by doing’ or self-effort of CPD. It is good that the number of academic institutions is growing in recent years but no any efforts are seen in the assessment of the quality of the human resource produced. At the same time, as mentioned above, formal CPD opportunities are quite less.

The other problems that this profession has been facing with regard to CPD are lack of vigor from the professional organizations, lack of sufficient activities in research and development in geo sector, lack of academic legacy; as this profession does not have long history of academic courses in geo-domain in Nepal, lack of promotional activities from the government sector, lack of active initiation in research and development from the private sector, and most importantly, lack of CPD regulating body.

The professional organizations working in the field of surveying profession need serious concern and great role to play in CPD of Surveyors. Leading organizations from the Government sector like Survey Department (as a professional practitioner) and Land Management Training Center (as a capacity builder), academia (such as Kathmandu University, Tribhuwan University, Purbanchal University, Nepal Open University, and Council of Technical Education and Vocational Training-CTEVT) and professional societies (such as Nepal Survey Association- NeSA, Nepal Institution of Chartered Surveyors-NICS, Nepal Remote Sensing and Photogrammetric Society-NRSPS, Nepal GIS Society, among others) should motivate, contribute and provide platform for CPD to surveyors in a planned manner. Such organizations should focus on organizing interactions, workshops, seminars and trainings in regular basis; bring research publications frequently; develop inventories of research publications; advance professional networking; contribute in research and development not only in its core field but also in related policy issues; lobbying for professional recognition; and make the professionals follow the ethics and code of conduct while performing their professional duties, CPD being one of them.

It is also worthwhile to mention that the academic course in this professional domain, more specifically, Bachelor of Engineering in Geomatics Engineering, at university level in Nepal began only in 2007 after the Land Management Training Center (LMTC) started collaboration with the Kathmandu University (KU). The other universities started the same in later years. This collaboration between LMTC and KU still exists and has further been extended to run post graduate course. Such collaboration, including other organizations, should further find room for CPD as needed in the professional domain.

Publication of GeoSpace by Geomatics Engineering Society (GES) can be considered as a commendable initiative to contribute in CPD. There are quite a few numbers of publications in the professional domain. GeoSpace can upgrade its objective to make the publication in the category of scientific journal so that the professionals in Nepal will have more space to publish their research and also motivate them to go for research publication. GeoSpace can further increase the frequency of publications and invite the professionals, researchers, scientists and academicians to contribute in it. As a patron body of GeoSpace, GES can arrange the motivational talk shows so that more and more youngsters can be attracted towards the professional domain.

To conclude, professional development for a surveying profession is greatly necessitated by the rapid technological advancement in the surveying filed. This profession needs more attention and continued efforts in professional development in order to serve the best interest of its consumers. In order to ensure systematic maintenance, improvement and broadening of knowledge and skills to execute professional and technical duties throughout the surveyors' working life, CPD is a must. Despite the evolution of surveying profession as a competent profession in Nepal, quite a few efforts of CPD are seen. The organizations including government organizations, academia, professional societies and private sector should take serious concern over CPD, and motivate, contribute and provide platform for CPD to surveyors in a planned manner.

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नेपाल सरकार

भूमिव्यवस्था,सहकारी तथा गरिबी निवारण मन्त्रालय

भूमि व्यवस्थापन प्रशिक्षण केन्द्र

धुलिखेल, काभ्रेपलाञ्चोक ।

टेलिफोन नं. ०११-४१५०५५

वि.सं. २०२५ सालमा नापी तालीम केन्द्रको रुपमा स्थापना भै वि.सं. २०५७ सालमा भूमि व्यवस्थापन प्रशिक्षण केन्द्रको रुपमा स्तरोन्नति भएको यो केन्द्र नापनक्सा र जग्गा प्रशासनको क्षेत्रमा शैक्षिक वा कार्यक्रमहरू संचालन गर्ने एक मात्र सरकारी निकाय हो। वि.सं. नाप नक्साको क्षेत्रमा हाल सम्म करीव ७५,०० भन्दा बढी जनशक्ति उत्पादन गरेको यस केन्द्रले विभिन्न लामो तथा छोटो अवधिका तालीमहरु संचालन गरी नाप नक्सा र जग्गा प्रशासनको क्षेत्रमा दक्ष जनशक्ति उत्पादन गर्दै आएको छ। वि.सं. २०६४ देखि यस केन्द्र र काठमाण्डौं विश्वविद्यालयको सहकार्यमा Bachelor in Geomatics Engineering तथा वि.सं. २०७० देखि Master in Land Administration विषयमा स्नातकोत्तर तहको कार्यक्रम संचालन गर्दै आएको छ भने, वि.सं. २०७६ मा गरिएको चौथो MOU अनुसार विगतका कार्यक्रमको निरन्तरताका साथै M.Sc./M.E. in Geoinformatics कार्यक्रम पनि थप संचालन हुने क्रममा छ । साथै वि.सं. २०७२ देखि यस केन्द्र, काठमाण्डौं विश्वविद्यालय र प्राविधिक शिक्षा तथा व्यवसायिक तालीम परिषद्को त्रिपक्षीय सहकार्यमा Diploma in Geomatics Engineering कार्यक्रम संचालन गरिरहेको छ।

<u>यस केन्द्रबाट संचालन भइरहेका प्राज्ञिक कोर्ष तथा तालीम कार्यक्रमहरू</u>

१) केन्द्र र काठमाण्डौं विश्वविद्यालयको सहकार्यमा संचालन भइरहेका प्राज्ञिक कोर्षहरु

क) Master Degree in Land Administration & ME/MS in Geoinformatics (दुई वर्ष)

ख) B.E. in Geomatics Engineering (चार वर्ष)- (गणित सहित विज्ञान विषयमा +२ उत्तीर्णहरूका लागि)

२) केन्द्र , काठमाण्डौं विश्वविद्यालयको र प्राविधिक शिक्षा तथा व्यवसावयक तालीम परिषदको सहकार्यमा संचालन भईरहेको कार्यक्रम

क) Diploma in Geomatics Engineering(तीन वर्ष)–एस.एल.सी./एस.ई.ई.उत्तीर्णका लागि

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ख) जुनियर नापी तालीम (एक वर्ष) – विभागीय कर्मचारीहरुका लागि

ग) जुनियर नापी तालीम (एक वर्ष) – खुला (गणित सहित विज्ञान विषयमा +२ उत्तीर्णहरूका लागि)

४) क्षमता अभिवृद्धि एवं पुनर्ताजगी सम्बन्धी छोटो अवधिका विशेष तालीमहरु

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ग) भूमि प्रशासन तथा व्यवस्थापन सम्बन्धी अभिमुखीकरण तालीम (मालपोत अधिकृत तथा सहायक कर्मचारीहरूको लागि) (१-२ हप्ता)

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नाप नक्शा तथा जग्गा प्रशासन सम्बन्धी आवश्यकता अनुसारका अन्य पुनर्ताजगी तथा अभिमुखीकरण तालीमहरू- (माग अनुसार)

Spatial Analysis of Relationship between Land Surface Temperature, NDVI and LULCC in Sindhupalchok District, Nepal

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KEYWORDS: Spatial Analysis, Relationship, Land Surface Temperature (LST), Normalized Difference Vegetation Index, Land use and Land Cover Change (LULCC)

ABSTRACT

In past decades, Sindhupalchok has suffered from land use and climate change. Due to rapid social and economic development that affect surface energy balance and hydrology. This study assesses spatial analysis of land surface temperature (LST) and Normalized difference vegetation index (NDVI) from Landsat 8 images. It explores its relationship with land use and land cover change (LULCC). The results show LST varies by surface types, such as higher LSTs in built-up areas, cultivated land, forest than water bodies. For LULCC, between 2015 and 2019, there was a significant decrease in the cultivated land (i.e., vegetation and agricultural land), whereas a substantial increase in built-up areas, barren land, and forest. NDVI is higher in the southwest and lowers in the northwest direction. LST has a positive association with NDVI (vegetation cover) that signifies high NDVI; the surface temperature is high and vice versa. Therefore, it is significant for understanding environmental change and human-environment interactions. However, a study about NDVI and LST in Sindhupalchok mountain areas with complex topography is scarce. Therefore, the combined knowledge of such research supports the formulation of appropriate land use planning and environmental protection.

1. Introduction

Land surface temperature (LST) reflects land surface characteristics, such as land use, cover, vegetation type, and climate change. It can provide information about the surface physical properties and climate, which plays a role in many environmental processes (Dousset et al., 2003). LST is applicable for various scientific studies (Khandelwal et al. 2018; Sun et al. 2013). It is crucial for measuring surface urban heat islands, land use, land cover change (LULC), and climate change (Fabeku et al. 2018; Lingo, 2019). Researchers have extracted and modeled the normalized difference vegetation index (NDVI) for finding vegetation biophysical variables using remotely sensed data (Jensen, 2000; Thapa, 2020). It is a significant research component on land-use and land-cover change, drought, desertification, soil erosion, and vegetation (Yengoh et al., 2016). The relationship between LST, NDVI, and LULC has received progressive attention from researchers (Fatemi & Narangifard, 2019; Martin et al., 2017).

LST and NDVI have a complex relationship that depends on the season of year and time of day. For example, the summer has a negative correlation between LST and NDVI, whereas winter has a positive correlation. Furthermore, significant negative correlations between LST and NDVI are exhibited occasionally during the warm seasons. It assumes that vegetation can lower the surface temperature, i.e., the plant has a cooling effect on an area (Weng et al., 2005). LST is determined by the heat of the vegetation, soil surface, and assesses the temperature of the Earth's surface, LUCC, and Climate change (Qin et al. ,2002). It will help mitigate the adverse effects of LUCC, Climate change-related risks, and support capacity buildings, policy, and decision making. Land use/cover change (LUCC) is an essential factor affecting LST (Munroe et al., 2007). Currently, innumerable scholars apply remote sensing to analyze the relationship between LST, land use, and NDVI (Deng et al., 2018). However, some problems and shortcomings in the existing research still need to be addressed, such as field verification and minimum land-use types for a large area. There are finite studies about the relationship among LST, LUCC, and NDVI in this area characterized by unique geographical features and a fragile ecological environment. Therefore, it is essential to analyze LST, NDVI, and LULCC and their relationship for estimating higher and lower temperature, vegetation, and land-use change in the particular study area.

2. Methods

2.1 Study Area

The study area, Sindhupalchok (Figure 1), is situated around 90 km northeast of Kathmandu.
In Sindhupalchok, an increasing trend in temperature is 0.8°C per decade and 0.08°C per year. (Bhattarai et al.,2017; Thapa, 2019). Similarly, it identified the average warming in annual maximum temperature between 1977 and 1994, with a rate of 0.06 °C/yr (Tse-ring et al., 2010). Also, several unusual weather events have been for a few decades (Salerno et al., 2015; Thapa, 2020). The warming is pronounced in Nepal's high altitude regions, such as the Middle Mountain and the High Himalaya, prone to earthquakes, floods, landslides, and soil erosion (Thapa, P. 2021). Moreover, due to global warming and climatic changes, it has experienced severe conditions over the last few years; the local communities have suffered floods, landslides that lead to migration to other places for their livelihood and shelter. Those who can afford to relocate to Kathmandu or elsewhere and others remain there to rebuild their houses. In addition, the district has experienced several land cover changes in the past decades due to the conversion of forests to cropland and settlement with a rapid increment of urbanization (Lei et al., 2017). Therefore, such a study is worth evaluating the trend of land surface temperature, standard vegetation index, land cover, and land-use change.

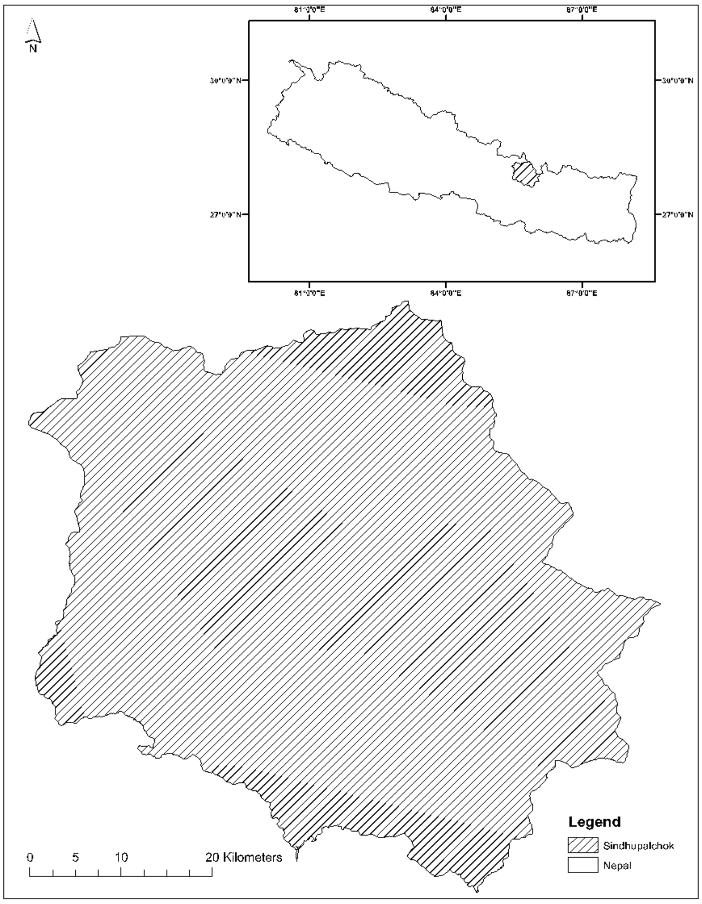

Figure 1: The map of the study area, the Sindhupalchok District

2.2 Methodology

Satellite images were used for LST, LULCC, and NDVI studies (Ding et al., 2013, Thapa P., 2021). Landsat 8 acquires eleven bands from two separate sensors: Operational Land Imager (OLI) and Thermal Infrared sensors with different spatial resolutions. The spatial resolutions of band 1 to 7 and 9 are 30-meters, whereas band 8 is 15 meters, and band 10 and 11 are 100 meters. These satellite images chose a suitable medium for assessing these changes due to these benefits, such as access to information difficult to obtain by other means, unusually high spatial resolution, and comprehensive geographic coverage for 2015 and 2019 (Donaldson & Storeygard, 2016). The LST retrieved for both the picture for Landsat 8 band 10 and 11 used and their mean used as LST final result of 2019. The satellite temperature converts to land surface temperature, using the following equation:

$$LST = \frac{TB}{[1+\left(\lambda*\frac{TB}{c2}\right)*ln ln\,(\,\varepsilon\,)\,]} \quad (1)$$

Where $_{\text{the}}$ wavelength of emitted radiance whose value is 10.8 for Landsat 8 and c2 is equal to 14.388 µmK. First, the DN values convert to the top-of-atmosphere (TOA) radiance measured by an instrument using the following equation (4):

$$L_{\lambda} = ((DN) - (QCAL)_{min}) + L_{min} \quad (2)$$

where λ is wavelength; L_λ is the TOA radiance at the sensor's aperture in W m^{-2} sr^{-1} μm^{-1}, and $QCAL_{max}$ and $QCAL_{min}$ are the highest and the lowest points of the range of rescaled radiance in DN, with values 255 and 1, respectively for images of Landsat 8 band 10 and 11. Lmin and Lmax are the TOA radiances scaled to QCALmin and QCALmax in W m^{-2} sr^{-1} μm^{-1} and the Landsat 8 Science Data Users Handbook (http://landsathandbook.gsfc.nasa.gov/pdfs/Landsat8_Handbook.pdf). The spectral radiance L convert to the at-sensor brightness temperature TB in Kelvin and the conversion equation:

$$TB = \frac{K2}{ln ln\left(\frac{k1}{L\lambda}+1\right)} \quad (3)$$

(kelvin into degree Celsius)
$$TB = \frac{K2}{ln ln\left(\frac{k1}{L\lambda}+1\right)} - 273.15 \quad (4)$$

Where TB is the at-sensor atmosphere brightness temperature in kelvin; K_1 (774.8853 K) and K_2 (1321.0789 Wm^{-2} sr^{-1} μm^{-1}) for band ten and K_1 (480.8883 K) and K_2 (1201.1442 Wm^{-2} sr^{-1} μm^{-1}) for band eleven of Landsat 8. Brightness temperature is that obtained by a blackbody to produce the same radiance at the same wavelength. Emissivity calculates according to the following equation:

$$\varepsilon = 0.004 \cdot{*}Pv + 0.986 \quad (5)$$

where ε is surface emissivity, and Pv is the vegetation proportion (Sobrino et al. 2004; Thapa P., 2021)

$$Pv = \left[\frac{(NDVI) - (NDVI)min}{(NDVI)max - (NDVI)min}\right]^2 \quad (6)$$

$NDVI_{max}$ = 0.5 is the threshold to separate the bare soil pixel and the mixed pixels; $NDVI_{min}$ = 0.2 is the threshold to separate the full vegetation pixel and the mixed pixels (Ding et al., 2013). It can express using the following equation:

$$NDVI = \frac{\rho(band5) - \rho(band4)}{\rho(band5) + \rho(band4)} \quad (7)$$

Where ρ(band5) and ρ(band4) are the spectral reflectance of bands 5 and 4, respectively, for Landsat Eight images. The parameters that convert DN to spectral reflectance in the metadata file are associated with Landsat images. During image acquisition, no cloud option was selected; thus, an atmospheric correction was excluded. The multispectral images were acquired in two years, 2015 and 2019. Image classification from maximum likelihood supervised classification for LULC classification using ArcGIS 10.5 software.

2.2.1 Image classification

Table 1: Land-use/land cover types for classification

Land use/Land cover types	Description
Forest	Farmland trees, Mountain Forest, Roadside trees, trees around water bodies
Water Body	River, Stream, Flowline, lake, pond, reservoir, wetland, Places with Snow, and Glacier
Barren Land	Uncultivated land, Vacant spaces
Cultivated Land	Cultivated land
Built-up Area	Permanent and Temporary houses

In the last five years, LULC changes were observed by image classification with a total of 50,243 point samples randomly selected from 1 December 2019. The ground truth samples are extracted from Google Earth. For this study, five types of land use are forest, waterbody, barren land, cultivated land, and built-up area given in below Table 1.

2.2.2 Accuracy assessment

The accuracy is checked on image data by creating confusion matrices using the test samples, as shown in Table 2. Overall accuracy is calculated by the kappa coefficient and confusion matrix (Foody, 2020). The two equations defined below are used for kappa coefficient and total accuracy calculation,

$$Overall\ Accuracy \sum_{i=1}^{r} \frac{Xii}{x} \quad (8)$$

Where X_{ii} is the diagonal elements in the error matrix, x is the total number of samples in the error matrix.

$$Kappa\ coefficient\ (\hat{K})\ \frac{n\sum_{i=1}^{r} Xii - \sum_{i=1}^{r} Xi+X+i}{n2 - \sum_{i=1}^{r} Xi+X+i} \quad (9)$$

Where r is the number of rows in the matrix, X_{ii} is the number of observations in row i and column i, X_{i+} and X_{+i} are marginal totals for row i and column i respectively and n is a number of observations (pixels).

The table below shows that the overall accuracy for 2019 was 59.55%, and the Kappa coefficients for corresponding maps were 0.595. The overall accuracy describes what proportion of reference data is map correctly—one of the simple methods to provide map users and producers with basic accuracy information. Here, diagonal elements represent that the land-use class is accurately classified (Table 2). A positive value of the kappa coefficient close to 1, i.e 0.595, indicates that the classification is significantly better than random.

Table 2: LULC classification Confusion matrices, 2019.

	Reference Data				
	Forest	Built-up Area	Barren Land	Water Body	Cultivated Land
Forest	25	0	5	0	6
Built-up Area	0	3	0	0	6
Barren Land	0	1	4	2	1
Water Body	0	0	1	3	1
Cultivated Land	4	3	2	4	18
Producer's Accuracy		50.00%	50.00%		58.06%

As a result, the land cover in Nepal mainly includes different types of forests, croplands, shrublands, grasslands, bare lands, and water bodies (Wang, 2004; Udd et al., 2015). Therefore, this study chose the suggested significant land cover/ land use for spatial analysis of Sindhupalchok.

3. Results and Discussion

3.1 Land Use/ Land Cover Changes

The land use and land cover maps for the Sindhupalchok of two years, 2015 and 2019, are shown in Figure 3. The total acreage of this study area is 254200 hectares. The detail about land use and cover classification in Table 1 with confusion matrices of 2019 in Table 2. Over five years, there is a significant decrease in the cultivated land (i.e., vegetation and agricultural land), whereas a substantial increase in built-up areas, barren land, and forest. It is a slight increase in a forest because the community forest monitors and manages the program. The significant built-up regions (i.e., commercial, residential, and administrative buildings) increased, and cultivated land decreased due to its conversion to built-up areas for residential purposes. Similarly, the rise of barren land is low production, a shift of rainfall patterns, and a lack of human resources. It will increase as the people's migrating trend is rapidly growing with a purpose for sustainable livelihood.

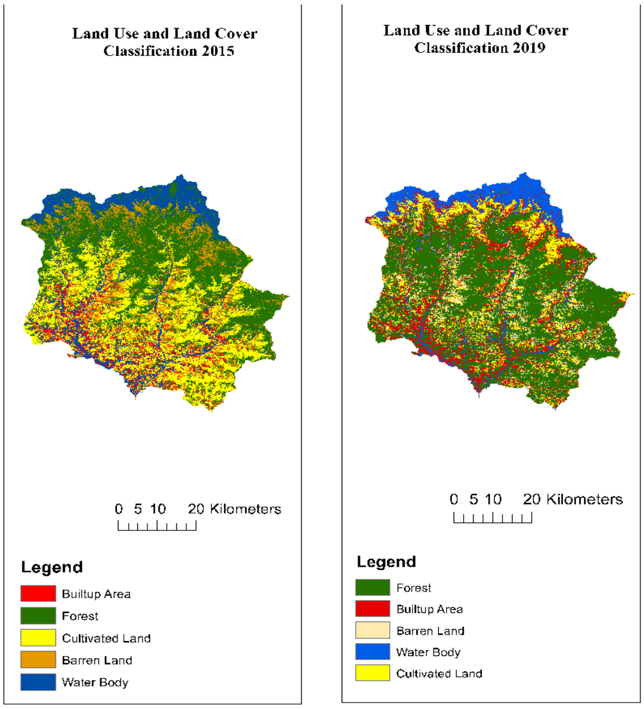

Figure 2: Land use and land cover classification of Sindhupalchok for 2015 and 2019.

3.2 Land Surface Temperature (LST)

The LST distribution of 2019 is in Figure 3. The mean temperature for individual land use/land cover is in Table 2. Based on Figure 3 and Table 2, the lowest and highest radiant temperature for 1991 is 25.8°C (in high-density tree area) and 30.8°C (in the built-up area). Meanwhile, for 2009 the radiant temperatures range between 24.0°C and 38.0°C. The highest mean temperature is within the built-up area, while the lowest is within water bodies. The implication of urban development by replacing natural vegetation (forest) with built-up surfaces such as concrete, stone, metal, and asphalt clearly can increase the radiant surface temperature. Although it is a significant increase in the built-up areas, the surface temperature is still relatively lower (refer to Figure 3 b). It could be due to the vegetation growth within the study area.

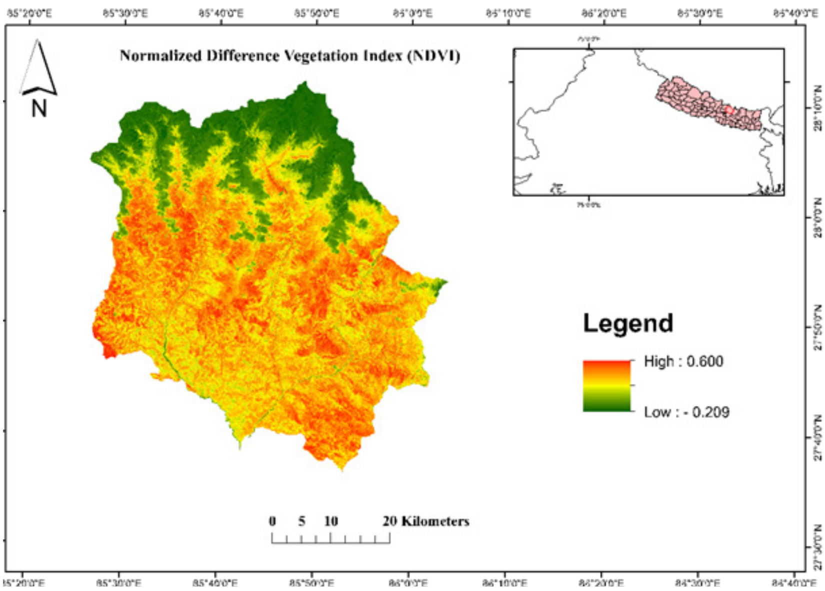

Figure 3: Spatial distribution of Normalized Difference Vegetation Index.

The NDVI value ranged between -0.209 to 0.600 (Figure 2). It shows that the NDVI is higher in the southwest and lower in the northwest direction.

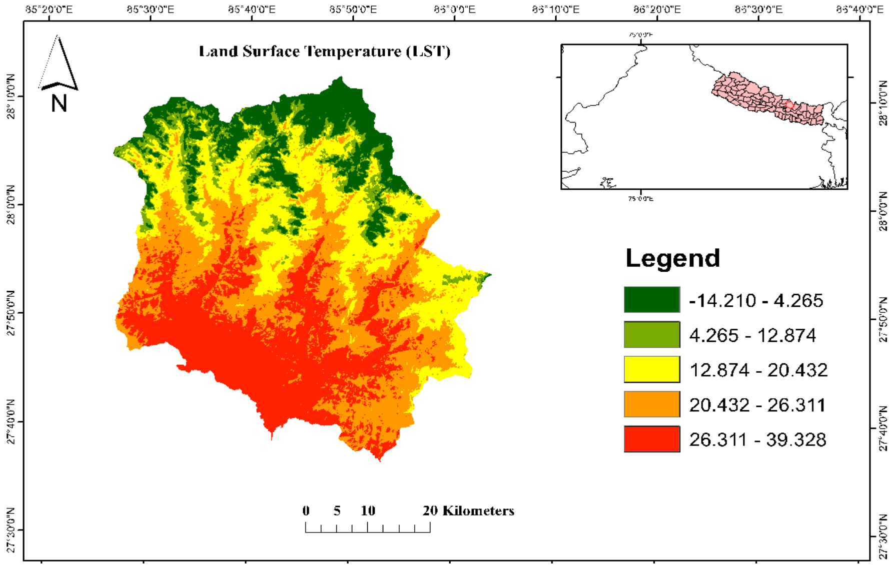

Figure 4: Spatial distribution of land surface temperature.

The LST map for the Sindhupalchok is shown above with a range between -14.210 to 39.328 (Figure 3). Higher elevation is one factor in the spatial variation of temperature (Karki et al. 2016;s Thapa P., 2021). The result shows the temperature decreases from south-east to north-west direction. With decreasing trend in the cool days and cold nights increasing trend in the warm nights has been identified (Baidya et al. 2007; Thapa et al. 2019). LST has a positive association with NDVI (vegetation cover) that signifies high NDVI; the surface temperature is high and vice versa. The LST and NDVI apply to analyze climate change, agriculture, environmental studies, land use, and land cover change.

4. Conclusion

Nepal's hilly regions are changing temperatures due to land use and land cover change. Sindhupalachok has similar land use, land cover, low cultivation, and climate changes that raise vulnerability and livelihood. This study applied remote sensing techniques for the spatial estimation and analysis of land surface temperature, normalized vegetation index, land use, and land cover of Sindhupalchok. Also, comprehensive studies find recent change in temperature, vegetation, and updated spatial databases. Spatial analysis of past climate data with land use, the land cover will be essential for finding patterns of weather, climate change, and natural disasters.

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Land Use Suitability Analysis for Urban Development of Lalitpur District

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KEYWORDS: Land cover, Landuse, GIS

ABSTRACT

The developing countries like Nepal are facing rapid urbanization resulting unplanned land development. Due to the haphazard development of urban area, flood and landslide destroy urban area as well as life of animals and human beings. Land-use suitability analysis is an important step for urban development as it helps locate the best potential site for urbanization. In this paper, the evaluation is done in the Lalitpur district of Kathmandu valley. The analysis is done based on the ten factors using GIS and weighted overlay and are grouped into four groups which are high suitable, moderately suitable, marginal suitable and not suitable. The analysis indicates that some areas conflict with the suitability map like land of the community, and thus policy makers should reassess these areas. Before doing any activities on land development the suitability analysis of particular purpose is recommended. In this way the weighted overlay computing approach has been used to identify the land-use suitable area for urban development.

1. Introduction

With the advent of time and technology, the conversion of lands into urban areas has been very rapid. The developing countries like Nepal have witnessed rapid urbanization in an unprecedented way. Nepal has also been listed as one of the top ten fastest urbanizing countries in the world (Bakrania, 2015). The centralization in the capital city, Kathmandu has become a pull factor for the people to move in.

The land use planning is supposed to be enabling sustainable management of land resources. But the rapid urbanization leads to unplanned land use and causes haphazard development of infrastructures. It has also caused pocket areas leaving the land unused. Therefore, the land use suitability analysis is done to determine and locate the best potential sites for land planning. It also aims to identify the most suitable settlements for residential development after the land use planning is done.

In recent years, suitability analysis has been done for urban development in many parts of Nepal, such as; Rampur municipality, Palpa (Shrestha, 2016), Kathmandu Metropolitan city, Nepal (Pokhrel, 2019), Bajura District, Nepal (Nab Raj Subedi, 2015). The technique used for the suitability analysis in our case is GIS based Weighted Overlay. GIS for analysis and decision making, and weighted overlay for weighting and ranking decision problems. Thus GIS-Weighted Overlay allows selection and combination of multiple features.

2. Study Area

Kathmandu Valley is the most populated and most urbanized part of Nepal. It consists of three districts, namely Kathmandu, Bhaktapur and Lalitpur. Lalitpur is the district with 6 municipalities and being neighbor to Kathmandu it has faced the city sprawl up to great extent. According to the CBS report of 2011 Lalitpur has the population of 468,132. The migration of people is one of the important factors for increased economic activities, traffic, waste and pollution

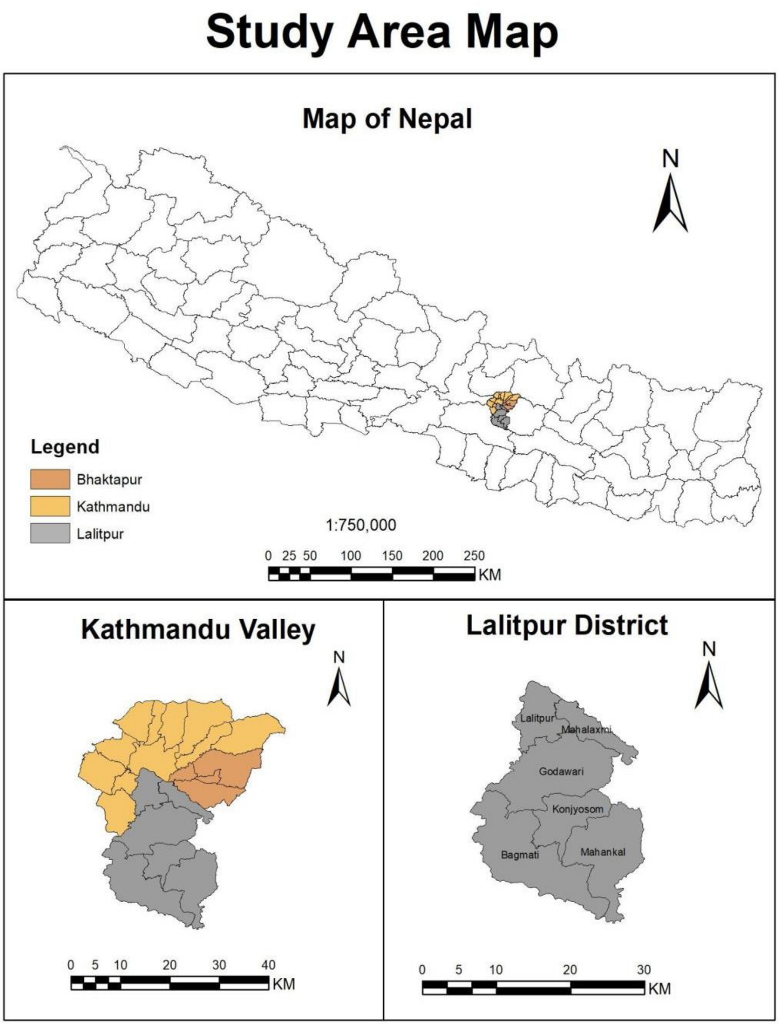

Figure 1: Study Area Map-Kathmandu Valley

3. Methodology

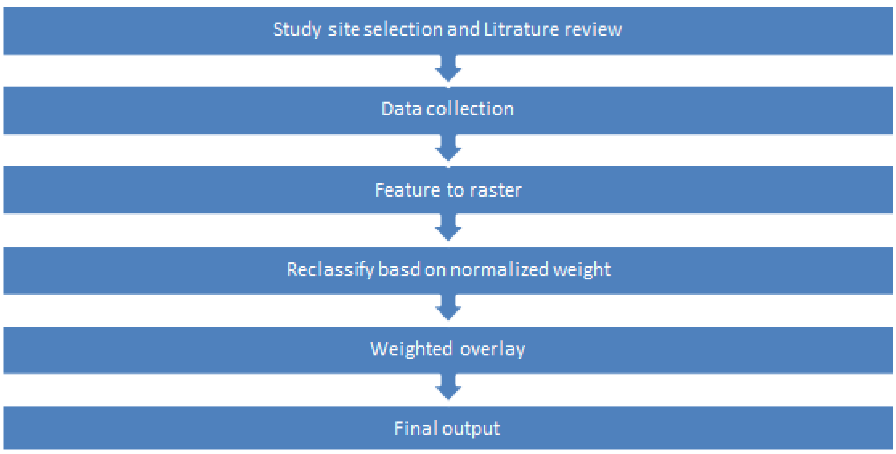

Figure 2:Methodology flow chart

The assessment factor for finding the land use suitability for urban development is considered based on the factor which helps to sustain human living standards and improve public health. The GIS based software was used for the analysis by considering the multiple factors which directly or indirectly play an important role in human health and needs. The software used for the analysis are QGIS, ARC Map

4. Data Collection

To consider the important factor for the study of the land use suitability for urban development several literatures were studied and following datasets were collected.

Table 3: Datasets Collection and their sources used in the study

Datasets	Data Source
Road Network, Landfill, Infrastructure, CBD, Brick factory	Open street data
Land Use	Earth explorer
Population Density	CBS
DEM, Slope	Earth data
Flood sensitivity	Sentinel

The other data except flood sensitivity was as per the source data. The following task was done for flood severity Map:At first sentinel 2 data was downloaded from sentinel hub of the year 2018, August,16 where flood had occurred in Lalitpur on August 15 2018 which was captured by sentinel data set. To calculate the flood sensitive area and flood free area. NDVI was calculated using NIR band and Red band which shows the value less than 0 to be water as a result of flooded area and unflooded area was properly monitored. This output was used for the study.

4.1 Determination of aggregation weight and decision:

The collected data are in natural format which is vector and raster format but for our study it should be in raster format. The nature of people is to stay in a safer place with almost all opportunities. So, following things are considered

Table 4: Rank of each criteria

Rank / Suitability grade	Very high opportunity 5	High opportunity 4	Moderate opportunity 3	Low opportunity 2	Very low opportunity 1
Land Cover	Bare Ground	Grass, Shrub	Built-up Area		Water
Slope	0-17	17-33	33-48	48-67	67-89
Terrain Elevation	0-446	446-1016	1016-1589	1589-2000	2000-2375
Population Density	Very low density	Low density	Moderate density	High density	Very high density
Proximity to Infrastructure	<500	500-1000	1000-1500	1500-2000	>2000
Proximity to Road	<500	500-1000	1000-1500	1500-2000	>2000

Proximity to Brick Factory	>2000	1500-2000	1000-1500	500-1000	<500
Proximity to Landfill	>2000	1500-2000	1000-1500	500-1000	<500
Proximity to Sensitivity Zone (Flood)	Not sensitive area	Mildly sensitive area	Moderately Sensitive area	Highly sensitive area	Extremely sensitive area
Proximity to CBD	<500	500-1000	1000-1500	1500-2000	>2000

In land cover the bare land, grass and shrub are given higher value as compare to the agricultural land, forest because according REDD principal the agricultural and forest area should be conserved to mitigate the climate change. The higher slope area is given less opportunity to mitigate the risk from the risk perspective. The flooded area is restricted to mitigate the risk from the risk perspective. The land fill site, brick-factory area closer are given less important as it directly play impact in public health.

Based on the ranking and scoring table, proximity analysis was done from all the vector file and reclassified into five classes which represent very high opportunity, high opportunity, moderate high, moderate low, and low opportunity.

Figure 3: **T**hematic Maps

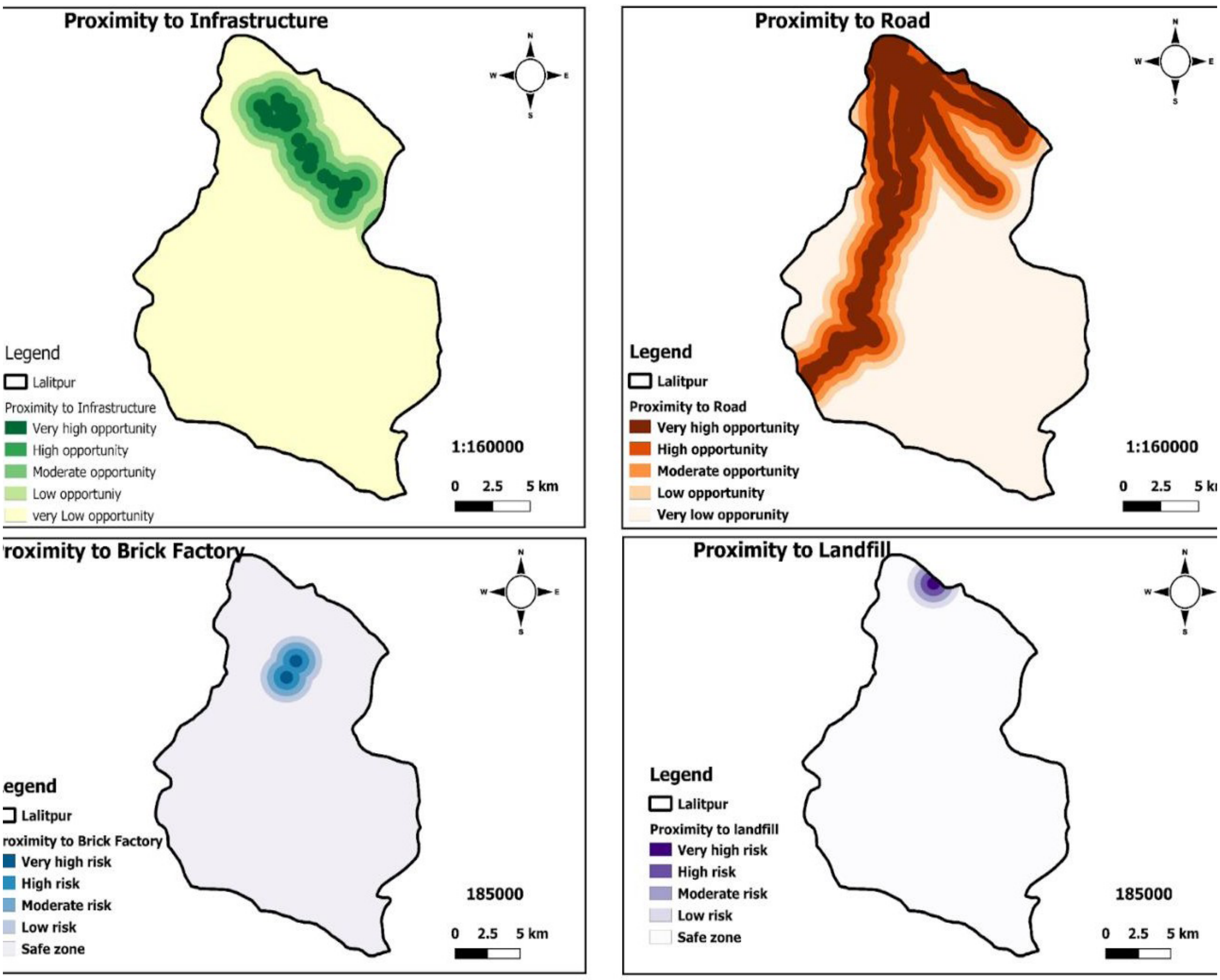

Figure 4: Thematic Map infrastructure, road, brick factory,landfill

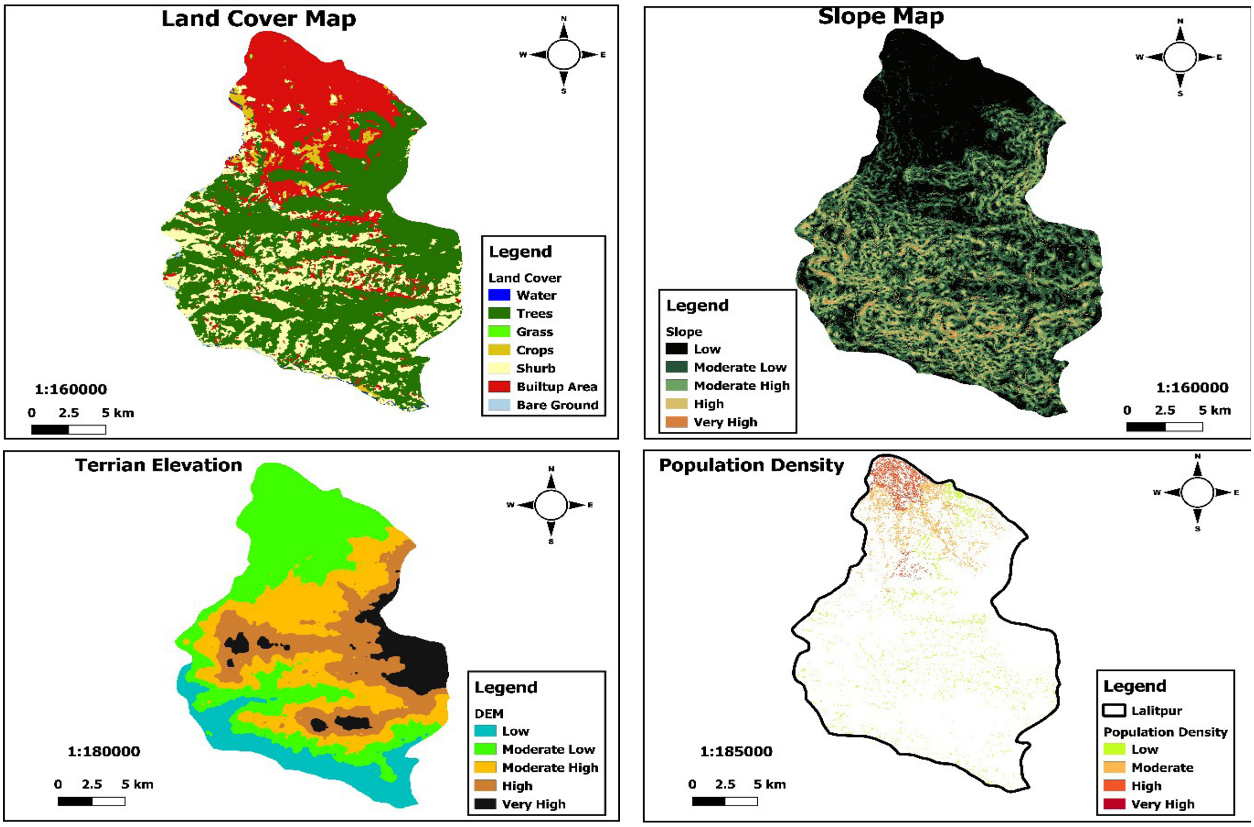

Figure 5:Thematic map of Land Cover ,Slope, terrain, population density

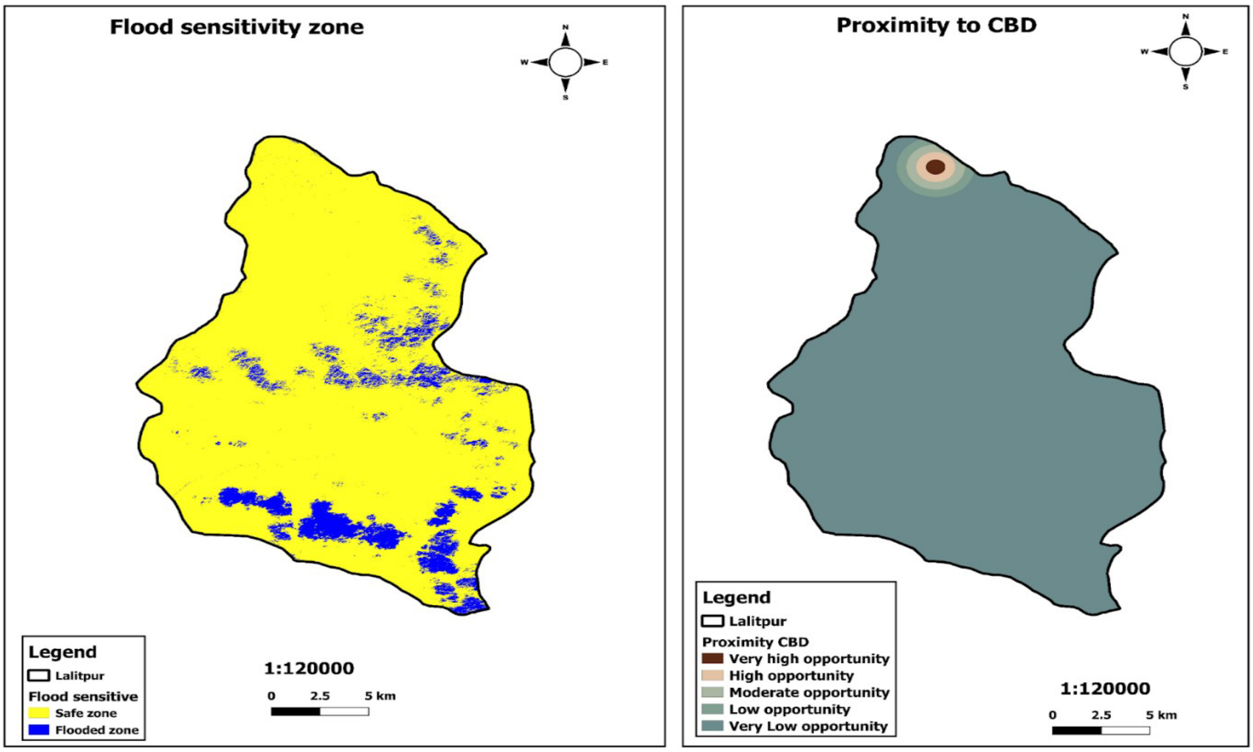

Figure 6: Thematic Map of Flood sensitivity zone

4.2 Evaluation Criteria:

The evaluation criteria are used to compare the influences of the one raster to another raster
.

Table 5: Evaluation between different data sets

Data sets	Influence (100%)	Reason
Land Cover	16	High percentage because it is the most important criteria for determining the existing land condition.
Slope	7	People general consider the slope because it is the cause of flood, landslide
Terrain Elevation	5	People consider elevation as people want to live in a place which has flat land and easy to build houses, crops etc.
Population Density	8	In our study we want to develop urban areas in the place which has the least populationdensity in the present situation.
Proximity to Infrastructure	12	People want to live closer to the opportunity.
Proximity to CBD	11	The distance from CBD pull or push people towards it.
Proximity to Brick Factory	6	Brick factories create pollution in the environment which may cause air related diseases.
Proximity to Road	14	People want accessibility and mobility.
Proximity to Landfill	9	Landfill is considered for better health.
Flood severity Map	12	For a safe place.

Based on the influence factor the multicriteria analysis was conducted using a weighted overlay tool. These are the criteria which are used to compare the different dataset which are important which are not. The internal criteria as defined in the ranking table was used for comparing internal criteria.

5. Result

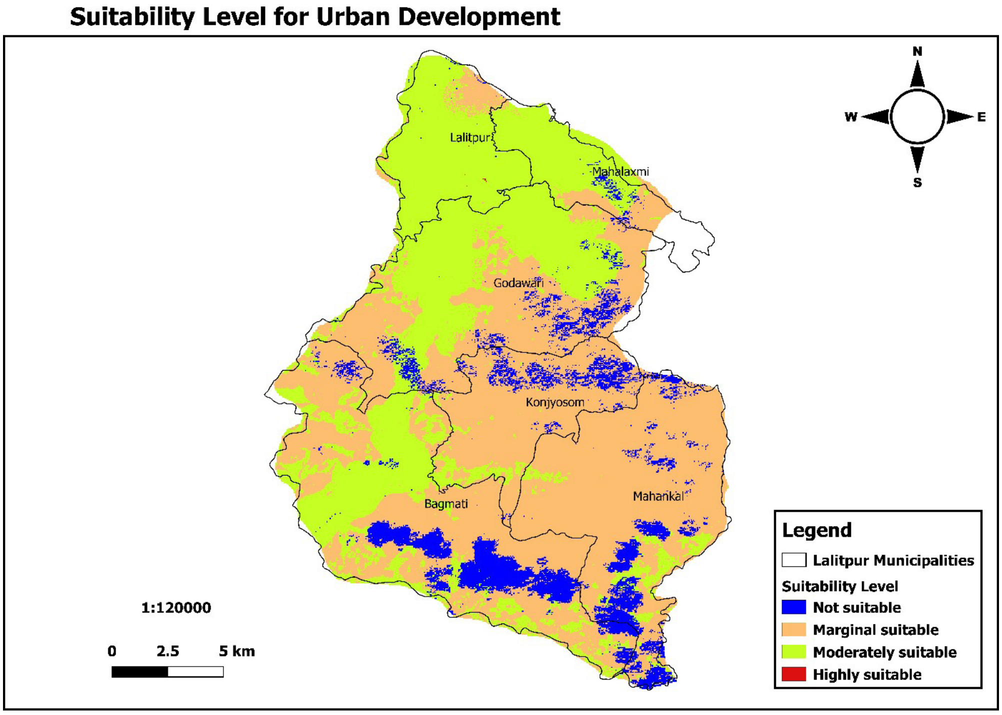

Figure 7: Suitability Map

The final output from the weighted overlay analysis was grouped into four groups which are high suitable, moderately suitable, marginal suitable and not suitable. The other data was no data which is the small pixel which was not represented in the map. This no data cell is not important for our work.

The municipality level data set was used to find the areas which are important for the development of the urban area in each municipality. Based on the result obtained, the Lalitpur district has the highly suitable area of 0.0234 km^2 , moderately suitable area of 146.0344 km^2 , marginal suitable area of 214.7742km^2 and 36.0680 km^2 area not suitable for urban development.

6. Conclusion

In this paper, the weighted overlay computing approach was used to identify the land-usesuitable area for urban development. Suitability maps were generated using ten criteria. The area of Lalitpur district was classified using four suitability levels: highly suitable, moderately suitable, marginally suitable, and not suitable. Further analysis was done to identify how much area belonged to suitable area for urban development. This output is based on the sustainable risk-free urban development as flooded zone are restricted while doing multi- criteria analysis in GIS. This helps to create better urban in Lalitpur district. The highly suitable and moderately suitable area can be used for land pooling for urban development. The service boundary can be defined only inside highly suitable, moderately suitable, and marginal suitable areas. So that people are demotivated tobuild their houses in a not suitable area. The tax should be increased in the not suitable area so that the people does not will to live near the not suitable area. The land can be grouped into different class to identify the most suitable land for urban development. People living in Lalitpur district should be made aware of the not suitable area so that the people will not use those land for housing activities but they used it for other activities like plantation to conserve the nature. The government and policy maker should focus on those risky area as in our study multiple criteria which focus on the risk and public health are integrated which helps to mitigate the risk.

In general, the land-use plan for Lalitpur district appears to have properly taken into account the land-use fitness for urban development; however, the analysis indicates that some areas conflict with the suitability map, and thus policy makers should reassess these areas. However, uncertainty arisen in the process of combining different raster based on the factors, if ground survey was conducted with different question to understand the psychology of the people to create appropriate proximity area based on their answer. If they are also asked about what type of area people want to live will play important impact on this analysis which can done in future study.

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Application of Spatial Data Infrastructure (SDI) for Disaster Risk Reduction (DRR)

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KEY WORDS: SDI, DRR

1. Discussion

Disasters are common phenomena in Nepal, primarily because of the heterogeneous terrain of the country, the staggering effects of climate change, and accelerated development activities to cater to the growing population and urbanization needs. While major disaster incidents have occurred in the last century, the last few decades have seen disaster events that caused huge damage and loss at the national and sub-national scales. The 2015 Nepal Earthquake caused over 8000 deaths, over 22000 injuries and affected around 8 million people from 31 districts in the country (Chaulagain, Gautam, & Rodrigues, 2018). Monsoon and abrupt flash floods in the Terai region have affected settlements lying in river basins every year. Similarly, landslides have swept villages overnight in various districts across the hills of the country. Fire incidents have been causing huge losses annually. Despite the recurring nature of most of these disasters, predicting, forecasting, and early warning have been near to impossible in the past. This limitation is due to the lack of an adequate spatial data infrastructure in place to aid in correlation among the diverse factors contributing to disaster occurrences.

Figure 1:Earthquake victims share tents in Tundikhel (left) and property damages caused by earthquake (right)

Spatial Data Infrastructure (SDI) refers to a set of policies, institutional arrangements, technology, spatial data, metadata, and users and tools that facilitate the exchange and effective use of geographic data (Tonchovska, Stanley, & Martino, 2012). SDI permits information from a range of disciplines to be combined for a variety of purposes in a flexible and efficient manner. SDI development efforts in Nepal started around 2006 with the commencement of the Geomatics Engineering program at Kathmandu University in partnership with the Government of Nepal. Giant leaps have been made in digital cadastre, topographic mapping, spatial data supply through web portals, and digital service delivery since the young engineers entered into public service. But the Department of Survey (DoS) is yet to take similar initiatives in the acquisition, management, analysis, and dissemination of geospatial data for disaster prediction and early warning. Decent steps have been taken by the Ministry of Home Affairs (MoHA), National Disaster Risk Reduction and Management Authority (NDRRMA) through web portals like the DRR Portal and Building Information Platform Against Disaster (BIPAD) Portal. But, discrepancies and lack of precise spatial components in the available datasets do not make the disaster prediction less challenging. The Department of Survey, as the national mapping agency, should aim at better aggregation, centralization, standardization, and warehousing of disaster-related geospatial data collected by various institutions, projects, and researchers.

In the immediate aftermath of the 2015 earthquake, a mega survey using digital tools was conducted that collected spatial and attribute data of damaged households in the 14 earthquake-affected districts. The National Reconstruction Authority (NRA) utilized this dataset to carry out reconstruction efforts and ensure resilient houses are built. Even though rescue and immediate response activities were less guided by data-driven decisions, utilization of spatial data in the reconstruction effort has been exemplary. The post-earthquake realization that better preparedness is possible only with better datasets led to several small to large scale initiatives from a wide range of organizations who piloted in hazard mapping, disaster incident reporting, weather forecasting for early warning, raising awareness, and resilient development. Donors and bilateral organizations like the World Bank, UKAID, USAID, JICA, Australian Aid, etc. funded heavily in disaster preparedness in partnership with UN Agencies, INGOs, NGOs, and private companies. The Government and especially the newly formed local governments have been primary stakeholders in most of these projects. While all projects acquired datasets for DRRM, lack of interest from the national mapping agency has led to either poor utilization of the data or loss of the data when projects are phased out. Aiming at both innovation as well as sustainable use of geospatial data through digitization, NAXA emerged as one of the earliest private sector companies in Nepal to shift its focus to applying geospatial technology for DRRM.

In the mid of 2016, to ensure the reconstruction of houses is done in a resilient manner, NAXA worked for the United Nations Office for Project Services (UNOPS) Nepal in developing a remote monitoring and quality assurance tool called FieldSight. The integrated web and mobile application allowing offline data collection and remote supervision to ground staff through a near real-time issue identification and feedback mechanism, FieldSight aided in the safe reconstruction of more than 23,000 houses in Nuwakot district supported by the Indian Embassy.

With the realization that open spaces are critical urban resources, various agencies have initiated the identification of suitable locations that can be used as open spaces in both pre and post-disaster situations. NAXA has supported organizations such as the International Organization for Migration (IOM) Nepal and the DanChurchAid (DCA) Nepal in identifying, mapping, and preparing geospatial data infrastructure of open spaces in some of the densely built urban and rural municipalities of central and western Nepal in 2019 through 2021. NAXA made use of frontier technology such as drones to map open spaces and their existing ground features. In addition to mapping open spaces with their potential use types and their precise measurements, NAXA also prepared a spatial database on the critical facility attributes around open spaces and presented geospatial information on risk and hazards, settlement densities, and safe evacuation routing. The concept of evacuation routes visualized in the maps will support the concerned authorities to develop preparedness plans and the people to safely evacuate to the nearest open spaces in the minimum possible time during an emergency.

Figure 2:A drone-based orthophoto image of an urbanizing area in Bheemdatt Municipality, Kanchanpur

Moreover, NAXA developed a module in the BIPAD portal to integrate open space datasets. So far, the open space datasets of Bagmati and Gandaki Provinces can be visualized over an interactive map in the portal. The visualization primarily consists of the spatial components of open spaces. The open spaces documented and stored in the national disaster portal support wider dissemination of geospatial databases among the government bodies, humanitarian actors, communities, and other relevant line agencies. The geospatial database on open spaces is also aimed at strengthening the emergency preparedness of the government authorities and emergency responders by providing the initial response planning frameworks pertaining to open spaces.

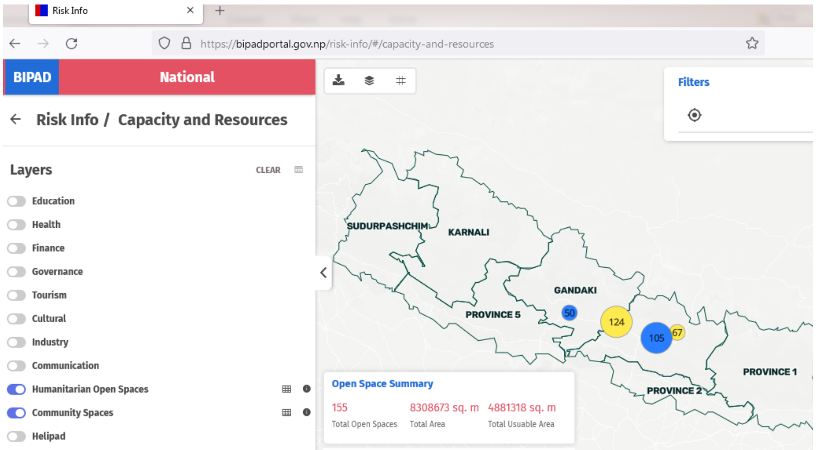

Figure 4: Display of open space data of Bagmati and Gandaki Provinces in the BIPAD portal

To plan effective strategies to reach the affected during a disaster, spatial information on infrastructures such as roads, trails, health amenities, educational institutions, open spaces, and other community resources is crucial. As a follow-up to the national gap analysis, NAXA provided technical support to the World Food Programme (WFP) Nepal in 2019 and 2020 to conduct local-level data gap analysis and trace the major trails and community infrastructures of Bajhang, Bajura, and Humla districts. These districts are some of the most remote, poverty-stricken, and hazard-prone districts of western Nepal. The data on the trail routes, access constraints, hazards, critical infrastructures, and community assets with their spatial attributes have been collected and integrated into the geodatabase of the respective districts and uploaded to the open-source mapping platform such as OpenStreetMap (OSM) as well. The spatial data infrastructure developed for these three districts can support strategic decision-making during an emergency at the local level. These decisions may include deploying ground responders or humanitarian actors with relief and rescue operations as well as developing plans for effective disaster risk reduction and impact mitigation based on the spatial data of trails and infrastructures.

Figure 3:A difficult river crossing in remote Bajura

Besides mapping and database development, developing technological solutions is one of the themes that NAXA focuses on. In 2021, NAXA supported the Comprehensive Disaster Risk Management Programme (CDRMP) of the United Nations Development Programme (UNDP), to develop an integrated mobile and web-based application for Global Positioning System (GPS) tracking of emergency or inspection vehicles. This is an online disaster response system that complements the BIPAD portal with emergency responder dispatch and near-real-time location tracking of emergency vehicles in the core urban areas of Lalitpur, Bharatpur, and Bhimeshwor Municipalities. With the mobile application, citizens can report an emergency in their area and request emergency vehicles. While on the other hand, the system administrators can review the emergency needs and dispatch the emergency vehicles immediately. The GPS device fitted in the emergency vehicle allows the responder to navigate through the map directions (Google Maps or OSM) to the area of the incident, therefore reaching the affected areas in minimum time.

Another important area of work required for effective disaster preparedness and response is to identify the most vulnerable people, considering the household characteristics (physical, socio-economic, demographic, and other aspects) as well as the overall geomorphological situation of the surrounding. NAXA has been a pioneer in vulnerability assessment at the household level in Nepal. Using a digital system for data collection, custom criteria for vulnerability classification to match the local context, and visualization of risks, NAXA worked with DCA Nepal in 2018 to classify households into three levels of vulnerability in the flood-affected areas in Saptari. Similar works were done subsequently with World Vision International Nepal in 2020 at Lamkichuha Municipality, Kailali and Krishnapur Municipality, Kanchanpur. Taking the initiative further, NAXA is currently working to carry out digital vulnerability and capacity assessment of schools in Sindhuli with HANDS Nepal.

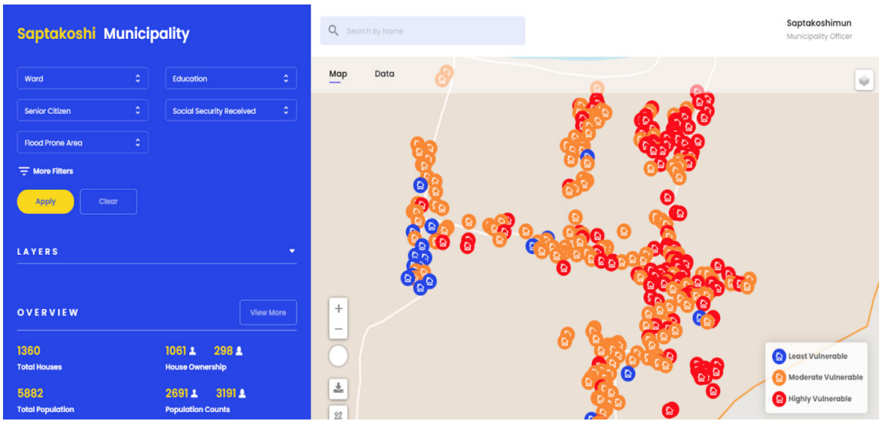

Figure5: Visualization of household vulnerability levels in Saptakoshi Municipality

Risk assessment, visualization, and dissemination is an area of work NAXA has been striving to innovate in. As a part of the World Bank innovation grant, NAXA worked with Practical Action Consulting to develop a digital solution for risk assessment using user-provided input datasets and custom criteria. The tool uses a powerful Google Earth Engine processing infrastructure to conduct complex geospatial and attributable analysis.

As a private sector stakeholder, NAXA is continuously working to apply spatial data for disaster risk reduction and preparedness. The company believes in small-scale piloting of innovative solutions before a wider scale-up. While companies and non-governmental organizations develop the proof of concepts and validate the effectiveness of solutions, it is ultimately the government that can scale solutions at the national level.

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Hello Open Source!

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What is the latgest software project on the planet earth? Is it by Google or by Microsoft or by Facebook? The answer is none. As they are the big tech companies but the largest software project is the one that is free for everyone to use, modify or even sell, its the Linux operating system kernel. It is an operating system kernel that powers more than 90% of the servers which then makes the internet possible. Its the one that lets us use over billions of android smartphones all over the world. Also, you remember the Perseverance rover that NASA sent to mars and the drone Ingenuity in it, the drone is also using linux code. Now the question is how is this even possible? How is the most powerful and useful piece of software technology free? This is what we call the power of opensource.According to wikipedia Open-source software (OSS) is computer software that is released under a license in which the copyright holder grants users the rights to use, study, change, and distribute the software and its source code to anyone and for any purpose. Linux is one of the most common and important example of opensource software. In fact our world is mostly powered by opensource software. VLC media player, Firefox browser might be some of the well known Open-source softwares that we use in daily basis.

1. Why Opensource?

1.1 Great Learning

If you want to learn coding or want to brush up your skills then Opensource might be the best way to go. You can get industry standard experience without joining a industry. Also, you get to choose the project you wish to work on and improve. The guidance you will get while contributing to opensource from people already working on it will also be of great value.

1.2 Getting jobs

Contributing to opensource will make you not only market ready but also market wanted as companies value someone who has alredy contributed to a piece of software that is useful. Opencource contributions are open to everyone to see and verify your skills. They can actually look at the code you have written and be sure about your skills during hiring process.

1.3 Giving back

As opensource softwares give us so much and its due to them we can enjoy many free or low-cost software tools. So, giving back to others and being a contributor instead of just contributor just feels good. It is a good motivation that your work is affecting thousands or even mittions of people in a good way.

2. Geospatial Opensource

Geospatial sector also has a ton of opensource projects that power our day to day work. You see those awesome maps on websites? There is a pretty good chance that they are developed using opensource libraries like openlayers, leaflet or similar. QGIS might be most familiar one to everyone in this sector. It is the way to go if you do not want to pay those hefty sum of money to corporations just to be able to analyze your data and generate a beautiful map. Actually in some areas like data format support and basemap support QGIS is better compared to its proprietery counterparts. There is no cracking to do just download, install and get on with your work. Also, postgresql and postgis are the tools of choice when it comes to having a geospatial database which are again part of opensource ecosystem.

Open Source Geospatial Foundation (OSGeo) is is a non-profit non-governmental organization whose mission is to support and promote the collaborative development of open geospatial technologies and data. It has developed many tools that we might already be using like QGIS, postgis, GeoServer, OpenLaysers, Tile Map Service (TMS) specification, Geonode etc. or can be of use to us in the future. You can visit them at osgeo.org . It is one of the many organizations that are there making the innovation in this sector and giving them for free to everyone.

So, you like the idea of opensource geospatial tools but you are not good at coding and wish to contribute? No worries there is a place for everyone. Heard of OpenStreetMap project? With the mapping skills you can contribute to it with digitization or adding attribute information. Afterall showing someone their way is a nobel work and with your simple edit in OpenStreetMap you would be showing way to all the people using these maps.

Still hesitant about getting on board on your own? Then a organized digitization event like Mapathon can be a great starting point. Here the mentors would guide you through the process and then you can explore the possibilities on your own.

3. How to Opensource?

So, you are all convinced that opencource is the nice awesome thing out there that you want to be a part of as a contributor? Here is a quick little guide then.

3.1 Contributing to existing projects

Here we contribute to existing opensource projects. This can be as simple as reporting a simple bug that you found in the software or as complex as ading a whole new fulctionatity. But question is how do you actually get started? In short you will need to explore. First good place would be the website of the project you want to contribute. They will often have a contributing tab where they will guide you through all the process of being a contributor. Also learning a version control system like git will be a good skill to have as most of the projects use systems like that to maintain the project. Each project will have a list of issues hosted somewhere and there could be issues tagged as good-first-issue or similar.

3.2 Creating your own projects

So you have this awesome piece of code that you want to show to the world. It might be a small script that helps with some calculation or a fully fledged software. Uploading it to a public code hosting sites like Github, Gitlab, BitBucket or any other platform of your choice is a great way to start. It feels good when other look at your project and give comments. You might also receive contributions from others.

3.3 Financial Support

We can also financially support the project that add value to our work. If we can we should be helping such projects so that they can sustain and we get to keep on using such helpful tools and software.

3.4 My Opensource journey

I came to know about the power and awesomeness of opensource when I had to deal with cracking softwares to use them and then there would come a computer virus/malware doing such illegal things. Also, I as a student could not pay the money to buy the license. Opensource was the way to go. With all the resources and great community forums it was same if not easier while learning to use these free tools copared to paid ones. At first I was just a user, then I started by opensourcing my college projects by uploading them to Github and then finally contributed to few libraries related to mobile maps. Still there is more to do and a long way to go.

4. Finally

To conclude this we can summarize this as:

- Opensource tools and software are great for those who cannot afford the costly ones and also for the learners who want to also know about the underlying technology behind the tool. So, student should always explore for opensource alternatives.
- Contributing back in any way to opensource is good for us personally and also to our community

At last, its all about freedom. And opensource is free as in free MoMo (i.e. free of cost) or free as in freedom to see, modify and use.

Recipient of Facebook Community Impact MicroGrant 2021

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1. Introduction

The Chepang community, also known as "Praja'', is one of the highly marginalized indigenous nationalities and resource-poor tribes of Nepal [NCA, 2013]. Chepangs are classified under the 'highly marginalized' category with no representation or access to representation in any social or political spheres on the basis of a set of socio-economic indicators, such as population size, language literacy rate, house type, land ownership, citizenship, occupation and access to higher education [NEFIN,2004]. The remoteness of Chepang settlements is regarded as one of the main reasons behind these low literacy rates. "We do not own land because we lack citizenship certificates required for land ownership", said local Chepangs in Makwanpur. They depend on forests and shifting cultivation for livelihood. However, introduction of new government policies put restrictions on hunting, gathering, and clearing of forest patches (Upreti & Adhikari, 2006), leading to the transition of their livelihood to sedentary rain-fed agriculture (FORWARD, 2001). Due to extreme poverty and lack of citizenship, Chepangs usually cannot afford to travel overseas in search of jobs. The problem of malnutrition and forced teenage pregnancies are common. Due to small parcels, the rugged topography and stony nature of the land, only a small percentage of Chepang households are fully food self-sufficient (Piya, Maharjan, & Joshi, 2011).

Figure 1: A typical Chepang family of Raksirang

Life must be callous while standing on the feet of each individual Chepangs. Thus, there is a need to bring the Chepangs forward and solve their existing problems for which our project of Mapping Chepang Community can be a bridge between the Chepangs and stakeholders government for uplifting the status of their community.

2. Project Update

The journey of the Facebook community impact microgrant by Humanitarian OpenStreetMap Team(HOT) started from 11th March, 2021. Geomatics Engineering Society(GES) officially receives this microgrant on the aforementioned date where the microgrant were GES Secretary 2019/20 Rabi Shrestha, Vice President 2019/20 Yukesh Byanjankar and member Prajwal Sharma. And after that a 14-member community was drafted which was led by Mr. Rabi Shrestha and the Advisors were respected Acting Head of Department Dr. Subash Ghimire, Asst. Prof. Dr. Reshma Shrestha, Asst. Prof. Uma Shankar Panday and Teaching Assistant Er. Sudeep Kuikel.

We had planned to execute this microgrant in three phases viz; remote mapping, field visit and data dissemination. On 18th April 2021, an inauguration event was organized where the chief guests were Regional Director of Asia Pacific Hub- Dr. Nama Raj Budhathoki, Community Manager- Mikko Tamura, Co-founder of Naxa- Uttam Pudasaini, Founder of Youth Innovation Lab- Pradip Khatiwada, Youthmapper Regional Ambassador and OSM Trainer Saurav Gautam and all the faculties from Department of Geomatics Engineering, Kathmandu University. After this event 11 other trainings were conducted by GES to about 140 new mappers on Introduction to Openstreetmap, Id-editor, hands on JOSM, advanced JOSM, plugins and validation. Besides to these trainings, we also attended 8 trainings organized by HOT like training on JOSM, Rapid, Mobile data collection, Mapillary and Quality Assurance tools. To encourage the mappers, weekly top 3 mappers were awarded with exciting gift hampers and certificate of appreciation and tshirts will also be distributed to the contributors of the project. Survey Field visit was done drafting necessary plans after consulting with respected Advisors, Naxa, Youth Innovation Lab and Institute for Indigenous Affairs and Development(IIAD). They helped us in many ways to ease our field survey. And now map making process to make mapbook is being carried out. All the field data so collected are already uploaded on OSM after data cleaning. Besides, a governmental portal BIPAD, departmental and national web portal GeoNode Nepal and GES website also will be used for data dissemination.

3. Project Implementation

New roads bring opportunity. Creating a building tile makes the remote building visualsable to the world. Creating and classifying the land use makes the community land distinguishable from various aspects. And the ambient factor “MAPPING” comprises all these aspects and supports the Chepangs to uplift their economic status. Mapping one of the indigenous nomads of Nepal: Chepang Community was a great learning and experience for GES and team. During this microgrant period, our team has been tirelessly working to map, validate, field verification, output and data dissemination for all this time. And during this time, this microgrant has helped us a lot to learn and train about OSM to all GES members and various OSM communities in Nepal. We are able to extend our hand with Kathmandu Living Labs for advice, Youth Innovation Lab as strategic partner, Naxa as technical partner, Institute for Indigenous Affairs and Development(IIAD) as field guiding partner, Department of Geomatics Engineering, Kathmandu University as guidance and supporting partner. We were able to interact and collaborate with different governmental bodies as well. We collaborated with 19 ward presidents and trained them locally to read and visualize the printed satellite imagery maps. Besides, we were also able to interact with the chepangs by listening to their problems and collecting the survey questionnaires. Our main objective was status upliftment and helping in poverty elimination for these nomads and we have been trying to implement our activities and plans engaging various other donating organizations and even their own local government. Through the help of different maps which helps them to analyze the problems, we have awakened the local government as well in order to help the backward chepang communities.

Beside to this, our maps and data that we have collected will be available freely on OSM as well as our official GES website and GeoNode for Nepal which can be accessed by anyone who wants to help the community and we are happy to help, collaborate and extend hand with any other organizations that want to aid the community.

4. Stakeholder engagement

In this short period of 8 months of project commencement, we had involved with various stakeholders. Some of the major stakeholders that we collaborated with along with other descriptions regarding the engagement, way forward are tabulated below:

	Stakeholders	Relation	Activities & way forward
	Department of Geomatics Engineering(DOGE), Kathmandu University	Advisory panel of our project team are all Asst. professors from DOGE.	1.Data that we had created, mapped will be used for research purpose and conducting various projects. 2. Students of DOGE are conducting various mini projects relating to Remote Sensing, Land use using the data of Makwanpur (Project site) 3. The data of the remote mapping and field survey data will also be disseminated via Geonode Nepal https://geonepal.info/ which is being managed by a team of Department of Geomatics Engineering.
	Institute for Indigenous Affairs & Development(I-IAD)	-Work as mediator between chepangs and GES Team due to language barrier of the chepang community -Help us in guiding during field visit	1. Possibility of using our land use and household data for analysing suitable area for afforestation and other purposes. 2. Planning to bring various other projects for indigenous tribes(Chepangs) in the locality using our data.
	Raksirang Rural Municipality	Coordination between University and Local Government	1. Pitched necessity of digital data and the officials of Municipality are seeking for different possible projects that can be carried out.
	Kailash Rural Municipality	Coordination between University and Local Government	1. Pitched necessity of digital data and the officials of Municipality are seeking for different possible projects that can be carried out
	Local Government		We have collaborated with 9 ward of Raksirang and 10 wards of Kailash Rural Municipality. We made the staffs of wards able to read and use the satellite maps. Also, we describe them about importance of OSM and devoted organization like HOT which is helping to maintain free and open data.
	Kathmandu Living Labs	Advisor	Helped us in remote mapping and upon necessity of project.
	Youth Innovation Lab	Strategic Partner	-Helped us to draft proper strategy during field survey. -And also made us 5 GPS devices and 3 power bank available for field survey. -Helps to disseminate our data via government portal called BIPAD and let us collaborate in BIPAD project for those Municipalities.
	Naxa	Technical Partner	Helped us in remote mapping and drafting plans and policies to execute the project.

5. Project Goals

We are on the track to achieve our community defined goals. Since the commencement of this microgrant, we have organized a number of OSM trainings. We have created 140+ mappers to OSM who are mapping daily and contributing to various HOT ™ projects. We are able to make them so familiar and close with Open Asia Pacific Hub as well and participate on Map and chat hours. Besides, after this microgrant their influence on OSM Nepal has also increased and as a result GES is again involved with Booster Grant to organize the training and event at Kathmandu University. We feel proud and thankful to HOT as because of this initiation OSM community is growing rapidly in GES, Nepal and it is equally helping other communities to deepen their roots in OSM. The most important part is that the mappers are happy to map not only on this project but they are mapping different parts of the world which helps other people to encourage and map for the cause. As the statistics have already shown that the mappers are very eager to learn about the OSM, this project has ultimately helped to evolve more other communities as well. Through this grant, GES is also helping to map 1.5 million people in OpenStreetMap (OSM) which is also one of the mission of HOT.

Figure 2: Five Project Principle

Our Sustainability plan is based on the principle "Development of Human Resource and Upliftment of the Community". Besides, we have also planned to properly follow and execute the five Project Principles of this grant, viz; Partnership (with the involvement of local authorities and residents of the same locality), Inclusivity (which includes the involvement of Women, backward communities inclusive of other all curious and interested manpower for learning and mapping), Expansion (Expanding our network and collaborations with local organizations and various other organizations), Collaboration, and Community Defined Project Goals.

6. Social Impact

We had extracted out the study area map before we started our remote mapping work where we had found that only one health post had been marked on the map though there were multiple health institutions. Not only health institutions, only about 4000 buildings, sparshed forest, paths distributed remaining invalidated. So with the help of this program we were able to map about 14,000 buildings and validated the paths, highways, waterways, forest, farmland which ultimately helped us to analyse the further data analysis part.

Figure 3: Map literacy by field volunteer to students of school

Besides this, it is very essential one to point out that this program has helped to mark multiple healthy lives on the map who were absent till date on the OSM along with recruiting about 150 new mappers. This program has helped to encourage multiple organisations to work in OSM and the importance of the OSM data. As both remote and field work has been accomplished, we are aware of the fact that there were numbers of the houses which are absent in the map and prone to the landslide area. So, this data has been helping us and engineering students in our University to work for the further analysis part in the landslide area, food security part and many more.

We have been on field visits interacting with the indigenous chepang communities and we had also prepared a list of survey questionnaires which help us know the ground reality and their major problems. During field visit, we were volunteered by many mappers and local government representatives. So we extended hands with them and be socially active to map and interact with the community. This project has been helping many other organizations to gather the information and list it to their portal for storing in their databases which ultimately helps as the broad databases for all to access for the further works and help the community. Besides, it has also positive affect toward building quality OSM data with attribute in the Makwanpur district.

7. Collaboration

We (GES) always believe in collaboration, this project has helped to extend our collaboration partners. Upon this project we have received both technical and social support. We are very glad that this project has not only helped in recruiting new mappers but has given great support to the OSM enthusiasts and other communities to work on the OpenStreetMap. This project has given the opportunities which have helped to reach our major objective; Uplifting Chepang Communities.

Figure 4: Collaboration with local government(ward-level)

In the remote mapping phase we along with Youthmappers mapped our project area recruiting around 100 new mappers ; Raksirang and Kailash Rural Municipality. In the meantime, Youth Innovation Lab who are working for the BIPAD portal in Nepal, we get technical support before proceeding to the fieldwork about the data collection and on being handy with GPS instruments. They said that our data will also be updated on the Bipad portal once it gets verified from the Municipality side. We also collaborated with IIAD which works for the development of the indeginious community, they provide us with guidance and assistance in cooperating with the Chepang Communities by providing the guide for collecting the entire data. NAXA (a Geotech company) helped us in preparation of the geodatabase of the field data, helped us in the dissemination of the collected data in the OSM database. Other than this, our work would not be possible without the support from respective Government offices such as Ward offices, health offices, police stations in the Raksirang and Kailash Rural Municipality who helped us in guiding and securing through the fieldwork.

8. Support

HOT has always been the greatest mentor for our every task. In every problem that occurs during our working phase, HOT provides us with major guidance, from providing training like mapping, validating and disseminating the data. HOT guided us throughout the documentation, data collection tools like KoBo Collect, finance management and arranging of all the miscellaneous data in the proper way. Besides these, HOT has given us the platform to present our work in HOT Summit 2021 with which we were able to showcase our work, visualize the actual problem of the Chepang Communities. Moreover, with the training provided by HOT like Id-Editor, JOSM, KoBo Collect, GPS tracker, OSM tracker helped immensely on our remote mapping and field mapping task. So, far we have always received guidance from the HOT as necessary, we are very grateful for it.

9. Learnings

HOT Micrograant is a great achievement for us since it has provided us the platform to learn the technical as well as the management skill. In this micrograant period, we not only mapped the remote part of Nepal but has provided us the chance to explore the unseen remote part of those remotely mapped regions. In addition, micrograant has helped us to shift our behaviour from the unmanaged documentation to the professional management of every file. Besides this we were able to use the optimum use of the OSM data during our field verification process. This grant has been able to motivate us to work further in OSM and similar projects in HOT. Moreover, not only with the mapping part, the demographic data obtained from the KoBo collect from the field activities help us to analyse the basic needs that need to be fulfilled in Chepang communities.

This initiative not only has motivated us to map but helps to recruit new members to the OSM community resulting in expanding new communities and growing on their own. It has helped in learning the use of different OSM tools like Id- Editor, JOSM, OSM Tracker etc. from which we are able to help newcomers who are interested in OSM. Most importantly, we get a chance to verify remote mapping data from the field activities.

10. Annexes

Figure 6: Group photo of Field Volunteers

Figure 11: In frame: Field volunteers with Chepang family

Figure 7: Visit to chepang household

Figure 8: Sharing smile with Chepang childrens

Figure 9: Introducing HOT to Chepang household

Figure 10: Map verification in presence of Ward chief and locals

Figure 11: Coordination with Youthmappers

Figure 12: In frame: Field volunteers with Chepang family

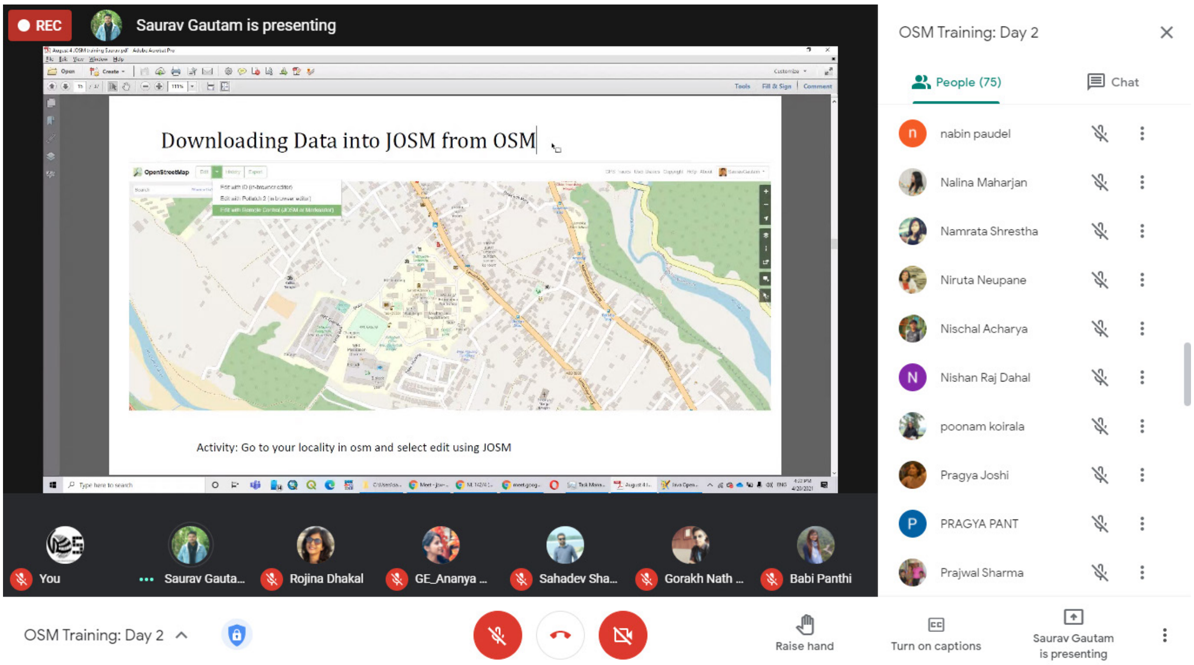

Figure 13: Remote Mapping from Youthmappers Ambassador and OSM Trainer Er. Saurav Gautam

Accuracy Assessment Of Land Cover Of Local Data In Comparison With Global Dataset

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KEY WORDS: Land cover, ESRI, Sentinel 2A, Image Classification, Confusion Matrix

ABSTRACT:

Land cover data is a valuable and often necessary product when performing studies and analysis in a number of fields. For classification multispectral satellite images are used. Image classification can be supervised and unsupervised. The performance of these classifiers is judged on the basis of kappa coefficient and overall accuracy. Image classification is a complex process that may be affected by many factors. The emphasis is placed on the summarization of major advanced classification approaches and the techniques used for improving classification accuracy. In this paper, we have compared the accuracy of two datasets (Global and local) with the help of confusion matrix involving the calculation of user's accuracy, producer's accuracy, kappa coefficient and the overall accuracy in general.

1. Introduction

The remote sensing community has long been interested in image classification research since classification results constitute the foundation formany environmental and socioeconomic applications. Before one can begin the classification process, it is necessary to prepare images for the areaof study. Care must be taken to properly geo- reference and standardize for the effects of temporaland atmospheric differences between images as wellas account for system errors (Ramsey, 2002). Image classification in the context of remote sensing applications has the overall objective to automatically categorize all pixels in an image into different classes according to their spectral behaviour s hown by them. The spectral pattern of surface materials belonging to a class determines an assignment to that class. In this time of large-scale planning and land management on public lands, organizations are increasingly looking for faster and less expensive methods of data collection. All of these needs can be filled with data gathered from remote sensors. The purpose is to assess thepossibilities of using remote sensing for the development of a land cover classification system,

2. Objective

The main objective of this project is to performaccuracy assessment of local dataset with global dataset. Similarly, the secondary objective is to find out the accuracy of the training sample with respect to global data.

3. Study Area:.

The study area comprises Lalitpur district which liesin Bagmati Zone, Central Development Region, Nepal. It covers an area of 396.92 km^2. Situating near to the capital Kathmandu, the built up area is gradually increasing. It is surrounded by Makwanpur,Bhaktapur, Kathmandu and Kavre.

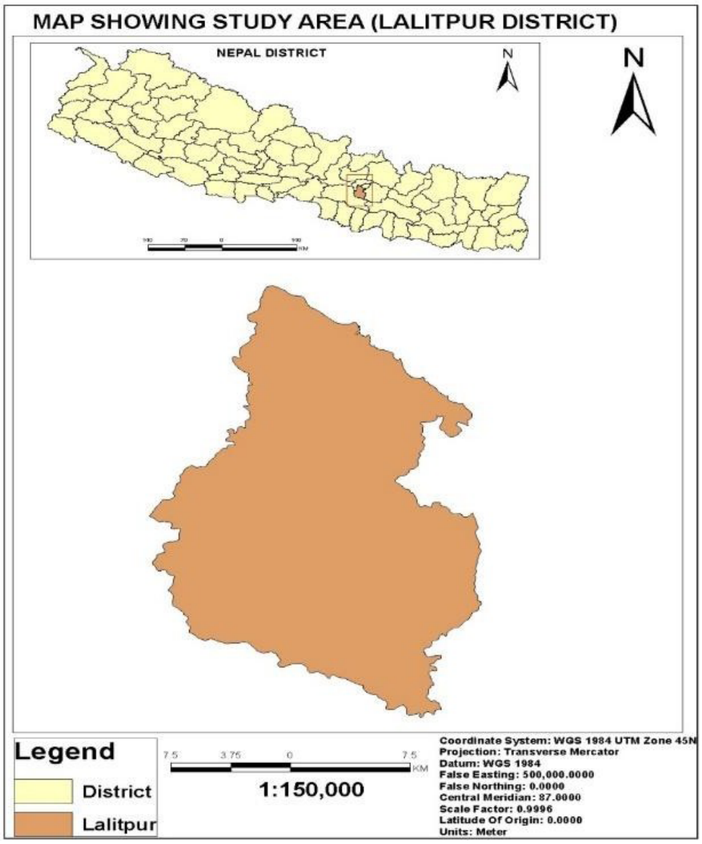


Figure 1: Map Showing study area: Lalitpur District

4. Methodology

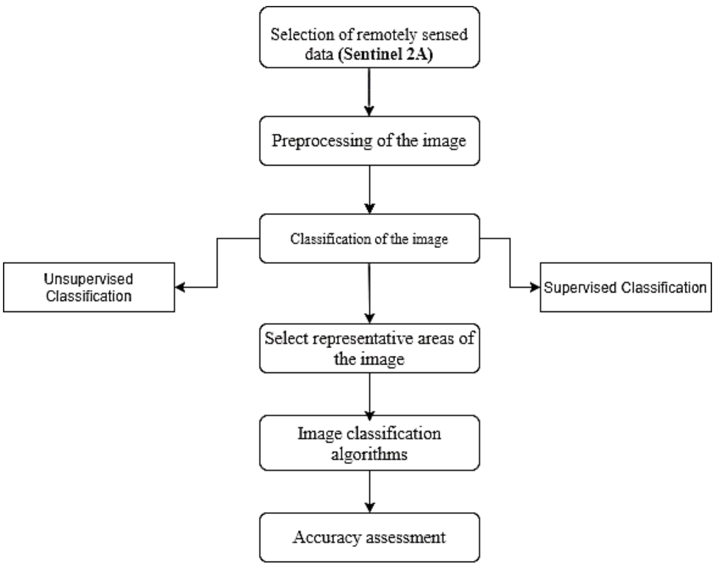


Figure 2: Image Classification Procedures

Remote sensing classification is a difficult technique that takes into account a variety of factors. Selection of remotely sensed data, design of image classification system, image pre-processing, feature extraction, selection of appropriate classification algorithms, and accuracy assessment are some of the important phases in image classification. Important elements impacting the selection of remotely sensed data, the design of the classification technique, and the quality of the classification findings include the user's requirement, the size of the study area, the economy, and the analyst's skills. This section focuses on the major steps in image classification that may be involved. This section focuses on the description of the major steps that may be involved in image classification. The procedures that has been applied for image classification is illustrated in the adjoining flowchart (Fig. 2).

4.1.Reclassify ESRI land cover

Since ESRI land use/land cover 2020 data contains 10 classes (water, trees, grass, crops, scrubs, bare ground, Built area, snow, clouds, No Data). In sentinel 2 imagery it is difficult to identify trees, scrubs and grass, so we reclassify them as 'vegetation' and snow clouds are not present in our data. Water bodies was not classified due to presence of swallow water. If water bodies are considered it affects other classes and decrease their accuracy. So, we reclassify ESRI land cover into only 4 classes (vegetation, crops, Built Area, and bare ground).

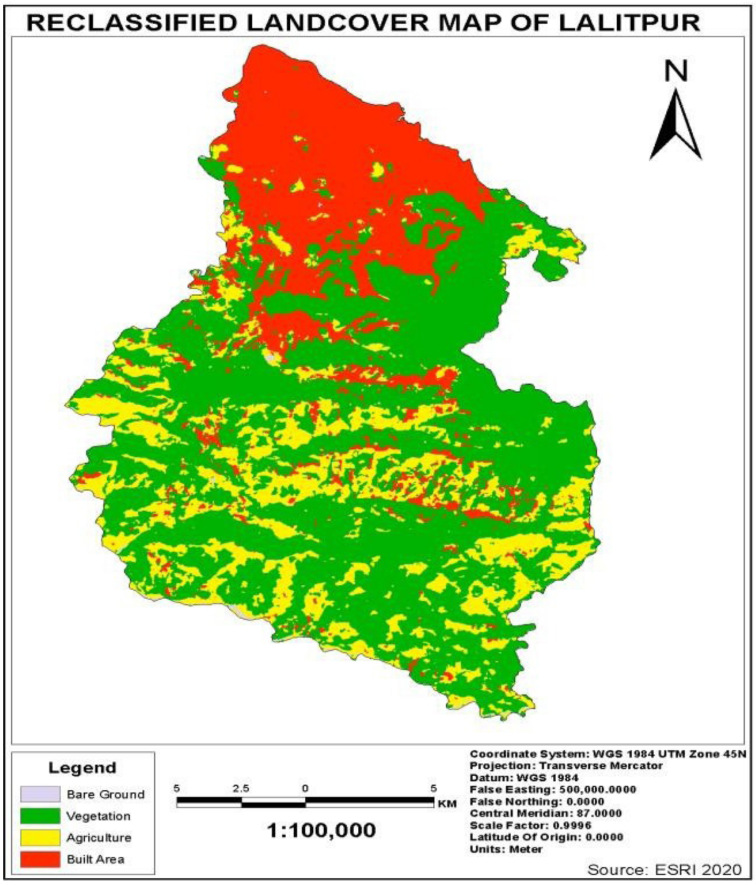


Figure 3: Reclassified Land cover map of Lalitpur (ESRI 2020 DATASET)

4.2 Selection of remotely sensed data

Spatial, radiometric, spectral, and temporal resolutions of remotely sensed data differ. Understanding the advantages and disadvantages of various types of sensor data is crucial for selecting appropriate remotely sensed data for image classification. The selection of suitable sensor data is the first important step for a successful classification for a specific purpose. Scale, image resolution, and the user's need are the most important factors affecting the selection of remotely sensed data. We have selected Sentinel 2A imagery of 10m resolution because Esri land cover data 2020 is also prepared using same imagery type.

Table 1: Spectral bands for Sentinel 2A

Sentinel 2A bands	Resolution (m)	Spectral Bandwidth Interval (nm)
Band 1 (Aerosol)	60	430-457
Band 2 (Blue)	10	440-538
Band 3 (Green)	10	537-582
Band 4 (Red)	10	646-684
Band 5 (Vegetation Red edge)	20	694-713
Band 6 (Vegetation Red edge)	20	731-749
Band 7 (Vegetation Red edge)	20	769-797
Band 8 (NIR)	10	760-908
Band 8A (Vegetation Red edge)	20	848-881
Band 9 (Water Vapor)	60	932-958
Band 10 (Cirrus)	60	1337-1412
Band 11 (SWIR, Cloud Discrimination)	20	1539-1682
Band 12 (SWIR, Cloud Discrimination)	20	2078-2320

4.3 Preprocessing of Image

Image preprocessing may include the detection and restoration of bad lines, geometric rectification or image registration, radiometric calibration and atmospheric correction, and topographic correction and initial image clustering. A combination of different source data in a classification procedure requires accurate geometric rectification of remotelysensed data. If a single-date image is used in classification, atmospheric correction may not be required. When multi-temporal or multi-sensor data are used, atmospheric calibration is mandatory. In our case, the obtained imagery was already geometrically calibrated and we had only calibrated radiometrically using ENVI software.

4.4 Image classification

A suitable classification system and a sufficient number of training samples are prerequisites for a successful classification. In general, a classification system is designed based on the user's need, spatial resolution of selected remotely sensed data, compatibility with previous work, image-processing and classification algorithms available, and time constraints. They are usually information classes such as urban, agriculture, forest areas, etc. Trainingsamples were developed manually selecting the region of interest in stacked Sentinel 2A-10m resolution

4.5 Select representative area of image

Spectral signatures, vegetation indices, altered images, textural or contextual information, multi- temporal images, multi-sensor images, and supplementary data are only some of the factors thatcould be employed in image classification. Usage ofmany of these factors in a classification technique canreduce classification accuracy due to differences in land cover separability capacities. It is important to select only the variables that are most useful for separating land-cover or vegetation classes, especially when hyperspectral or multisource data areemployed.

4.6 Image classification algorithm

When choosing a classification method, manyelements must be considered, such as the spatialresolution of remotely sensed data, different datasources, a classification system, and the availability of classification software. Different classification systems have their benefits. The intent of theclassification process is to categorize all pixels in a digital image into one of several land cover classes, or "themes". This categorized data may then be usedto produce thematic maps of the land cover present inan image. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. The objective of image classification is to identify and portray, as a unique gray level (or color), the featuresoccurring in an image in terms of the object or type of land cover these features actually represent on theground.Basically we have used two types of classification.s

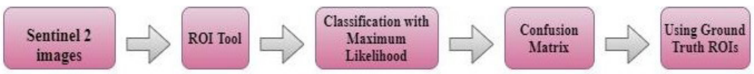
4.7 Unsupervised Classification

Unsupervised classification is a technique that analyses a large number of unknown pixels and separates them into groups based on the image values' natural groupings. Unsupervised classification does not require analyst-specified training data, unlike supervised classification. The primary idea is that in the measurement space, values within a given cover type should be close together (i.e., have similar gray levels), whereas data from different classes should be very far separated (i.e., have highly different gray levels). The classes that result from unsupervised classification are spectral classes which based on natural groupings of the image values and their identity will not be initially known, thus should be compared to some form of reference data such as large scale imagery, maps or site visits to determine the identity and informational values of the spectral classes. In our project, the images were imported in the ENVIenvironment. The image was visualized in the grey scale as well as in the RGB mode. The unsupervised-ISODATA was selected under the classification menu. The maximum iteration was set to 10 and the maximum number of classes to 4. Thus, after classification a total 5 number of classes were observed. Thus, classified images were verified against the actual image and classes were merged in order to correctly represent the reality. The thick vegetation was classified into different classes. Thenthe corrected applied classified image was exported in the form of map with class labelled with different land cover themes.

4.8 Supervised Classification

Supervised image classification is a procedure for identifying spectrally similar areas on an image by identifying 'training' sites of known targets and then extrapolating those spectral signatures to other areasof unknown targets. With supervised classification, we identify examples of the Information classes (i.e.,land cover type) of interest in the image. These are called "training sites". Each pixel in the dataset is then compared numerically to each category in the interpretation key and labelled with the name of the category it looks most like

Prior to collecting the training sites, four landscape types were defined such as: vegetation, agriculture, bare land and built area. The region of interests (ROIs) was selected considering the homogeneity ofthe features as well as the variability across differentparts of the image scene. Then the image was classified with supervised- minimum distance technique. For the verification of the thus classified image, again different samples of ROIs were selectedacross different regions in the image.



5. Accuracy assement

Accuracy assessment and Kappa coefficient are common measurements used to demonstrate the effectiveness of the classifications (B. Satyanarayana, 20011). Assessment of classificationresults is an important process in the classification procedure. Different approaches may be employed, ranging from a qualitative evaluation based on expert knowledge to a quantitative accuracy assessment based on sampling strategies. Based on the referencepixels, a confusion/error matrix (also called contingency table) is generated. Error matrices compare, on a category-by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification. Such matrices are square, with thenumber of rows and columns equal to the number ofcategories whose classification accuracy is being assessed. From the error matrices kappa (κ) statistics,overall accuracy and producer's and user's accuracy are computed, which determine how far our classification is accurate (Veldkamp A. & Verburg P. H,2004).

Overall Accuracy = (Total number of correct pixels/ Total number of observed pixels) *100 User Accuracy

= (Correct pixels/ row total)*100Producer accuracy = (Correct pixels/column total)*100

$$\hat{k} = \frac{N\sum_{i=1}^{r} x_{it} - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \cdot x_{+i})}$$

N = Total number of observations
r = Number of rows in matrix
Xii Number of observations in row i and column iXit Total number of observations in row i
Xi Total number of observations in column i

6. Results and discussions

This paper aims to obtain a land cover mapping of theLalitpur district by using Sentinel 2A images. The performance of the supervised classification algorithms and training datasets were assessed. The Sentinel imagery was classified and analysed with different tools in ENVI software. To validate the classification result, we computed the confusion matrix using the ground truth data. In this classification using ROI Tool for classification images in four classes (Built up Area, Vegetation, Agriculture and Bare Land).

Table 2:Confusion matrix 1- supervised classification (local landcover)

Class	Builtup	Agriculture	Vegetation	Bareground	Total	Commi-sion	Omis-sion	Prod. Acc.	User. Acc.
Vegeta-tion	0	0	3216	0		0/3216			
Builtup	273	0	38	11	322	49/322	51/324		273/322
Agricul-ture	28	179	0	0	207	28/207	0/179		179/207
Bare-ground	23	0	0	39	62	23/62	11/50	39/50	39/62
Total	324	179	3254	50					

Overall Accuracy = (6961/7804)= 89.1978% Kappa Coefficient = 0.7392

Table 3: Confusion matrix 2- supervised classification (global landcover)

Class	Vegetation	Builtup	Agriculture	Bare-ground	To-tal	Commi-sion	Omis-sion	Prod. Acc.	User. Acc.
Vegeta-tion	5749	0	2	0		2/5751			
Builtup	147	669	553	39			91/760	669/760	
Agri-culture	5	69	553	6		80/613			
Bare-ground	0	22	0	10	32	22/32	45/55	10/55	10/32
Total	5901	760	1088	55					

Overall Accuracy = (6961/7804)= 89.1978% Kappa Coefficient = 0.7392

Table 2 & 3 shows these values according the four different classes. The CM includes the Commission (producer accuracy) and Omission errors (user accuracy).

According to the confusion matrix, the overall accuracy of the local land cover classification was better than global land cover classification. Overall accuracy for the local land cover was 97.3733% whereas the accuracy for the global land cover was 89.1798%. Similarly, the Kappa coefficient for local and global datasets was 0.9020 and 0.7392 respectively.

In the case of local dataset, both producer and user accuracy for vegetation is 98.83% and 100% respectively which means vegetation is classified perfectly. Also, producer and user accuracy for bare area, built up and agriculture area is only 78.00%, 62.90% and 84.26%, 84.78% and 78.00%, 62.90% respectively which is acceptable. Similarly, in the case of global dataset, both producer and user accuracy for vegetation is 97.42% and 99.97% respectively which means vegetation is classified perfectly. Also, producer and user accuracy for bare area, built up and agriculture area is only 18.18%, 31.25% and 88.03%, 47.51% and 48.99%, 86.95% respectively which is acceptable.

The above classified chart shows that the bare groundis zero precent , but it doesn't mean that there is no bare ground. This result was the outcome due to the round off of extremely negligible area. And the vegetation, agriculture, and built area are 57, 23 and 20 percent respectively in global classified land cover. However, in case of the supervised classification chart the percentage of theclassification are either increased or decreased whichmay be differed due to the change in season of the year or the classification techniques. We can see thatthe differences in agriculture, built area and bare ground are 6%, 5%, and 1% percent respectively which is acceptable.

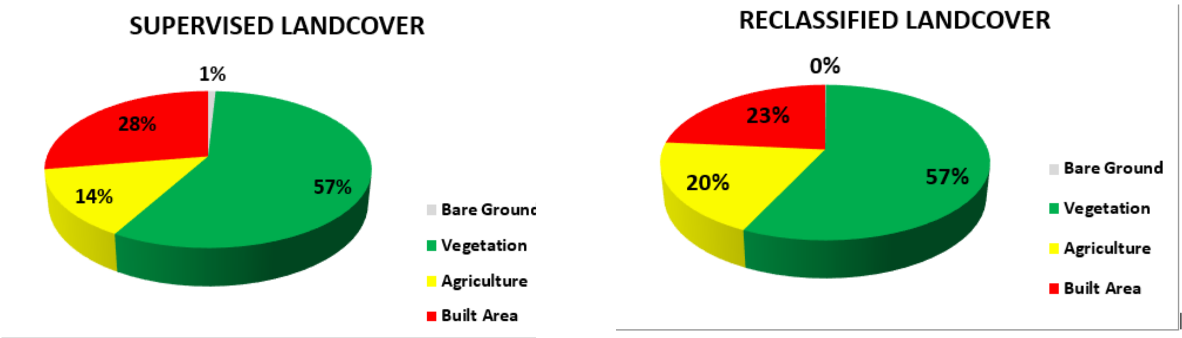
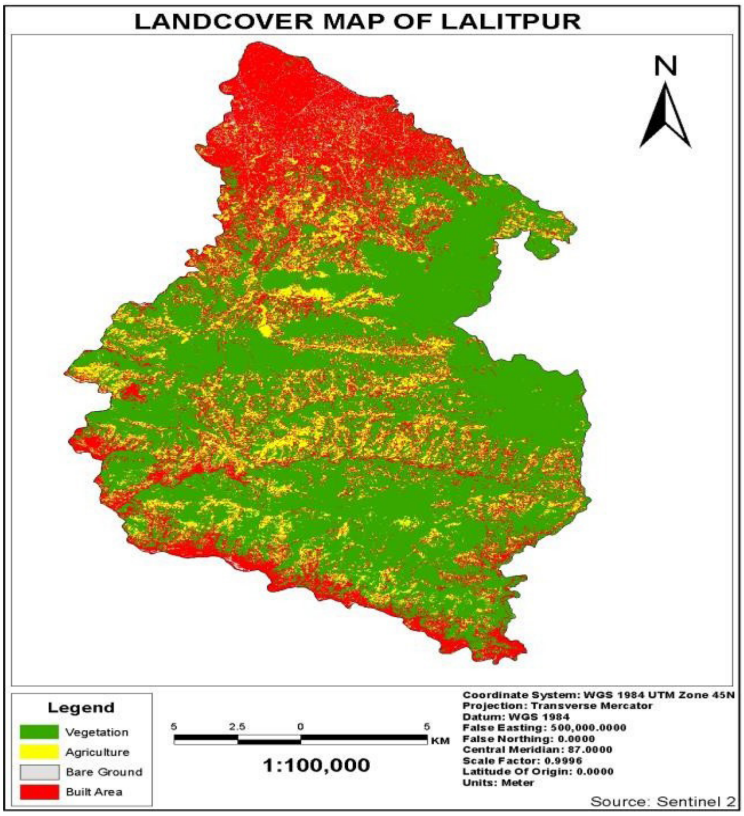


Figure 4: Comparison of re-classified(Global) andSupervised(local) land cover and final lancover map of Lalitpur



The above classified chart shows that the bare ground is zero percent, but it doesn't mean that there is no bare ground. This result was the outcome due to the round off of extremely negligible area. And the vegetation, agriculture, and built area are 57, 23 and 20 percent respectively in global classified land cover. However, in case of the supervised classification chart the percentage of the classification are either increased or decreased which may be differed due to the change in season of the year or the classification techniques. We can see that the differences in agriculture, built area and bare ground are 6%, 5%, and 1% percent respectively which is acceptable.

7. Conclusion

The multispectral satellite image was classified through unsupervised and supervised classification. The result of the supervised and unsupervised classification is shown in four land cover classes. Theclasses were vegetation, bare land, agriculture and built up area. The CM results by using ground truth ROIs were found to be high overall accuracy for Lalitpur district. The overall accuracy and the kappacoefficient were used to compare the two datasets viz; local and global. The result shows the local landcover data have overall accuracy and kappa coefficient higher than the global land cover data i.e,ESRI 2020.

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Geographic and Projected Coordinate System of Nepal

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First of all, one needs to be clear about the difference between a geographic coordinate system (GCS) and a projected coordinate system (PCS). A GCS defines where the data is located on the earth's surface and is based on a spheroid and utilizes angular units (degrees) whereas, PCS is based on a plane (the spheroid projected onto a 2D surface) and utilize linear units (feet, meters, etc.). A geographic coordinate system (GCS) uses a three-dimensional spherical surface to define locations on the earth. A GCS is often incorrectly called a datum, but a datum is only one part of a GCS. A GCS includes an angular unit of measure, a prime meridian, and a datum (based on a spheroid). Unlike a geographic coordinate system, a projected coordinate system has constant lengths, angles, and areas across the two dimensions. A projected coordinate system is always based on a geographic coordinate system that is based on a sphere or spheroid.

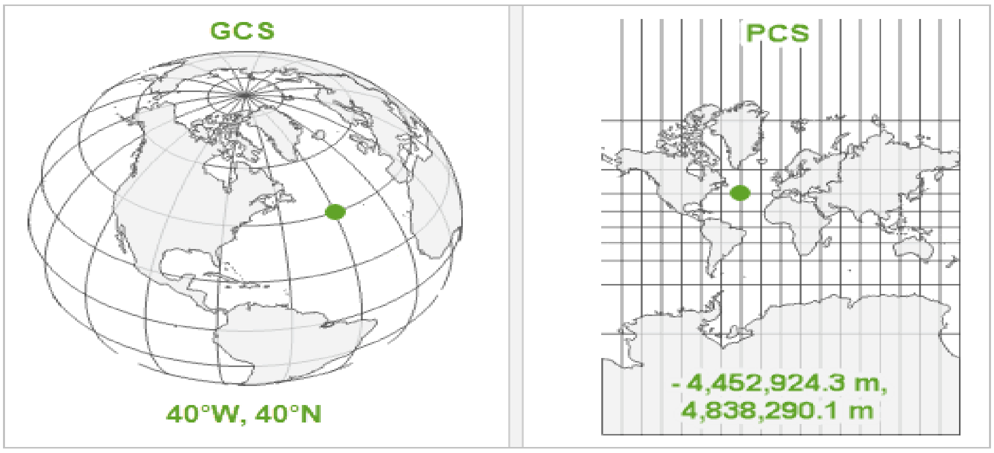

Figure 1: Geographic coordinate system (GCS) and a projected coordinate system (PCS).

In Nepal, the maps produced by the Survey Department are in Everest 1830, but the data available over the internet, google earth, or other secondary and primary sources are referenced in WGS84. The World Geodetic System (WGS) is a standard for use in cartography, geodesy, and satellite navigation including GPS. The coordinate origin of WGS 84 is meant to be located at the Earth's center of mass; the uncertainty is believed to be less than 2 cm.

Table 1:Everest 1830 and WGS 1984

GCS	Everest_1830	WGS_1984
Angular Unit	Degree (0.0174532925199433)	Degree (0.0174532925199433)
Prime Meridian	Greenwich (0.0)	Greenwich (0.0)
Datum	D_Everest_1830	D_WGS_1984
Spheroid	Everest_1830	WGS_1984
Semi-major Axis	6,377,276.345	6s378137
Semi-minor Axis	6356075.413	6356752.314
Inverse Flattening	300.8017	298.2572236

Universal traverse Mercator (UTM), a plane coordinate grid system named for the map projection on which it is based (Transverse Mercator) is used in Nepal. The UTM system consists of 60 zones, each 6-degrees of longitude in width. The zones are numbered 1-60, beginning at 180-degrees longitude and increasing to the east. Similarly, the zone is divided north-south with a difference of 8^0. This zone extends from 80^0 S Latitude to 84^0 N latitude. Based on WGS84, Nepal lies in two zones of the UTM projection system which are 44^0N and 45^0N dividing the country into two half. On the other hand, due to the larger East-West extent of Nepal, UTM has been modified, based on Everest 1830, where the earth is divided into 120 zones each of 3^0 and Nepal lying on three zones with a central meridian of 81^0, 84^0, and 87^0. Each of these three zones of modified UTM (MUTM) covers west, central and eastern Nepal respectively. The following table gives a clearer overview of the PCS mentioned above

. **Table 2:** WGS 1984 based PCS and Everest 1830 based PCS

Reference	**WGS 1984 based PCS**	**Everest 1830 based PCS**
Zones	UTM 44^0N & 45^0N	MUTM 81^0,84^0 & 87^0
Projection	Transverse Mercator	Transverse Mercator
False Easting	500000	500000
False Northing	0	0
Central Meridian	81 & 87	81, 84 & 87
Scale Factor	0.9996	0.9999
Latitude of Origin	0	0
Linear Unit	1	1
GCS	WGS 1984	Everest 1830

To transform the data layer from MUTM to UTM, there is a need to transform data from Everest 1830 to WGS 1984. For this following parameters are used.Source GCS: Everest 1830 and Target GCS: WGS 1984
Molodensky method
Translation parameters:
Translation along X axis (in meters) = 293.17
Translation along Y axis (in meters) = 726.18
Translation along Z axis (in meters) = 245.36
In order to do the geographic transformation from WGS 1984 (Source GCS) to Everest 1830 (Target GCS) we use the same method with the same values with negative signs in front.

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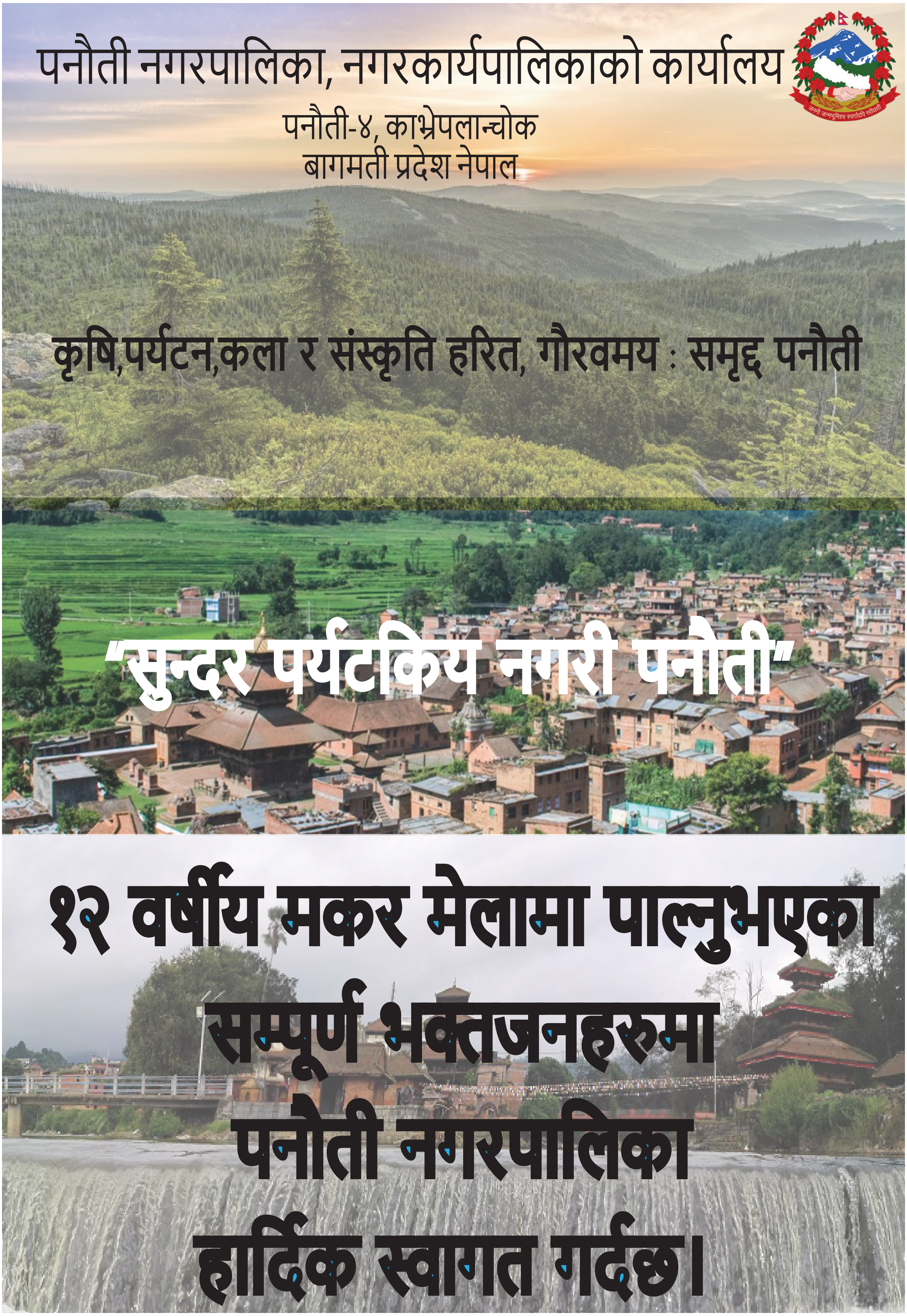
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