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GEOSPACE

VOLUME IX

Annual Geo-ICT Magazine of Geomatics Engineering Society (GES)
Kathmandu University, Department of Geomatics Engineering

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EDITORIAL

We are honored to have been able to continue the tradition of the GES annual Geo-ICT magazine "GeoSpace" and are thrilled to publish the ninth volume of GeoSpace magazine. Since its founding, Geospace has unquestionably helped educators, professionals, students, and novices alike by bridging the knowledge gap with all of the accomplishments, discoveries, and research in the field of geoinformatics. The ninth edition carries on that legacy.

GeoSpace's success is the result of a diverse group of contributors. I want to start by expressing my gratitude to the entire Department of Geomatics Engineering for their unwavering leadership and assistance. I would like to take this opportunity to thank each and every author for their insightful submissions to the magazines; it is because of their work that our magazine is so profound.

Without our tireless team and all the helping hands that have worked day and night to make this magazine a reality, we could not have accomplished this. It serves as a reminder that advancement is fueled by the combined efforts of innumerable committed people.

I hope this issue is of great importance to each and every one of you. I hope everyone enjoys their reading!

Rishav Khatiwada
Chief Editor
GeoSpace Volume IX

MESSAGE FROM VICE CHANCELLEOR

Prof. Dr. Bhola Thapa
Vice Chancellor
Kathmandu University

It gives me great pleasure to view the ninth edition of the yearly Geo-ICT magazine Geo-Space, which is published by the Geomatics Engineering Society (GES), the departmental club of Kathmandu University's Geomatics Engineering. 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.

"GES" has been bringing forth various geospatial issues through articles, interviews, research papers and others, authored by the students, faculties, alumni and professionals working ideas showcasing the talents and engagements of our students, which provide opportunity to enhance their knowledge and skills.

With our nation entering the decentralization era that drives development, there is a growing need for geomatics engineering knowledge. I have high hopes that our Geomatics Engineering team will contribute to this by offering locally relevant, applicable expertise and knowledge. Working together, we will open up opportunities for societal advancement and growth. I am confident that in coming days, GES will take our institution to newer heights and will actlike 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 offer my support and best wishes for their future endeavors.

MESSAGE FROM REGISTAR

Prof. Dr. Achyut Wagle
Registar
Kathmandu University

I am very pleased to know that the Geomatics Engineering Society (GES), a departmental club of the Department of Geomatics Engineering is releasing their IX volume of the magazine 'GEOSPACE'. I extend my heartiest congratulation for this accomplishment. Through this magazine, it is the club's duty to impart positive impact on everyone involved – those working on the magazine and those who will read it. It is a way for GES to show how much work as a departmental club, representing all the students, has done and will do. And finally, this magazine is a platform that help the students to show their creativity through the vast collection of ideas and knowledge present within them and the skills that cannot be learntin the class. To publish a magazine is challenging task. But GES has taken the initiation to continue this path. I am confident that this achievement is something which will allow the juniors and newcomers to look a badge of experience and this experience can further contributes to excel in the future while they are into their respective professional field.

Moreover, the Department of Geomatics Engineering has developed an outstanding national and international reputation for academic and research activities. I hope that the department will continue achieving its mission with disciplined students, dedicated teachers and cooperative staff and finally continue to strengthen the status of our school. I sincerely congratulate the team of GES for publishing this magazine and kudos to the hard work. I wish all the best for the future endeavors.

MESSAGE FROM DEAN

Prof. Dr. Manish Pokharel
Dean OF School of Engineering
Kathmandu University

I'm Pleased to hear that the Department of Geomatics Engineering, in partnership with the Geomatics Engineering Society (GES), is gearing up to launch the latest edition of 'GEOSPACE Vol. IX: GES's Annual Geo-ICT Magazine.' The creation of this magazine has involved a significant amount of effort and I am confident that readers will appreciate the hard work that has gone into it. Thank you for publishing thiswonderful magazine. It serves as an excellent reminder of how to tackle the opportunities and challenges that geomatics engineers face on a regular basis.

It is crucial to remember that "GEOSPACE Vol. IX" is the result of the combined ideas of several creative faculty members and students who have contributed significantly to the magazine. I am proud of the editorial team and grateful for their individual and collective knowledge, talent, judgement, and disciplinary backgrounds, which have advanced engagement.

I offer my congratulations and best wishes to the GeoSpace team, GES, and the Department of Geomatics Engineering for the publication. I appreciate your effort and commitment to achieving our common objectives. I'm excited about the prospect of many more productive discussions and partnerships.

MESSAGE FROM NEPAL ENGINEERING COUNCIL

Dr. Bikash Adhikari

Assistant Professor,Kathmandu University
Vice Chairperson, Nepal Engineering Council

A hearty "hi" to everyone! My name is Bikash Adhikari, and I hold the positions of vice chairperson of the Nepal Engineering Council and assistant professor at Kathmandu University. It is also a privilege for me to have been a member of the University Grants Commission in the past. It gives me great pleasure to present the eighth edition of the yearly magazine Geospace, which is published by the Geomatics Engineering Society (GES), the departmental club of the University of Kathmandu's Geomatics Engineering department.

As a pillar of our engineering community, the Nepal Engineering Council (NEC) is committed to advancing innovation, upholding professional ethics, and encouraging excellence. The NEC is responsible for administering the engineering licensing examination, which is one of its major roles. Our goal is to guarantee that individuals who obtain their licenses are not only knowledgeable about theory but also capable of handling real-world problems that arise in the engineering field.

I offer my congratulations and best wishes to the GeoSpace team, GES, and the Department of Geomatics Engineering for this publication. We appreciate your time and commitment to achieving our common objectives. I look forward to the possibility of many more fruitful collaborations and discussions.

MESSAGE FROM HOD

Dr. Reshma Shrestha
Head of Department
Geomatics Engineering
Kathmandu University

I am delighted to address you on the occasion of the release of GEOSPACE vol. VIII: Annual Geo-ICT magazine of GES. Let me start my message with a quotation and a scientific statement.

“Knowing where things, are why, is essential to rational decisions”. Jack Dangermond, ESRI. Eighty percent of data used by decision makers are geographically related” (Worrall 1991). Hence ,”Spatial Enabled Society” is today’s need to tackle any issues that are embedded at global, national and local level. Without any doubt, I can say that ”GEOSPACE” is one of the ”GEO knowledge hubs” which can capture a range of readers from the Geospatial Community by offering some interesting pieces of “ Geo Literacy” and ”Geo Science”. Therefore, the series of this magazine has grown to be a beacon of knowledge and innovation, not only for professionals in the field of surveying and mapping but also for the wider scientific community and researchers.

It brings me immense joy to extend my heartfelt congratulations to the entire team, including our dedicated students, esteemed faculty members, and diligent staff, for their collective efforts in bringing “ Geospace Vol. VIII” to fruition. Department of geomatics engineering, stands as a testament to our commitment to excellence in education and research by connecting “data, Technology and Society”. Overtime, we have grown dynamically, offering a comprehensive range of programs from undergraduate to doctoral levels in collaboration with LMTC. Our state-of-the-art labs, and teaching/ learning pedagogies that include project based and inquiry based approaches, reflect our dedication to providing our students with the best possible learning environment.

MESSAGE FROM LMTC

Janak Raj Joshi
Executive Director
Land Management Training Center

It is with great pleasure that I have the privilege of sharing my message in the latest issue of GeoSpace Vol. IX. I would like to extend my heartfelt gratitude to the editorial team and the entire GES community for their unwavering dedication, enthusiasm, and hard work in producing such a high-quality publication.

Each successive issue of GeoSpace demonstrates growing maturity, reflecting the professional dedication and enthusiasm of our future geomatics engineers. I am confident that the dedication instilled in these students from the start will lead to successful careers, and I have great faith in this dynamic group of future geo-stars. For those new to GeoSpace, allow me to introduce the LMTC, the organization I represent. LMTC is the only government training center dedicated to producing skilled human resources and enhancing the capabilities of government officials in surveying, mapping, and land management. LMTC played a pivotal role in establishing the Geomatics Engineering courses at Kathmandu University (KU). Since the collaboration between LMTC and KU began in 2007, it has continued to strengthen each year. LMTC is committed to ensuring that the profession is continually enriched by the high-quality education provided to new graduates, a commitment that will persist in the years to come.

I extend my heartfelt thanks to the editorial team and the entire GES community for their devotion, dedication, and enthusiasm in publishing such a high-quality magazine. Their efforts significantly contribute to the professional development of both students and practitioners. Reading GeoSpace is a refreshing experience that keeps you informed and inspired on Geospatial technologies, its developments and innovations. Enjoy your time with GeoSpace, and let it be a source of knowl-

MESSAGE FROM GES

President
Geomatics Engineering Society
Department of Geomatics Engineering
Kathmandu University

Greetings to all readers and enthusiasts of geospatial science,
The publication of our Geospace Magazine, now in its ninth volume, continues to showcase the hard work, creativity, and commitment of our members. This year's "Annual Geo-ICT Magazine of GES, Volume IX" upholds our tradition of excellence in learning, sharing, and contributing to the field of geospatial science and technology.

Producing this magazine required immense teamwork and dedication. I am deeply grateful to my team for their unwavering support and tireless efforts. Their passion turned our vision into reality. I extend my heartfelt thanks to all the contributors, from writers and editors to designers and coordinators, who have made this publication possible.

Geospace began with the aim of providing exposure to students' projects and offering them a platform to showcase their talents. We continue to encourage innovation and creativity, helping students and researchers enhance their analytical capabilities. The articles and research papers in this volume reflect the vibrant intellectual activity within our community.

I would like to express my gratitude to all the organizations, institutions, and individuals who have supported us. Your support and collaboration have been instrumental in our success.
In closing, I wish everyone a wonderful reading experience. May the insights and knowledge shared in this magazine inspire you and contribute to your professional and personal growth.

HIGHLIGHTS

विशेषज्ञ

GEOMATICS ARTICLE

STUDENTS' ARTICLE

नेपालमा जियोम्याटिक्स इन्जिनियरिङ्गको सुरुवात

बाबुराम आचार्य

पूर्व सचिव भुमिव्यबस्था, सहकारी तथा गरिबी निवारण मन्त्रालय

पूर्व कार्यकारी निर्देशक भुमि व्यवस्था प्रशिक्षण केन्द्र

मल्लकाल देखि यता हेर्दा जग्गाको नापी डंगोल जातिहरुले 'टाँगो' को सहाराले गर्थे । प्रथम विश्वयुद्द लडेर फर्केका गोर्खा सैनिकहरुले नाप नक्साको केहि ज्ञान प्राप्त गरेर फर्केका हुनाले सरकारले "मिलिटरी कम्पास स्कुल" स्थापना गर्यो जसलाई "कम्पासे" नापी भनिन्थ्यो । पछि यसैलाई काठमाडौँको सुन्धारामा अमिन तालिम भनेर नामाकरण गरियो । यो कार्यक्रम ३ वर्ष सञ्चालनमा आएपछि बन्द भयो, सन् १९५० (बि:स २००७) को क्रान्ति पछि सरकारले भूमिसुधारको कार्यक्रमलाई जोड दियो।

त्यसपछि नापी गर्ने उद्देश्यले नापी गोश्वाराहरु खडा गरिए जसको निरन्तरतामा २०२१ साल देखि भूमिसुधार अभियान सुरु भयो र नापी गोश्वाराहरु परिचालित भए। उता नापी गोश्वाराहरुलाई आवश्यक पर्ने जनशक्ति/अमिन तालिम २०१४ ,२०१८ ,२०२० ,२०२१ सालमा दिइयो भने On The JOB तालिम पनि दिइयो।

UNDP अन्तर्गत बेलायती विज्ञ JRG HARVOP २०२१ सालमा नापी विभागको निर्देशक भई जिम्मेवारी सम्हाल्नु भयो अनि २०२४ सालमा नापी तालिम केन्द्र स्थापना गर्नभयो, जनशक्ति उत्पादन गर्न उहाँले दुइवटा बाटो अपनाउनुभयो, एउटा विभागीय तालिम गराउने र अर्को योग्यता पुगेकाहरुलाई शिक्षा मन्त्रालयबाट छात्रवृत्तिमा भारत, बेलायत, रसियामा पढ्न पठाउने, उहाँको १५ वर्ष मा "B.E. IN LAND SURVEY ENGINEERING" मा डिग्री अध्यापन नेपालमै सुरु गर्ने योजना थियो तर पछि कसैले अङ्गीकार गरेनन् र योजना विफल भयो । क्रमशः नापी तालिम केन्द्रले विभागीय कर्मचारीलाई जुनियर र सिनियर तालिम दिने र आइ. एस्सी. गणित र विएसी गणित भएकालाई खुल्ला प्रतियोगिताबाट छनौट गरी क्रमश, जुनियर सर्भेयर कोर्ष र सिनियर सर्भेयर कोर्ष सञ्चालन गर्न सुरु गर्यो । यसका लागि प्रारम्भमा ५, ७ वर्षका लागि भारतको ICM (Indian Cooperation Mission)बाट देहरादून र हैदरावादका शिक्षकहरु आउनु हुन्थ्यो । म आफैं यस विधामा २०३३ सालदेखी प्रवेश गरेपछि नै नापीको युनिभर्सिटी कोर्सको आवश्यकता महसुस गर्न थाले, जसका चारवटा कारणहरु थिए :

- धेरैजसो कृषि, वन, मेडिसिन विषयका डिग्री कोर्स भइसकेकाले नापी विषयको पनि हुनुपर्ने थियो ।
- विदेशी सँग कुराकानी हुँदा "तिम्रो देशमा कतिवटा सर्भे इन्जिनियरिङ कलेज छन्?" भनेर सोध्यो भने के भन्ने ?
- एकेडेमिक कोर्स अपरिहार्य छ , किन ढिलो गर्ने ?
- People related subject , scientific subject and utility and/or infrastructure subject भएकाले एकेडेमिक कोर्सको खाँचो महसुस भयो ।

त्यसैले आफूले सकेसम्म डिग्री खोल्न लेख मार्फत बोलियो, तर अरुले साथ दिन चासो नगर्दा सम्भव भएन। अझ नापी विभागको योजना शाखामा बस्दा त सर्भे इन्जिनियरिङको स्नातक कक्षा सञ्चालन गर्न भनेर वार्षिक र अर्धवार्षिक योजना समेत समावेश गरियो तर कार्यान्वयन भएन ।

त्यस बेलासम्म पनि विभागीय प्रमुखहरुले वास्ता गर्नु भएन भने अरूले चासो राख्नुभएन त्यसपस्चात, २०६२ सालमा मेरो सरुवा भूमि व्यवस्थापन प्रशिक्षण केन्द्र, साविकको नापी तालिम केन्द्र धुलिखेलमा भयो ।

अनि मैले जियोमेटिक्स इन्जिनियरिङ कोर्स सञ्चालन गर्न काठमाडौं विश्वविद्यालयका तत्कालीन स्कुल अफ इन्जिनियरिङका डिन हालका उपकुलपति डा. भोला थापा ज्यू सँग बिस्तृत छलफल गरें ,उहाँ सकारात्मक पनि हुनुभयो, त्यसपछि हामीले उपकुलपति डा. सुरेश राज शर्मा सरसँग कुरा गर्यौं र मेरो प्रस्ताव प्रशिक्षण केन्द्र सम्पूर्ण काठमाडौं विश्वविद्यालयलाई हस्तान्तरण गर्ने थियो तर सुरेश सरले यो नयाँ विषय भएकाले सरकार र विश्वविद्यालय सहकार्य गरि चलाउने कुरा गर्नु भयो । सोही अनुसार प्रारम्भमा विद्यार्थीहरुलाई ७५ प्रतिशत शुल्क सरकारले छात्रवृत्ति दिने निर्णय गरी कक्षा प्रारम्भ गरियो, ५ वर्षपछि फेरि मास्टर्स खोल्न केयूलाई म आफैं पटकपटक अनुरोध गरे, अलि ढिलो गरी भए पनि सञ्चालन हुन थाल्यो ।

यसै बीचमा त्रिभुवन विश्वविद्यालय अन्तरगत इन्जिनियरिङ्ग अध्ययन संस्थान पनि सञ्चालन गर्न अनुरोध गरिरहेका थिए, क्याम्पस चाँडै सकारात्मक भयो र सन् २०१३ मा बि.ई कक्षा सुरु भयो, हाल मास्टर्सको कोर्स पनि सञ्चालन भएको छ जसका लागी प्रा देवराज पौडेलको पनि सक्रियता छ, उहाँ पढाउने अष्ट्रेलियाको Queensland University सँग सहकार्य भइरहेको छ ।

हाल विद्यार्थीहरूको संख्या घट्दो छ, रिसर्च बिधामा पनि प्रोत्साहन गर्नपर्ने बेला भएकाले Masters by Research कोर्ष सञ्चालन गर्दा राम्रो हुनसक्छ , साथै विद्यावारिधिको पनि सुरुवात गर्ने बेला भइसक्यो ।

" जहाँ इच्छा त्यहाँ उपाय "

अब विश्वविद्यालयले सहयोग गरीदिनुपर्ने ऐनअनुसार नापी विभागले लाइसेन्स प्राप्त सर्भेयरको अविलम्ब व्यवस्था गर्नपर्ने देखिन्छ, विकास मन्त्रालय, स्थानीय तह र सम्बन्धित क्षेत्रमा जियोमेटिक्स सेवा विस्तार गरि जियोमेटिक्स को महत्व बुझाउने र आवश्यक सहयोग प्राप्त गर्न पनि सकिन्छ ।

Application of Spatial Digital Twin in the Context of Nepal

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KEY WORDS: digital twin, 3DGIS, geospatial, BIM, IoT

ABSTRACT:

Digital Twin (DT) technology, defined as a virtual representation of real-world entities and processes synchronized at a specified frequency and fidelity, has emerged as a powerful tool across various industries worldwide. In the context of Nepal, the integration of spatial digital twin technology holds immense promise for enhancing decision-making processes and improving social, economic, and environmental outcomes. This paper explores the applications of spatial digital twin technology in the context of Nepal across six sectors, design and construction, smart utilities, geospatial, land administration, traffic management, and disaster management through literature review approach. Each application areas are briefly discussed. This paper outlines the challenges faced in integrating spatial digital twin technology in Nepal, such as the lack of infrastructure resources, insufficient skilled human resources, and lack of awareness. Possible solutions to overcome these challenges are proposed, including attracting investments, capacity-building initiatives, and raising awareness among stakeholders. By addressing these challenges and leveraging the opportunities presented by spatial digital twin technology, Nepal can pave the way for infrastructure development, operational efficiency improvement, and overall societal advancement.

Keywords: Spatial digital twin, BIM, IoT, 3DGIS

1. INTRODUCTION

Digital Twin (DT) is a “virtual representation of real-world entities and processes, synchronised at a specified frequency and fidelity” (Digital Twin Consortium, 2022). It also acts as a tool that supports the effective use of data to understand the place-based policy and planning issues, test potential interventions, and deliver more sustainable planning and development; thereby improving decision making efficiency and effectiveness and improving social, economic, and environmental outcomes (ANZLIC, 2019). Currently, many industries such as manufacturing, health, agriculture, and mining are developing their digital twin to build digitally enabled business systems. Among these industries, the spatial industry is also considered to build digital twins (WGIC, 2022). However, until 2021 there wasn’t any formal definition that could integrate digital twin with spatial context. In early 2022 WGIC (2022) introduced a new terminology called “spatial digital twin” to integrate spatial value and digital twin. Spatial digital twin is the digital twin that includes “a specific spatial context and provides a holistic; dimensionally accurate and location-based representation of assets, infrastructure and systems”.

Accordingly, a study carried by WGIC (2022) investigated that 13 sectors have initiated the building of digital twins in spatial context. The 13 sectors include Infrastructure, Utilities and Construction, Public Sector & Defense, Real Estate / Property Development / Asset or Facilities Management, Transport & Logistics, Energy, O&G, Mining, Renewables), Manufacturing /Product Development and Consumer Goods, Telecommunications, Industrial & Heavy Manufacturing, Technology & ICT Service Providers, Healthcare, Agriculture, Institution, Association or Professional Body/Organisation, and Finance & Insurance. Among these, infrastructure, utilities and construction are very strong contributors to digital twin initiatives whereas the oil and gas industry is the fifth contributor to digital twin initiatives (WGIC, 2022).

Research in the field of spatial digital technology (DT) and its applications, particularly in the context of Nepal, is still relatively limited because it is an emerging concept. While there is growing recognition of the potential benefits of DT in addressing various challenges across sectors such as urban planning, disaster management, infrastructure development, and natural resource management, there is a lack of literature focusing on the applications of DT to Nepal’s context. Therefore, there is a need for literature that explores the practical applications of spatial DT in addressing Nepal’s specific development challenges, providing actionable insights for policymakers, practitioners, and scholars. This article could be point of departure for the developing spatially enabled DT for Nepal.

2. METHODOLOGY

To achieve the aim of this study, literature review approach was used as illustrated in Figure 1. Firstly, the different resources were searched using the keywords such as digital twin, 3DGIS, UAV, IoT, BIM. The reviewed articles encompass journal papers, webpages, government reports, corporate reports, article, blogs etc. Then after using the application categories defined on WGIC (2022), applications of spatial digital twin were classified in the context of Nepal. The categorized applications are discussed in next section.

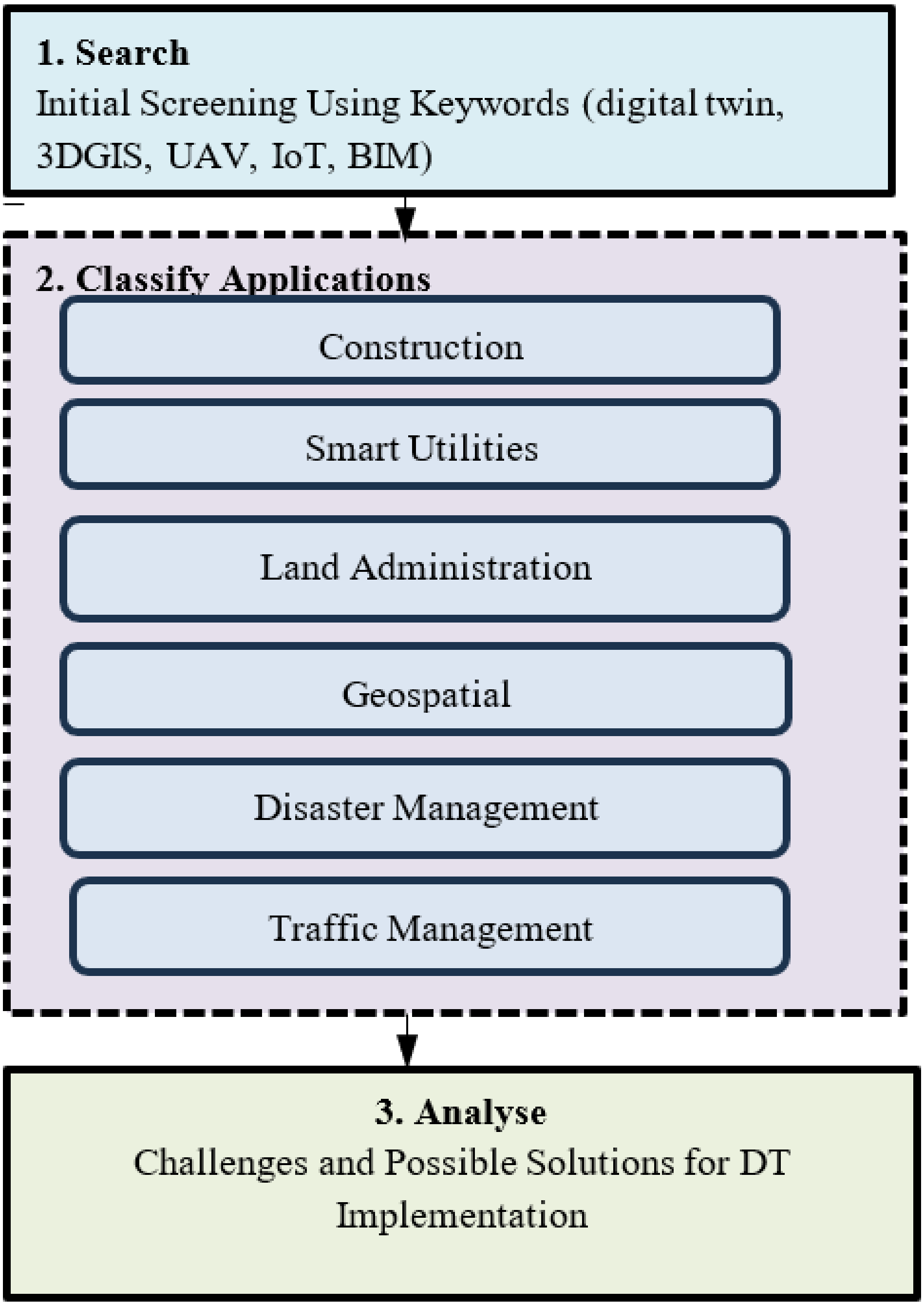

Figure 1 Methodology

3.APPLICATIONS OF SPATIAL DIGITAL TWIN IN THE CONTEXT OF NEPAL

3.1 Design and Construction

Nepal being a developed country there are numerous construction activities carrying out across the country. Leveraging the spatial DT could be promising technology. A study carried out by the Zhang et al (2024) has outline that spatial DT can be used throughout any typical construction project that support in enhancing productivity, safety and management. Similarly, Yitmen et al. (2021) reveal that use of the spatial digital twin technology also facilitates in entire life cycle of building project from design, construction, operation and maintenance, renovation, and demolish. Furthermore, a study carried out by Abdolrasol et al. (2021) has also leverage spatial DT technology (BIM) to construct a static model of the tunnel scene that conforms to the real tunnel main structure. To implement this technology in the context of Nepal for construction industry Department of Roads and Department of Urban Development and Building as shown on Figure 2 should take an initiative for piloting few projects and assessing its feasibility in the context of Nepal. The spatial digital twin offers very detailed construction design for roads and buildings as illustrated in Figure 3 developed by Bentely company (Bentley, 2020).

Figure 2 Authorities for construction sectors

Figure 4 Authorities for utilities sectors

Figure 3 Spatial DT developed by Bentley
Source: (Bentley, 2020)

3.2 Smart Utilities

Spatial DT technology, by creating virtual replicas of physical assets, processes, and systems, offers significant enhancements to the management of telecommunications and electrical utilities in Nepal. For the Nepal Electricity Authority (see figure5), DT technology enables improved asset management, enhanced grid monitoring, and optimization of operations, thereby increasing efficiency and reliability. Also, Nepal Telecom (see figure5) can similarly benefit through infrastructure monitoring, network optimization, and better planning and development. A study by Fernandes et al. (2022) has shown that using DT technology in electrical distribution systems significantly improves workforce operations by providing real-time data and predictive analytics, leading to proactive task prioritization, cost savings, and improved service reliability. The spatial DT of utilities visually represents the interconnected infrastructure, aiding in strategic planning and operational efficiency. A spatial DT application developed by Kwak (2019) is demonstrated in Figure 5.

Figure 5 Spatial DT model for utilities
Source: (Kwak, 2019)

3.3 Geospatial

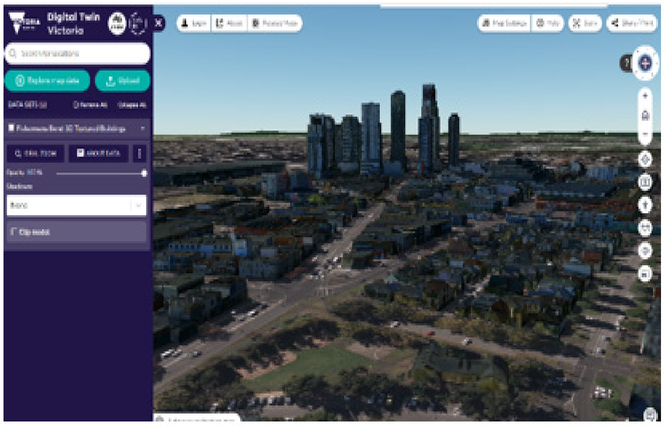

Figure 6 DT platform of victorian government
Source: (Victoria Government, 2024)

The use of spatial DT technology is revolutionizing the management of large-scale geospatial datasets by providing an advanced platform capable of handling multiple formats, including 2D, 3D, and even 4D representations (WGIC, 2022). This technology is leveraged by the Digital Twin Victoria platform developed by the Victorian government in Australia as shown in Figure 6. Developing a similar platform in Nepal could significantly enhance the management of geospatial archived in the National Geoportal's developed by Survey Department, Nepal (See figure7) which are limited to 2D visualization. By incorporating various geospatial datasets into a digital twin platform, it would offer real-time data access and comprehensive visualization capabilities. Users would benefit from the ability to view and analyze data in multiple dimensions, enabling a deeper understanding of spatial relationships and temporal changes.

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

Figure 7 Authority for geospatial sectors

3.4 Land Administration

With increase in urbanization number of multi-story and high-rise buildings are also increasing. Consequently, the conventional land administration methods, primarily reliant on 2D cadastral maps, face challenges in Nepal. Recognizing this, there arises an urgent necessity to integrate spatial DT technology into the existing land administration framework. Spatial DT technology offers the capability to visualize multi-dimensional models in 3D, providing a clearer depiction of rights, responsibilities, and restrictions (RRR) associated with land parcels. An illustrative example is depicted in the Figure 8. This integration would not only address the limitations of traditional methods but also enhance accuracy and efficiency in managing land rights and regulations amidst the evolving urban landscape. Therefore, the responsible authority (See figure7) can take initiatives and assess the feasibility of spatial DT for replacing the current land administration process.

Figure 8 DT for land administration
Source: (Kwak, 2019)

3.5 Traffic Management

In the context of Nepal, urban traffic is significant problem. The spatial DT could play a pivotal role to address the traffic management challenges in the urban areas of Nepal. For example, in the Kathmandu metropolitan city, department of traffic management (see figure9) has limited technology to control the traffic volumes. This could be addressed leveraging the spatial DT technology. With the development of Internet of Vehicles (IoV) and 5G communication technology, the generation of real-time traffic data has become abundant (Gao et al., 2024). A study carried out by Li & Zhang (2023) reveals that integrating the DT technology can enable the traffic system not only to use past and present information, but also to predict traffic conditions, providing more effective optimization for autonomous driving and intelligent transportation, to make long-term rational planning of the overall traffic state and enhance the level of traffic intelligence. The Figure 10 illustrate the use of the DT technology for traffic management.

यातायात व्यवस्था विभाग
Ministry of Physical Infrastructure
Department of Transport Management

Figure 9: Authority for traffic management

Figure 10 Traffic management using DT technology
Source: (Li & Zhang , 2023)

3.6 Disaster Management

Nepal's susceptibility to natural disasters like landslides, floods, and earthquakes underscores the critical need for effective disaster management strategies. Leveraging spatial digital twin technology could be highly beneficial. By integrating this technology into disaster management efforts, authorities (see Figure 12) can gain valuable insights and make more informed decisions to mitigate risks and respond effectively to emergencies. One example of digital twin technology applied to disaster management is the Hydrological Information and Prediction (HIP) system in Denmark (Henriksen et al., 2023). This system demonstrates the integration of real-time dynamic updating with digital twin technology to enhance disaster preparedness and response. The responsible authority (see Figure12) should take an initiative to fully implement disaster risk reduction and management authority (NDRRMA) to upgarade the existing Bipad portal in the form of spatially enabled DT platform for disaster management.

Figure 11 DT for flood prediction
Source: (Mankowski,2020)

Government of Nepal
Ministry of Home Affairs
National Disaster Risk Reduction and Management Authority

Figure 12 Authorities for disaster management

4. CHALLENGES AND ITS POSSIBLE SOLUTIONS

Spatial digital twin technology is a revolutionary concept that offers a multitude of benefits across various sectors, including construction, smart utilities, geospatial, traffic management, and disaster management. systems, and other utility infrastructures. Despite its immense potential, integrating spatial digital twin technology in a country like Nepal poses significant challenges. One major obstacle is the lack of infrastructure resources. Nepal may struggle with inadequate internet connectivity, power supply, and computing infrastructure necessary to support the complex data processing and communication requirements of digital twin systems. Additionally, there is a shortage of skilled human resources with expertise in digital twin technology. Without a sufficient number of trained professionals, the development, implementation, and maintenance of digital twin systems become challenging. Furthermore, there is a general lack of awareness about digital twin technology among stakeholders and policymakers in Nepal. Currently, they may not fully understand the concept of spatial DT and its potential applications and benefits. There is also lack of awareness that hinder efforts to secure funding, support, and drive adoption of digital twin initiatives across different sectors. To address these challenges, concerted efforts are needed. Attracting investors willing to invest in infrastructure development and technology deployment is crucial. These investments can help improve internet connectivity, upgrade computing infrastructure, and establish training programs. Additionally, capacity-building initiatives, such as educational programs, integrating it into university curriculum and workshops, can help address the shortage of skilled professionals in the field of digital twin technology. Moreover, spreading awareness about the capabilities and benefits of digital twin technology is essential. Awareness campaigns, workshops, and training sessions can educate stakeholders about the potential applications of digital twins in improving infrastructure resilience, optimizing resource management, and enhancing decision-making processes. By overcoming these challenges, Nepal can unlock new avenues for infrastructure development, enhance operational efficiency.

5. CONCLUSIONS

In conclusion, the emergence of DT technology has offered transformative potential across diverse industries globally. Within the context of Nepal, the integration of spatial digital twin technology could be also a promising avenue for enhancing decision-making processes and driving positive socio-economic and environmental outcomes. Through an exploration of its applications in six key sectors, design and construction, smart utilities, geospatial, land administration, traffic management, and disaster management this paper outlines the impact that spatial digital twin technology can have on Nepal's development. However, there are significant challenges, including the lack of infrastructure resources, a deficit of skilled human resources, and a lack of awareness about this technology. To address these challenges solutions such as attracting investments, capacity-building initiatives, and raising awareness among stakeholders, Nepal can fully leverage benefits of spatial digital twin technology.

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Wetland vegetation mapping with Hyperspectral Imagery using OBIA.

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Keywords: OBIA, Machine Learning, Wetland Vegetation, ArcGIS Pro, Accuracy Assessment

Abstract:

Hyperspectral Remote Sensing imagery combined with Object-Based Image Analysis (OBIA) offers a robust method for mapping wetland vegetation. This study explores the classification of wetland vegetation focusing on the Fort Drum Marsh Conservation Area (FDMCA) within the St. Johns River Water Management District using OBIA and Machine learning techniques. The research utilizes Hyperion EO-1 imagery acquired in 2003 and reference datasets to classify eight wetland vegetation communities. Utilizing Random Forest (RF) and Support Vector Machine (SVM) algorithms, the study achieves overall accuracies of 83.6% and 80.5%, respectively, with RF demonstrating higher performance. However, challenges such as misclassifications persist, particularly in distinguishing between similar vegetation classes. Despite limitations inherent in coarse-resolution imagery and potential misclassifications, the study highlights the efficacy of OBIA integration with machine-learning techniques for wetland vegetation mapping. It emphasizes the significance of post-classification assessment for improving accuracy and identifies areas for future improvement.

1. Introduction:

Satellite-based imagery is an essential approach for examining changes and mapping wetlands. Using hyperspectral imagery makes it easy to detect patterns and discern the types of vegetation or land cover categories. It provides high spectral resolution data, allowing it to detect subtle differences in vegetation. This capability is precious in wetland environments, where vegetation plays a significant role in ecological functions. It gives opportunities to obtain more scrutinized information than other multispectral data. This technology has been promising in geospatial research, monitoring, and exploration applications (Shipert, 2004) and wetland vegetation classification (Zhang & Xie,2013). Classification of wetland vegetation using hyperspectral remote sensing and Object-Based Image Analysis (OBIA) can be a convincing means for monitoring and managing wetlands. OBIA offers a more precise and detailed analysis compared to pixel-based methods. It is commonly known that a pixel-based classification approach leads to an effect known as “salt and pepper” during mapping heterogeneous landcover types. This effect can be mitigated using OBIA and is valuable and promising for vegetation classification (Zhang & Xie,2012). It operates by grouping similar pixels into ‘objects,’ which can then be classified based on spectral and spatial characteristics. This method enhances the accuracy and reliability of wetland vegetation change detection, facilitating more effective wetland management and monitoring. Wetlands offer numerous ecosystem benefits, but their historical documentation has been inadequate. However, researchers have made significant progress in addressing this gap through remote sensing technology and a method known as change detection (Mahdianpari et al.,2021).

Wetlands contain many ecosystems and applications, including carbon sequestration, water supply and monitoring, wildlife and vegetation, and flood and sedimentation control (Davidson et al., 2019). Vegetation species found in wetland environments are challenging to identify due to low accessibility. Wetlands are crucial in preserving and conserving critical habitats and monitoring water quality. Mapping the vegetation of wetlands has been made easier with recent advancements in remote sensing technology. Using deep learning techniques and machine learning has also helped solve half of the problems associated with vegetation classification (Jafarzadeh et al., 2022). A meta-analysis of 30 years of research has shown that data obtained from remote sensing and machine learning approaches are valuable for wetland observing and multi-representation findings. They may open newfound viewpoints for research studies and advance scientific support for management decisions.

Support Vector Machine (SVM) and Random Forest (RF) are popular machine-learning algorithms for supervised classification because of their high accuracy than other methods for land cover (Nery et al., 2016; Chhetri & Rijal,2023) and vegetation mapping (Sabat-Tomala et al., 2020). SVM is a supervised classification algorithm designed to obtain a hyperplane that effectively divides the input dataset into distinct, pre-defined categories, aligning with the patterns observed in the training data. This approach is widely employed in numerous real-world classification problems due to its strong theoretical foundation and

superior performance in terms of generalization (Cercantes et al., 2020). On the other hand, RF is an ensemble classifier based on decision trees (Brieman,2001) representing a sophisticated and powerful machine-learning model.
Generally, vegetation species found in the wetland environment are challenging to reach and identify. Moreover, wetlands are one of the essential components that help in the preservation and conservation of critical habitats and water quality monitoring. With the difficulties in identifying the plant species due to low accessibility, it is hard to map the vegetation of wetlands. However, with the recent advancements of remote sensing technology, mapping of wetland vegetation has become relatively easy. Along with remote sensing imagery, modern machine learning and deep learning have solved half of the problems of vegetation classification. In this study, I aim to analyze the classification of wetland vegetation using OBIA and Machine learning algorithms. This study will utilize Hyperspectral Remote sensing imagery and carry out the supervised classification of wetland vegetation, and areas of classified vegetation will be quantified and analyzed. This process helps to save labor-intensive and manual interpretation, which may take a long time.

2. Materials and Methods

2.1 Study Area

For this research, I utilized the portion of the Fort Drum Marsh Conservation Area (FDMCA) wetland in the St. Johns River Water Management District (SJRWMD) (Figure 1). This conservational area contains a combination of wetland and upland communities jointly acquired by the U.S. Army Corps of Engineers and the Upper St. Johns River Basin project for controlling floods and revitalizing the basin (SJRWMD, 2022). This area has diverse wetland communities, which are vital for improving water quality and enhancing or restoring wetland habitat. Wetland vegetation communities within this area consist of wet prairie, hardwood swamp, cypress, shrub swamp, and many more.

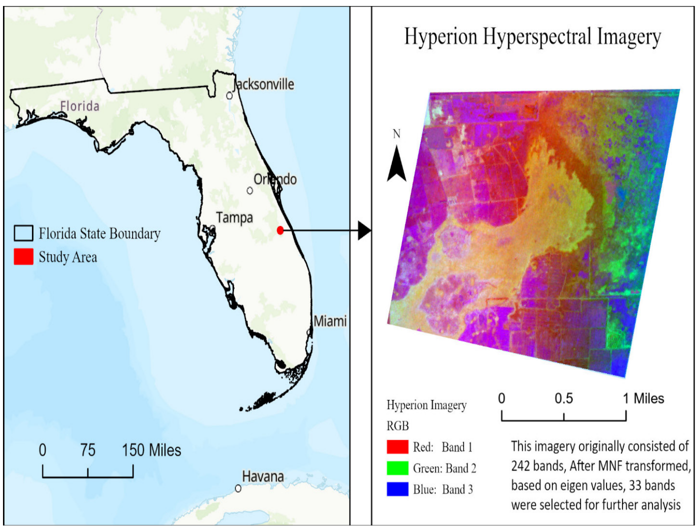

Figure 1 Map Showing the Study area at FDMCA, illustrating Hyperspectral imagery with three MNF transformed bands on it.

Data

Data sources include hyperspectral imagery EO-1/Hyperion and reference datasets. Hyperspectral imagery was collected in 2003/05/04 by the Hyperion Imaging Spectrometer onboarded on the EO-1 spacecraft. The orbit path was 15, the Row was 41, and the target path and row were 15 and 41, respectively. This sensor has 242 contiguous spectral bands with wavelengths of 0.4-2.5 µm and a 30 m spatial resolution. The reference datasets were obtained from the SJRWMD.

2.2 Methodology

A detailed flowchart of this research's methodology is given below in Figure 2. After acquiring hyperspectral imagery, radiometric and geometric corrections were performed using ENVI 5.7 software. The imagery was spatially and spectrally subset- by manually visualizing the noisy bands and removing them. A Minimum Noise Fraction (MNF) transformation was harnessed to enhance the accuracy of subsequent classification (Zhang & Xie, 2012). This process decreased noise and eliminated statistically insignificant bands, and 32 bands were selected based on eigenvalues.

Subsequently, the preprocessed imagery was imported into ArcGIS Pro for object-based classification. The initial step involved segmentation using the image classification wizard (ESRI, n.d.). Given the small size of the study area and the diverse vegetation communities, a spectral and spatial size of 15 and a segment size of 10 were chosen to optimize segmentation.

Following segmentation, training samples were selected for eight classes, considering reference datasets to ensure precision. The training datasets were then employed to classify the imagery using SVM and RF methods. The classification results were subjected to accuracy assessment based on the training samples.

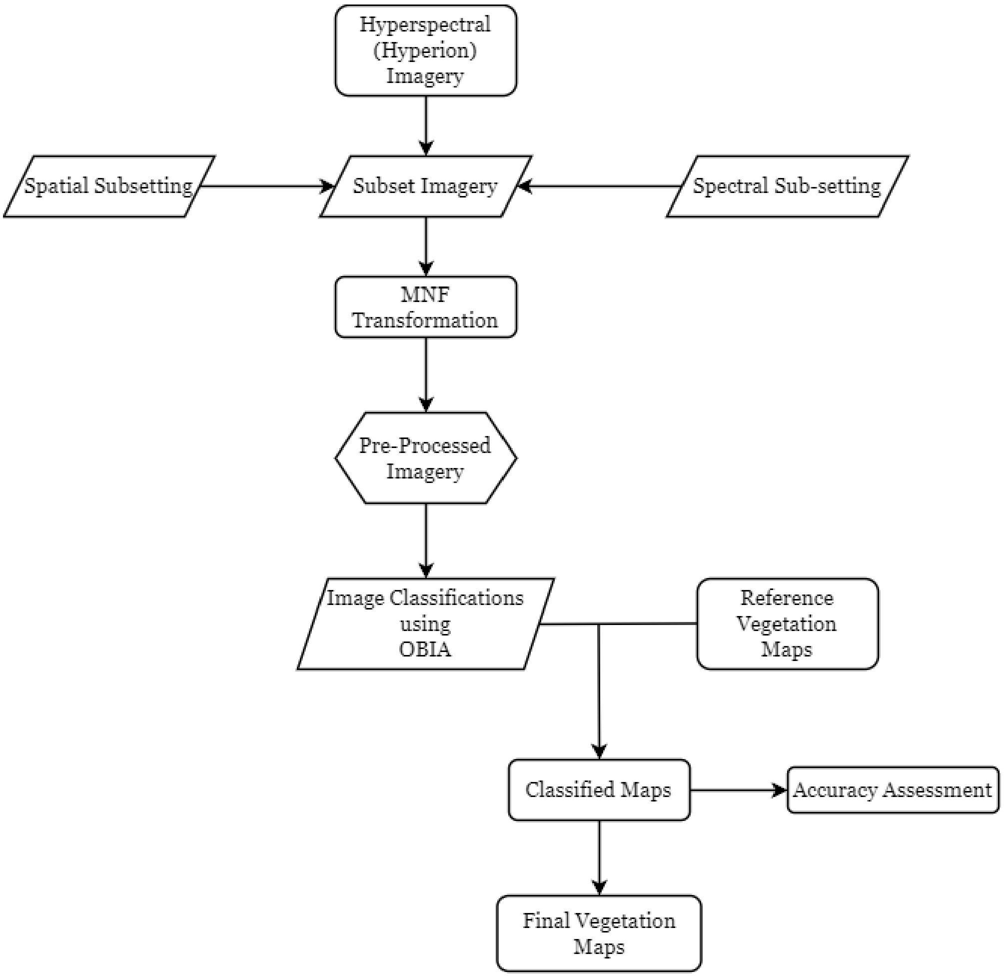

Figure 2 Flowchart for the entire procedure for wetland communities' vegetation mapping.

3. Results and Discussion

The classified maps using Hyperion Hyperspectral Imagery based on RF and SVM are presented in Figure 3. The vegetation classes mapped in this study are listed in Table 01. Although the reference datasets have more vegetation class, due to the imagery being from 2003, I selected eight communities based on visual inspection analyzing their spectral signatures.

Table 01: Wetland Vegetation Mapped in this project:

Plant Communities	Abbreviation	Community Type	Abbreviation
Mixed Herbaceous Marsh	HM	Herbaceous Wetland	HW
Pasture	PA	Herbaceous Upland	HU
Shrub Swamp	SS	Shrub Wetland	SW
Upland Hardwood	UH	Forested Upland	FU
Wet Prairie/Wet Pasture	WP	Herbaceous Wetland	HW
Cypress	CY	Forested Upland	FU
Grass/Sedge Marsh	GM	Herbaceous Wetland	HW
Hardwood Swamp	HS	Forested Wetland	FW

The classification accuracies were assessed by creating a Confusion Matrix, and the overall assessment is shown in Table 02. RF showed better overall accuracy and kappa statistics than the SVM during classification. Both classified imageries seem to have good synchronization with reference datasets upon visual inspection and verification.

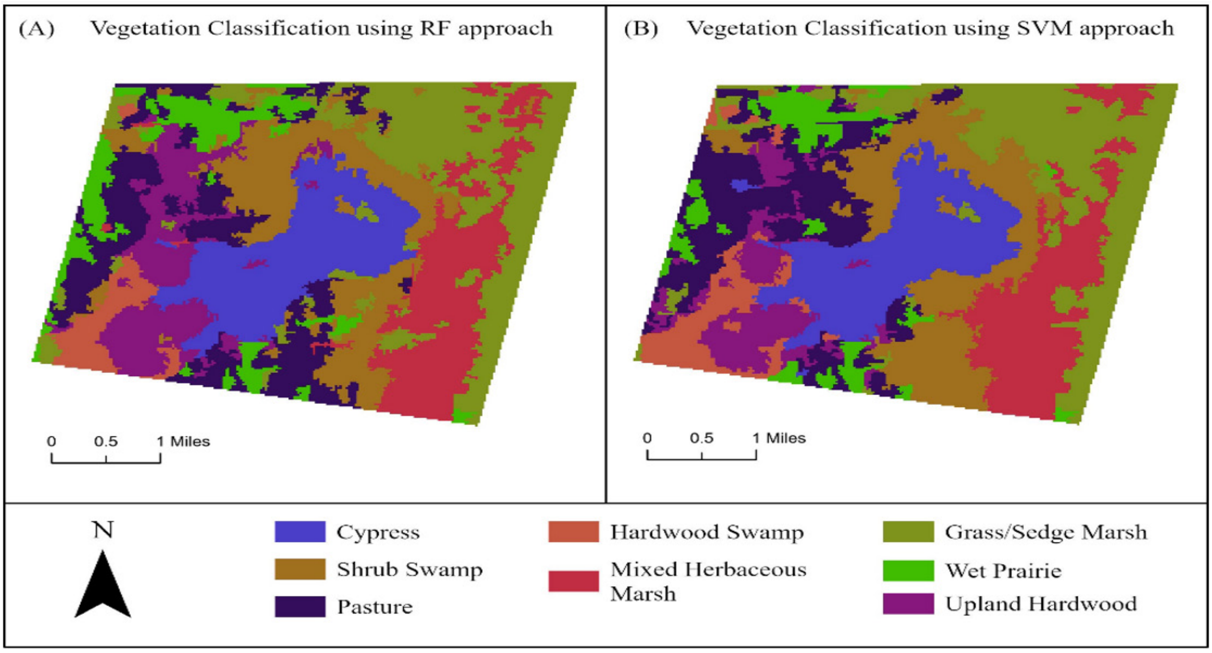

Figure 3 Maps illustrating vegetation classification of a portion of FDMCA wetland, SJRWMD, using hyperspectral remote sensing imagery with OBIA machine learning approach: a) Random Forest and b) Support Vector Machine. Legend and color combinations are common for respective vegetation classes in both maps.

Table 02: Accuracy assessment summary for the performance of two OBIA classifier.

Methods	**RF**	**SVM**
Overall accuracy %	83.6	80.5
Kappa statistics	0.81	0.77

While looking for the RF classification approach, the users' and producers' accuracy was above 70% based on training samples. Mainly, hardwood swamp was misclassified with upland hardwood and cypress, whereas pasture was misclassified to wet prairie and grass/sedge marsh. Mixed Herbaceous Marsh was also misidentified as grass/ sedge marsh due to their similar spatial characteristics. A detailed error matrix showing the accuracy of each class in terms of users and producers is given in **Table 03.**

Table 03: Error matrix of RF classification of the Hyperion imagery

Classes	CY	SS	PA	WP	HS	HM	UH	GM	**Row Total**	UA (%)
CY	18						1		**19**	94.7
SS	2	16							**75**	80
PA		3	14			1			**28**	77.8
WP			1	8				1	**36**	80
HS					7		2	1	**34**	70
HM						15		2	**57**	88.2
UH	1	1				1	8		**22**	80
GM	1		1	1		1		21	**32**	87.5
Column Total	**20**	**20**	**18**	**9**	**7**	**18**	**11**	**25**	**OA = 83.6%**	
PA (%)	90	80	77.8	88.9	100	83.3	72.7	84	Kappa = 0.81	

In the SVM classification approach, user and producer accuracies exceed 60%. However, producer accuracy has notably decreased, primarily due to misclassifications. Wet prairie, for instance, is consistently misclassified as various other classes, except cypress. Similarly, misidentification occurs with grass/sedge marsh, misclassified as pasture, wet prairie, and mixed herbaceous marsh. Challenges persist in correctly classifying hardwood swamp, as it tends to be misclassified as shrub swamp and upland hardwood. These misclassification patterns contribute to the observed decrease in producer accuracy, highlighting areas for improvement in the classification model.

Table 03: Error matrix of SVM classification of the Hyperion imagery

Classes	CY	SS	PA	WP	HS	HM	UH	GM	**Row Total**	UA (%)
CY	16				1		2		**19**	84.2
SS	2	16	1	1		1		1	**75**	80
PA		1	15	1				1	**28**	83.3
WP			1	9					**36**	90
HS		1		1	7		1		**34**	70
HM			1	1		13		2	**57**	76
UH	1				1		8		**22**	80
GM			2	1	1	1		19	**32**	79.2
Column Total	**17**	**18**	**20**	**14**	**10**	**15**	**11**	**23**	**OA = 80.5%**	
PA (%)	94.1	88.9	75	64.3	70	86.7	72.7	82.6	Kappa = 0.77	

Generally, the vegetation of wetlands plays a crucial role in various activities like flood control and treatment of storm and wastewater. Vegetation in the wetland is also controlled systematically such that it helps maintain the ecosystem. Using OBIA, diverse vegetation of communities can be quickly and easily mapped using modern machine learning approaches. The classified vegetation in Figure 3, derived using the methodology presented above for the FDMCA portion, shows alignment upon visual inspection.

Despite using identical training datasets, slight differences in vegetation class classification were noted. Mapping individual vegetation classes is complex due to similarities of spectral signature, leading to occasional misclassifications, such as shadows being identified as water. The analysis, focusing on community-level distinctions, adopts an OBIA approach, favoring better classification for a given area.

Acknowledging inherent limitations, the OBIA approach, as employed in this study, proves highly effective in wetland vegetation mapping, similar to studies on mapping Everglades vegetation (Zhang & Xie, 2012). Similarly, using RF outperforms K-Nearest Neighbors (KNN) in pixel and object-based analyses (Martinez Prentice et al., 2021) when applied to coastal wetland vegetation. The choice of RF underscores its efficacy in accurately classifying wetland vegetation in both this and my studies.

The effectiveness of mapping Everglades vegetation using multispectral imagery, specifically the Landsat imagery series, was demonstrated successfully (Zhang et al.,2017). The approach employed OBIA with the SVM algorithm, and results indicated an acceptable overall accuracy exceeding 87%. The overall classification accuracy was 94%, and the kappa statistics value was 0.94 on average when classifying the 15 vegetation classes (Zhang &Xie.,2012). However, based on these two studies, my study has less overall accuracy; this may have resulted from misclassification and coarse resolution of hyperspectral imagery. In addition, improper labeling and lack of ground truth data make the outcomes less accurate. Despite having access to Ecognition for segmentation, I encountered challenges in exporting classified images based on machine learning due to software issues. Consequently, I shifted the focus of the entire research to ArcGIS Pro for Object-Based Image Analysis (OBIA).

4. Conclusion

In the context of vegetation classification in wetlands, this study investigates the utilization of coarse-resolution imagery in contrast to the high-resolution imagery trends. It specifically explores the applicability of coarser resolution, exemplified by Hyperion EO-1 imagery, for wetland vegetation classification. Despite the inherent coarser resolution, the classification of images demonstrates a notable resemblance to reference datasets. The study underscores the efficacy of modern machine learning techniques, namely RF and SVM, for such classifications. Both classifiers show overall accuracies exceeding 80%, with kappa statistics surpassing 0.75, affirming their efficiency in vegetation classification. Notably, RF achieves an overall accuracy of 83% and a kappa statistic of 0.8, outperforming SVM, which attains 80% overall accuracy and 0.77 kappa statistics. Despite these high accuracies and resemblances to reference datasets, certain misclassifications and misidentifications across classes were seen. The study suggests that implementing post-classification assessment could enhance accuracy by addressing such discrepancies. It is acknowledged that the overall accuracy in this study falls below that reported in studies involving very high-resolution imagery. In conclusion, the research asserts that OBIA coupled with machine learning approaches proves effective for mapping wetland vegetation cover while recognizing areas for potential improvement.

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Analysis of the trend in the accident-prone areas on the existing Ring Road of the Kathmandu Valley

Tejendra Budhamagar

LIST OF ACRONYMS AND ABBREVIATIONS

- AADT: Annual Average Daily Traffic
- GIS: Geographic Information System
- KMC: Kathmandu Metropolitan City
- RR: Ring Road
- MVA: Motor Vehicle Accident
- NTA: Nepal Telecommunications Authority
- RHD: Road and Highway Department
- RTIR: Road Traffic Incident Response
- TMC: Traffic Management Center

Acknowledgement

The Analysis of the trend in the accident-prone areas on the existing Ring Road of the Kathmandu Valley report is prepared by Group

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Executive Summary

The Kathmandu Valley Ring Road has been subjected to a comprehensive analysis focusingon accident-prone areas. Nepal's vulnerability tomultiple hazards, including road accidents, has prompted a detailed examination of this critical transportation infrastructure. The analysis sought to identify and understand the trends in accidents along the Ring Road. Factors such as traffic flow, road conditions, environmental elements, and human behavior were considered in this study. Data collected and analyzed spanned a significant timeframe to capture year wise variations and long-term patterns 2075- 2080 B.S. Findings revealed Top ten areas exhibiting higher accident frequencies, attributed to various factors. These accident- prone zones were predominantly characterized by congestion, poor road maintenance, visibilityissues, and inadequate signage. Additionally, instances of human error, such as reckless driving and non-compliance with traffic regulations, were significant contributors to accidents.

The analysis highlighted the need for targeted interventions in these identified areas. Recommendations include infrastructure improvements, enhanced road safety measures, strategic traffic management, and public awareness campaigns. Collaboration between relevant authorities, local communities, and transportation experts is crucial to implementing these measures effectively. By focusing on mitigating risks in these accident-prone zones, the goal is to significantly reduce the occurrenceand severity of accidents along the Kathmandu Valley Ring Road. This proactive approach aligns with broader initiatives aimed at enhancing road safety and ensuring the well- being of commuters and local residents.

1. Introduction

The Ring Road of Kathmandu Valley, a crucialarterial network, serves as the primary gateway for commuters travelling in and out of the capital city ofNepal. This road system plays a pivotal role inconnecting various parts of the valley and provides access to major highways leading to other parts of the country. Over the years, the escalating traffic volume and changing road dynamics have raised concerns about road safety and accident rates on theRing Road.

1.1 Background

The Ring Road of Kathmandu Valley was initially constructed to alleviate congestion within the city and streamline traffic movement. However, urbanization, population growth, and economic development have led to a substantial increase in vehicular traffic on this vital road network. The Ring Road has witnessed a surge in the number of vehicles, including motorcycles, cars, buses, andtrucks, resulting in complex traffic conditions. The alarming rise in traffic accidents on the Ring Road has become a major concern for both commuters andauthorities. These accidents often lead to fatalities, injuries, and property damage, impacting the lives ofresidents and travelers passing through the valley. Factors such as speeding, reckless driving, inadequate road infrastructure, and poor traffic management have been identified as key contributors to the high accident rate. Understanding the relationship between traffic flowand traffic accidents on this critical road can providevaluable insights for mitigating safety risks, optimizing traffic management, and enhancing overall transportation infrastructure in theKathmandu Valley. Road safety is one of the most serious public health and development challenges inthe world (National Council for Educational Research and Training [NCERT], 2019)

.Approximately, 1.35 million people die and 20-50 million get injured each year as a result of road traffic crashes (RTCs) (WHO, 2018c). Roads can bemade safe if road traffic injuries and deaths arecontrolled. Road traffic crashes and injuries involvemassive costs to often overburdened healthcare systems, occupy scarce hospital beds, consume resources and result in significant losses of productivity and prosperity with deep social and economic consequences (WHO, 2020a). Of all the systems that people have to deal with daily, road transport is the most complex and the most dangerous one (Mittal, 2018). It is the eighth leadingcause of death for all ages (WHO, 2018c). It is also the second leading cause of death in the economically active population group of 15-44 yearsof age. More than 75 percent of RTC causalities occur in the above-mentioned age group (Teferi & Samson, 2019)

2. Objectives

Primary Objectives:

- Trend analyzing in the accident-prone hotspotsin ring road of Kathmandu Valley.

Secondary Objectives:

- Determining the factor behind the injury anddead.
- Mitigating and managingaspect of road accidents.

3. Scope of Work

Analysis of trends in accident area is carried out in order to determine the cause or causes of an accident (that can result in single or multiple outcomes) so asto prevent further accidents of a similar kind. This analysis of trend is carried towards answering following questions:

- What are the trends in factors affecting road traffic accidents in the ring road of Kathmandu valley?
- Which is the most influencing factor affecting road traffic accident in the ring road ofKathmandu valley?

The study focuses on the existing Ring Road within the Kathmandu Valley. Key areas of interest includeintersections, sharp curves, and high-density zones. Our analysis will inform targeted safety measures toreduce accidents and enhance overall road quality.

4. Study Area

Our analysis covers the following aspects: Accident Data Collection: Gathering data onaccidents from relevant authorities.

Geospatial Analysis: Using GIS to map accidentlocations and indicate hotspots.

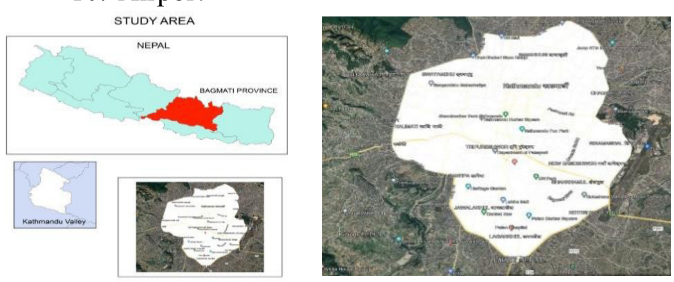
Traffic Flow Assessment: Evaluating traffic volume, speed, and congestion.

Level of Service (LOS): Assessing Road capacityand performance.

Stakeholder Consultations: Engaging with localcommunities, traffic police, and experts.

Top ten location of Ring Road of Kathmandu valley which are the area of focus:

1. Koteshwor
2. Gwarko
3. Satdobato
4. Chakrapath
5. Swayambhu
6. Kalanki
7. Machhapokhari
8. Chabahil
9. Gaushala
10. Airport



This area faces heavy traffic congestion, especially during peak hours. Road maintenance is a concern, with some sections displaying potholes and uneven surfaces, contributing to accidents.

5. Literature Review

There is tremendous rise in RTAs due to increase in vehicular volume on roads, incredible speeding of the vehicles, poor drivingskills, drunk driving, bad roads, poor trafficcontrol, and lack of public awareness, rampant indiscipline, incompetent authorities and lack of implementation of existing law to tackle themenace of disrespect to law and rules (Sharma,2016). The maximum number of accidents occur due to the lack of traffic knowledge, negligence of drivers, and the vulnerable condition of roads (Dhakal, 2018).Road traffic accidents results from a combination of factors related to the components of the systemcomprising roads, the environment, vehicle androad users, and the way they interact (Shantajit, Kumar, &Zahiruddin, 2018). Road traffic accident (RTA) is defined as a situation. causedby the collision of one or more motorized vehicles, such as cars and motorcycles. Theconsequences of RTAs can be injuries, propertydamages, death, and congestion, disruption, anddelays to public transport. Alam, &Alharthi (2019) investigated the impacts of sandstorms, temperature, and rainfall on road traffic accidents.

Srinivasa, Kumar and Srinivasan (2013) found that more (60.7 percent) accidents, and bright light favored for 78.1 percent of accidents and this could be because of the bad condition of roads due to rains and density of traffic in day light respectively. Shrestha (2013) explored causes of RTAs and deaths due to that, the reports show negligence, over speed, drinking and driving, poor condition of the vehicles, overtaking as major causes. Drinking anddriving is also found to have significant space inRTAs and deaths. Though less significant in comparison to the aforesaid causes, poor condition of the vehicles and overtaking are alsofound to have caused many RTAs and deaths. Dhakal (2018) stated that the negligence of the driver to the weather condition and the condition of road. Despite the dense presence of government and its bodies, the study showed that maximum number of road traffic accidentsoccur in Kathmandu valley. Youngsters riding bikes and driving cars involved in accident are found maximum in number.

6. Project Methodology

Our methodology involves a systematic approach to understanding and mitigating accidents on the existing Ring Road. The projectis divided into several phases:

Phase 1: Preparatory Phase

Stakeholder Engagement: Engaging with trafficpolice, Road Department and community representatives to understand their perspectivesand concerns.

Phase 2: Planning and Coordination

Clearly define the boundaries of our study, including the specific hotspot of the Ring Roadto be analyzed. **Data Collection Plan**

Developing a comprehensive plan for collecting accident data, traffic data, road geometry data, and other relevant information about accident in Kathmandu ring road.

Phase 3: Data Collection

Accident Data: Gathering historical accident data from Kathmandu traffic head office.

Traffic Flow Data: The information on traffic data, speed, zebra cross and Lighting data fromtraffic head office.

Road Geometry and Infrastructure: The Ring Road data from the Road department Surveying the existing road layout, and otherinformation collected with the help of googleearth and OSM.

Phase 4: Data Compilation, Cleaning, andGIS Analysis

Data Integration: Compiling and organizingthe collected data into a coherent dataset.

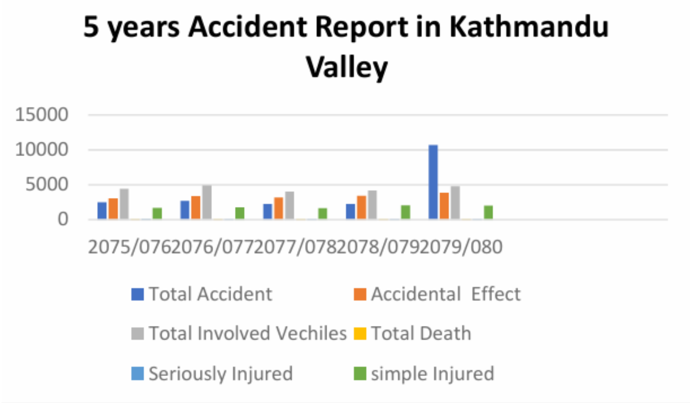
Statistical Analysis: analysis of traffic datawith the help of Microsoft excel and other google tools.

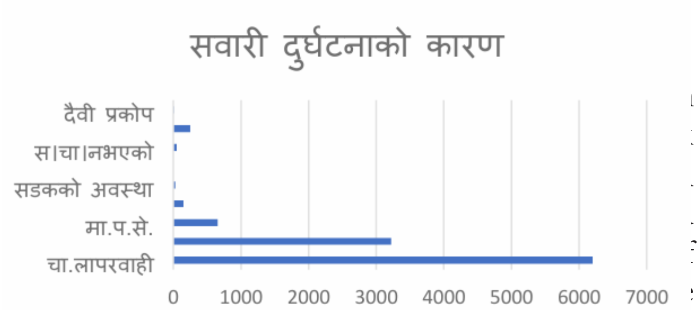
Geospatial Analysis: Utilizing Geographic Information System (GIS) tools to map accident locations, indicating hotspots, andassess road conditions.

Accident Density Mapping: Creating visualrepresentations of accident density along thelocated hotspot in Ring Road Kathmandu.

Phase 5: Statistical Analysis

we delve into the statistical aspects of our study. Our focus is on understanding accidenttrends, identifying patterns, and quantifying risk factors. The following analyses were conducted:



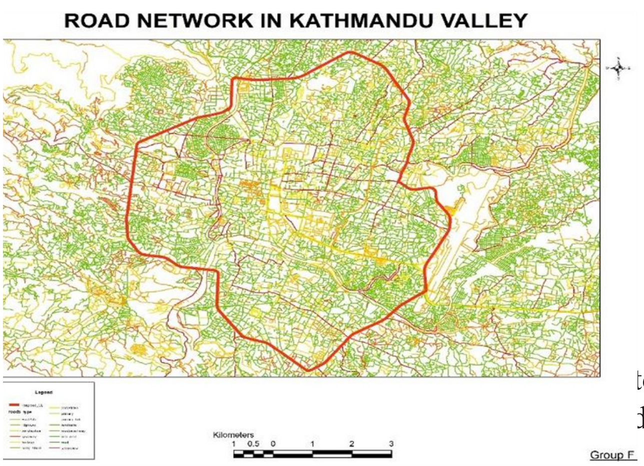


the number of deaths and injuries fluctuated over the years.

Main Cause of accident

- speed
- C. Negligence
- M.P.S.
- mechanical disturbance
- State of the road
- vandalism
- S. Cha. Not
- overtaking
- divine disaster

Phase 6: Geospatial Analysis:



tools

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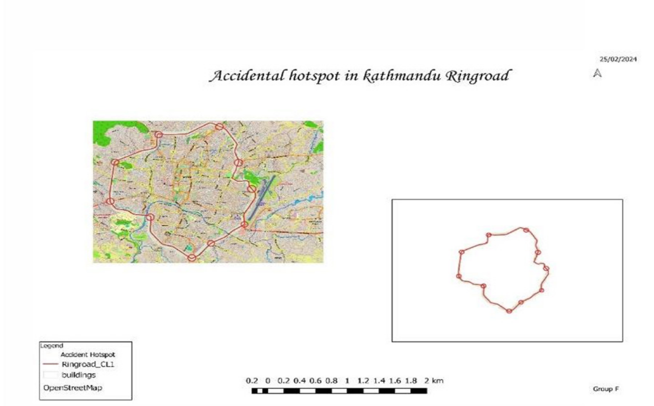
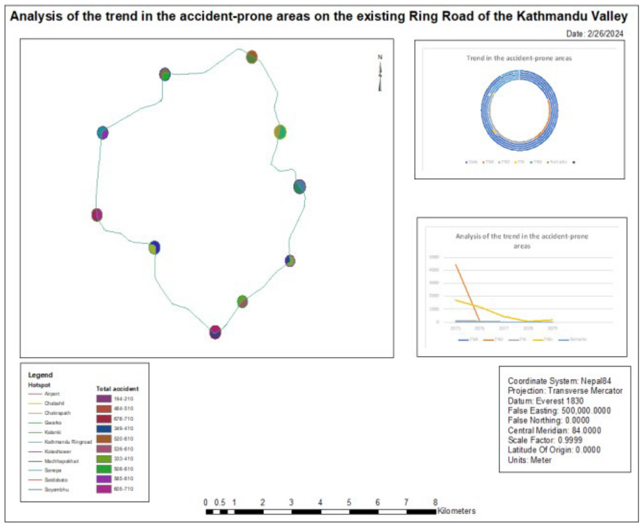


dent-prone areas along the existing Ring Road. And geospatial analysis provided a topological map of accidental hotspots and analyzed the trend of accidents in ring road Kathmandu using last 5 years traffic data. Our findings will inform targeted safety measures, enhance emergency response, and contribute to overall road safety in the Kathmandu Valley.



7. Results

To analyze accident-prone areas on the existing Ring Road of the Kathmandu Valley, we developed an integrated geodatabase. This geodatabase combines accident data, road network information, and spatial data to create acomprehensive dataset for our analysis. Key components of the geodatabase include:

- **Accident Records**: Detailed information on each reported accident, including location, date, time, and condition.
- **Road Network**: Geospatial representation of the existing Ring Road, including Hotspot, near building, and condition.
- **Traffic Flow Data**: Traffic data, speed limits, and zebra cross data and traffic light.

Analysis:

Using the integrated geodatabase, we conducteda risk analysis to identify accident-prone areas. Our approach involved the following steps:

Multivariate Logistic Regression: By considering various factors (e.g., road geometry, traffic flow, time of accident), we modeled the likelihood of accidents occurring in specific hotspot of ring road locations.

Mitigating and managing road accidents:

It is a critical challenge that requires a multifaceted approach. Here are some strategies from our study and analysis give you 6 points of mitigating and managing road accidents, that can contribute to improving road safety:

a. **Infrastructure Improvements:**

- **Road Design**: Enhance road design by considering factors of road safety such as visibility, signage, lane markings, and safe intersections.
- **Pedestrian Crossings (footpath management)**: Install pedestrian crossings (zebra cross) at appropriate locations to ensure safe passage for pedestrians.
- **Speed Bumps**: Implement speed bumps or humps (Warning plate) in residential areas and near schools to reduce speeding

b. **Education and Awareness:**

- **Driver Education**: Educate drivers about safe driving practices, traffic rules, and the importance of speed limits.
- **Pedestrian Education**: Raise awareness among pedestrians about safe crossing practices and the use of designated crossings.
- **School Programs**: Introduce road safety education in schools to instill good habits from an early age.

c. **Enforcement by government:**

- **Traffic Police**: Strengthen traffic law enforcement to penalize reckless driving, speeding, and other violations.
- **Random Checks**: Conduct random checks for alcohol and drug impairment to deter intoxicated driving.
- **Seat Belt and Helmet Laws**: Strictly enforce seat belt and helmet laws to protect.

d. **Technology Solution**

- **Speed Cameras**: Deploy speed cameras to monitor and deter speeding on highways and busy roads. Some of area in ring road got installed speed camera.
- **Automated Traffic Signals**: Implement smart traffic signals that adjust timing based on traffic flow.
- **Vehicle Safety Features**: Encourage the adoption of vehicles with safety features like airbags, anti-lock brakes, and stability control.

e. **Emergency Response:**

- **Ambulance Services**: Improve emergency medical services to provide timely assistance to accident victims.
- **Helpline Numbers**: Promote helpline numbers for reporting accidents and seeking immediate help.

f. **Community Engagement:**

- **Community Watch**: Involve local communities in monitoring road safety and reporting hazards.
- **Youth Engagement**: Engage youth in road safety campaigns and encourage responsible behavior.

8. Conclusion

Our study revealed several key findings:

a. Hotspots: We identified accident hotspots near intersections, sharp curves, and high- density zones along the Ring Road.

b. Contributing Factors: We identified Poor Road design, inadequate signage, and heavy traffic flow were main significant contributors to accidents. And other major factors are below:

<u>Some of reason beyond accident are:</u>

- तिव्रगती (Speed)
- चा.लापरवाही (Careless of driver)
- मा.प.से. (Drunk and Drive)
- यान्त्रीक गडवडी (Mechanical problem)
- सडकको अवस्था (Road condition)
- तोडफोड (Vandalism)
- सा।चा।नभएको (Ass. Driver unavailable)
- ओभरटेक (Overtake)
- दैवी प्रकोप (Divine Disaster)

c. Recommendations: Based on our analysis, we recommend targeted safety measures, including road improvements, traffic management with smart way, and public awareness campaigns will be add in smart traffic management.

In conclusion, understanding accident trends and accidental factors are crucial for enhancing road safety. By implementing our recommendations, we can reduce accidents and create a safer environment for commuters in the Kathmandu Valley.

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What is API?

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"What is API?" API is the acronym for Application Programming Interface. The word "Application" refers to any data, functions or software and "Interface" stands for a method of communication between two applications. This method defines how they communicate with each other using requests and responses in a client and server model. A simple way to understand APIs and related terminologies would be using "The Waiter Analogy".

Here's how it works:
Imagine you are visiting your favourite restaurant.
You (Client): You're the program that wants food and orders something (data or functionality).
Menu (API documentation): This is the guide that tells you what options (functions) are available and how to request them (parameters).
Waiter (API): This is the one who takes your order (request) and delivers it to the kitchen and chef (server). The waiter doesn't cook the food themselves, they just relay the information. After a while, the waiter comes back with your food (response) from the kitchen.
Food (response): This is the data or functionality that the program provides you after receiving your request through the waiter (API).
Kitchen/Chef (Server): This is the program that actually has the food you need (data or functionality). They prepare what you requested based on the waiter's message, i.e. API's request message.

Here, just like you wouldn't have to go to the kitchen at the restaurant or know how the chef cooks your food, the client also doesn't need to know the complex inner workings of the server. This also means you are never directly meeting or exposed to the kitchen or chef of the restaurant. Likewise, the chef is never directly meeting you or exposed to you. Similar to the waiter, the API handles all the communication between the client (you) and the server(kitchen). The way this works in practice is that - both the client and server are never fully exposed to each other and share only what is requested and absolutely necessary. This is how APIs are able to function adding up to the greater security and governance of both client and server. To sum up, you don't need to know how the kitchen works and the chef doesn't need to know who you are, just order what's on the menu (what the API offers); the waiter takes care of the rest.

APIs are all around us. Every time you use a ridesharing app, make an online payment in an e-commerce app or check daily weather updates on your phone in the weather app, you are using an API. Modern APIs are designed for specific users like software developers. They're well-documented, with different versions available, making them easy to understand, access, and integrate into various applications. As such, today APIs are treated more like products and services, not just cryptic code.

Why use API?
APIs serve numerous purposes. Generally, they simplify and speed up the software development process. These APIs are usually accessible for Android, iOS, and web browsers and also as HTTP web services that enable data exchange between different systems. This eliminates the need for developers to code everything and build every functionality from scratch. For example, while developing a complex e-commerce application from scratch, you'd need to develop features for product listings, secure payment processing, user authentication, and more. Then, the significant time saved by integrating a pre-built payment processing system into your e-commerce app, rather than developing your own secure payment gateway from scratch. The developers can focus on building a beautiful and user-friendly interface, add functionality (like a recommender system) or build new applications using services by third-party providers.

So,What does API for maps specifically do?
A typical Map API is a specific category of API, that goes beyond the basic features and specialises in adding various location-based features to your applications, like geocoding and reverse geocoding, directions and navigation, different types of maps (e.g. terrain or satellite), nearby searches and customisable control objects. Let's elaborate on their use cases further.

- Search suggestions, using the Search API: The Search API is a service that returns suggestions for names of places in response to the client's request.
- Address generation, using the Reverse Search API: The Reverse Search API is a service that returns an address in response to the geographical coordinates of the location provided through the client's request.
- Geographic location information, using the Places API: The Places API is a service that returns detailed geographic information like centroids and geometry in response to the client's request.
- Nearby places information, using the Nearby Plaes API: The Nearby Places API is a service that returns suggestions for nearby places of a particular location in response to the client's request. The request usually contains a radius within which to look for results.
- Navigation and routing, using the Directions API: The Directions API is a service that returns navigation routes, along with their distance and time estimates in response to the client's request. The requests usually contain the start and end destinations, as well as, the mode of travel.
- Map display, using the Map Styles API: The Map Styles API is a service that returns map tiles, usually

vector tiles (sometimes raster tiles).

These are just a few examples of map APIs. To learn and explore further about the different ways in which you can integrate these map APIs with your applications, you may visit https://docs.baato.io/#. Baato Maps provides various map APIs, data and solutions, specifically tailored for the Nepali Spatial ecosystem.

Let's translate their applications into a practical example. Imagine you are developing a ride-sharing app. The map style API provides a visually appealing and customizable map experience for your app users. When a user opens the app, and looks to find points of interest (like restaurants, and landmarks) to set a pick-up location and drop-off destination, the Search API comes into play. What if a user pins a location on the map at an unknown address; the reverse search API can be integrated to convert those coordinates into a user-friendly address. Once the user sets their pickup and drop-off points, you can utilise Direction API to retrieve the best route for the driver, including estimated distance and travel time and calculate the trip fare accordingly.

To sum up, the Map APIs collectively provide location intelligence for the software developers creating location-based products and services. It is the base building block for location-aware applications, accessing geographic data, and creating feature-rich maps with visualisation aids. The world of APIs can be vast and the power of map APIs can be even more intriguing for location-aware systems. By leveraging these map APIs, developers can effectively tap into geospatial capabilities and build rich location-based applications. Imagine the possibilities!

Trash to Tech: Using AI and Drone Technology to Tackle Environmental Challenges

Rubi Khatri

Janakpurdham's Waste Crisis

Janakpurdham is a sub-metropolitan city located in Dhanusha district of Nepal. The city has a rich cultural history that goes back to hindu mythology symbolized by the famous Janaki Temple. The city hosts various festivals throughout the year, including the Ram Navami, Vivah Panchami, chhath puja and holi where thousands of people gather to celebrate the vibrant culture and tradition. Additionally, Janakpur is home to several historical sites, landmarks and art that showcase the rich heritage of the region. In addition to its religious importance, Janakpur is one of the cities of Nepal where urbanization has taken off at a rapid pace. The city has witnessed significant infrastructural development, with modern amenities and facilities being introduced to cater to the growing population.

Despite its significance as a pilgrimage site, the city has been dealing with the pressing issue of unregulated waste disposal, resulting in environmental degradation. An analysis of available datasets revealed alarming amounts of solid waste accumulation in various key areas, including barren lands, railway trails, and roads. This waste accumulation poses a severe threat to the health and well-being of the residents.

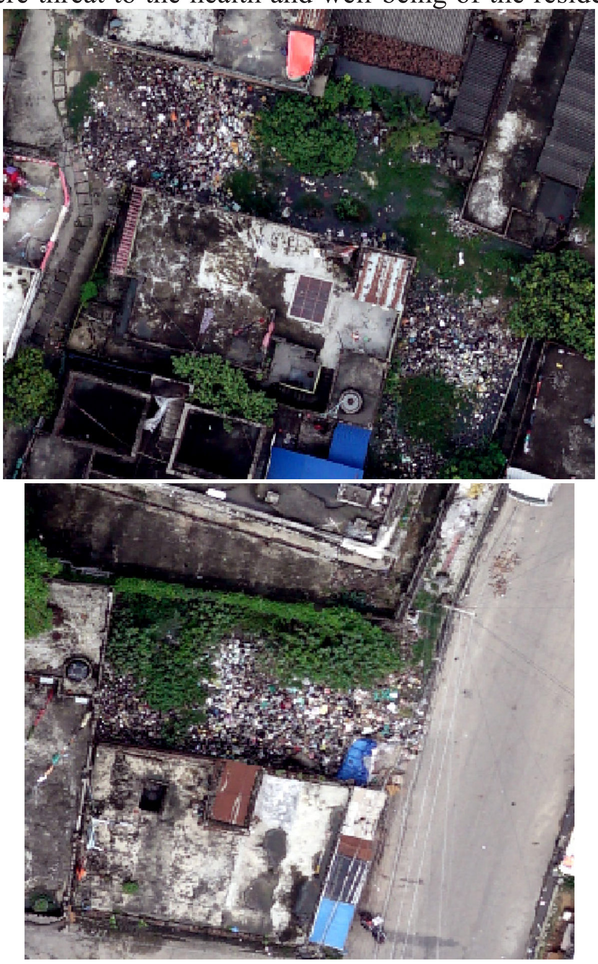

Figure 1 Haphazard solid waste disposal in Janakpur

Various news sources have reported that locals have voiced concerns about the ongoing waste issue time and again, yet waste continues to affect the surroundings, posing a persistent challenge to the community and its environmental well-being. Realizing the challenge of waste management, an innovative approach for waste monitoring and observation was developed using drone imagery and artificial intelligence(AI).

1. Research and Collaboration for Sustainable Solutions

After the problem identification, we engaged in extensive review of literature; studying various related articles and papers. Through our research, we discovered that we could successfully implement AI technologies to tackle waste accumulation along with valuable insights and best practices. Additionally, we reached out to experts in the field and collaborated closely to gain a deeper understanding of the challenges and potential solutions. We expanded technical knowledge by working under mentorship of seasoned experts to develop a comprehensive plan that integrates drone imagery and AI.

A very high resolution data was captured using a drone. The theorized AI solution was modeled to identify patterns and trends, allowing for targeted interventions, and improved waste management practices.

Figure 2 Labeling areas with waste

2. From Data Collection to Analysis

The team first collected images using a hybrid VTOL drone - Wingtra One Gen 2.The mapping crew processed the images captured by the drone using PIX4D software to produce high resolution orthophoto, and digital surface models. The drone-captured images had a high spatial resolution, approximately 8 cm, ensuring detailed and precise representation of the land of interest.

With the available imagery, we conducted experiments utilizing a range of tools and methodologies encompassing both supervised and unsupervised learning. In the context of unsupervised learning, we employed methods such as k-means clustering, thresholding, and contouring. The resulting outputs were rendered unusable due to the similarity in pixel values between buildings, roads and waste, causing them to be grouped together in the same cluster.

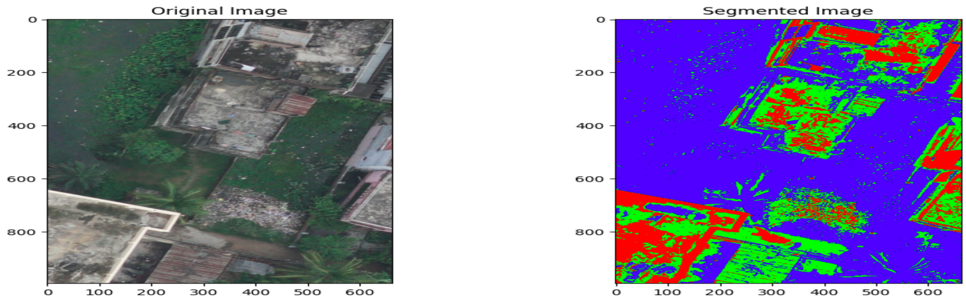

Figure 3 Result after clustering

As a result of these issues, we transitioned to supervised learning, which required us to annotate the data and generate a corresponding mask. A Tiff image of a specific region in Janakpurdham, specifically ward number 7 was taken, and then a mask was generated. The dataset was generated by annotating waste regions using Quantum GIS (QGIS). This annotation process involved the precise labeling of waste sites within the specified area of study on the drone-captured images. The annotations established a ground truth dataset that accurately represents the spatial distribution of garbage, which was for training and validation purposes.

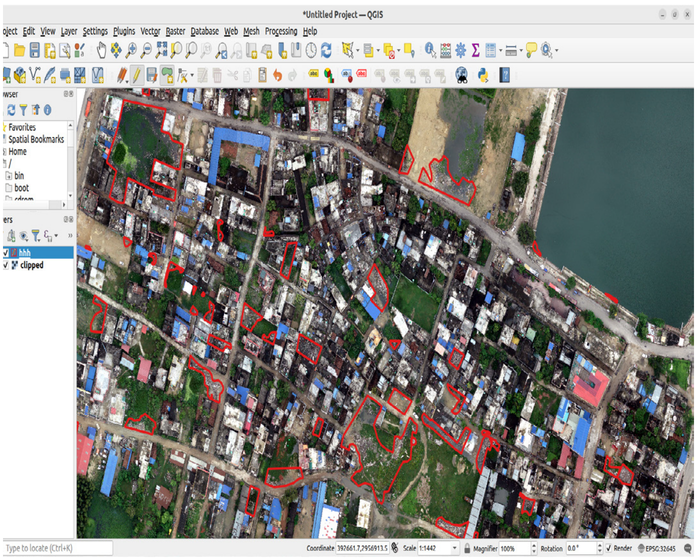

Figure 4 Annotating image in QGIS

Following the annotation process, masks were generated for the annotated images. These masks served as binary representations of waste and non-waste areas within the images. The annotated images were then divided into patches of size 256 by 256 pixels to facilitate the training process.

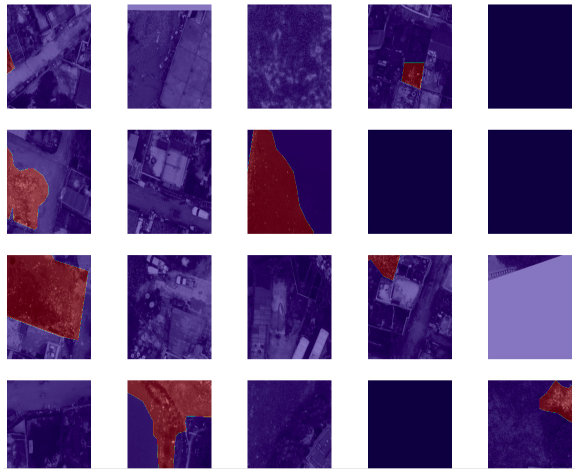

Figure 5 256*256 images and mask

3. Building Effective Waste Detection Models

After a few rounds of experimentation, U-Net segmentation_models architecture was selected as suitable for our purpose due to its demonstrated effectiveness in accurately segmenting similar data. The U-Net design is distinguished by its encoder-decoder structure, in which the encoding path uses a sequence of convolutional layers to extract features, while the decoding path employs transposed convolutions to do upsampling. The segmentation_models library was used to smoothly configure the U-Net architecture, incorporating the ResNet34 backbone network. This functionality offered a wide range of feature extraction architectures for our U-Net model, improving its capacity to catch complex patterns that are important for waste detection in images acquired by UAVs. Leveraging the library's intuitive API, the model's architecture, loss functions, and optimization parameters were defined. Further, class weight was also introduced to handle the class imbalance problem resulting in more accurate prediction, , particularly in scenarios where waste patches were less prevalent in the dataset.

4. Achievements and Future Directions

The model was trained for 100 epochs, saving the model after every epoch. This approach ensures that the model captures the most accurate and up-to-date information, allowing for continuous improvement and optimization. Additionally, by saving the model after every epoch, it becomes easier to track and analyze the training progress, facilitating further enhancements to the waste detection model. We chose the best model with the highest IOU, and lowest loss for deployment in our waste detection system. It has a training IOU of 0.7538, a training loss of 0.3116, a validation IOU of 0.7238, and a validation loss of 0.2833.

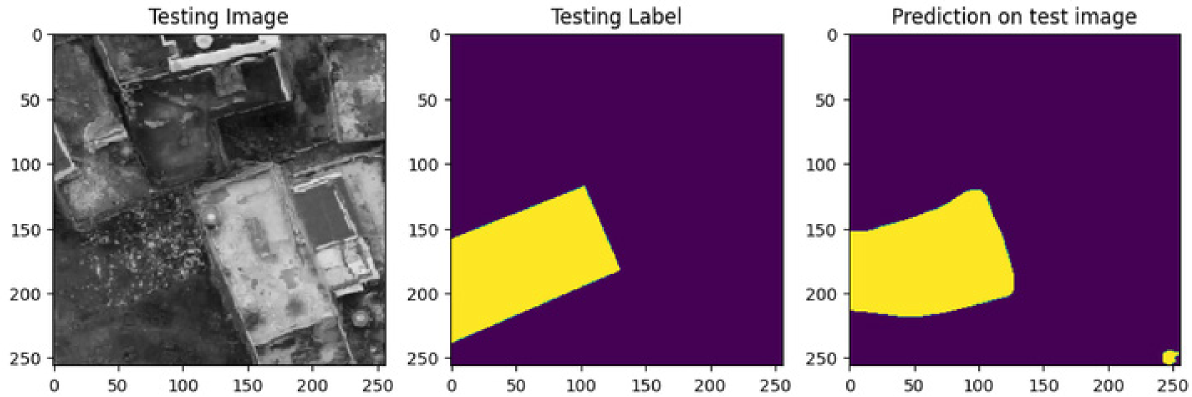

Figure 6 Testing image, testing label and prediction on test image

Another region of Janakpur was taken and the model was tested on it. For the testing purpose, the selected area was converted into tiles of 256×256 using the gdal2tiles package. Each tile was fitted into the model and the solid waste accumulated areas were highlighted.

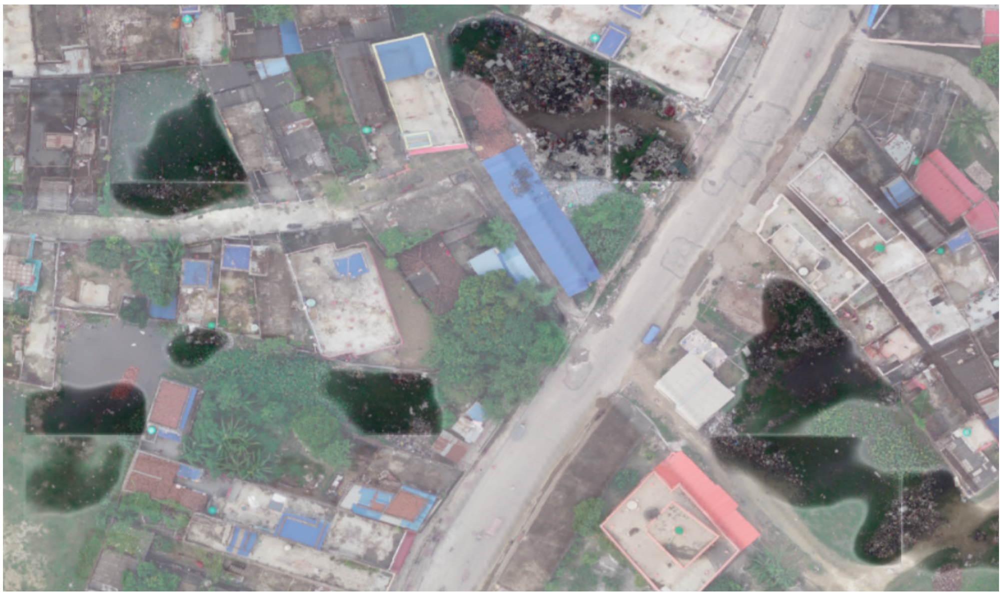

Figure 7 Output of trained model

The solid waste detection model showcased opportunities for real-world impact using GeoAI. Furthering this project, a system capable of detecting and classifying different types of solid waste by providing UAV imagery can be drawn. It allows for immediate detection of any potential issues and prompt action to be taken. By analyzing trends, we can also predict future waste accumulation patterns. This can greatly improve the efficiency and effectiveness of waste management operations. Integrating the model with Internet of Things (IoT) devices and remote sensing technologies enables real-time monitoring, which broadens the use cases of our waste detection model.

Land Development for Residental Area Using UAV

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KEYWORDS: Aerial Imageries, Land Development, Residential Use, Urbanization, Unmanned Air Vehicle (UAV)

ABSTRACT:

This report outlines a comprehensive land development project aimed at systematically designing residential parcels ofregular shapes through modern technological approaches. To minimize the problem of unmanaged urbanization due to the ever-increasing population, this project aims to prepare a land development plan for residential use using advancedtools like Unmanned Aerial Vehicles (UAVs) and Differential GPS (DGPS) to collect accurate and detailed data, streamlining the process. However, using the geo-tagged images only does not meet the need for locational accuracy. Thus, DGPS has been used, as another surveying method to enhance the reliability of the outputs.

The land development map obtained from this study divides the study area which is 4.5 Hectare located in Ward-4, Bhakundol, Dhulikhel, Nepal into several regular shaped residential plots, serviced plots, open spacesand canalsas wellas designing road networks that touch all the parcels, all under the guidelines set by the governmental body. The result shows that among 4.8 Hectares of land 61% have been developed for residential plots, 25% for roads, 7% for serviced plots, 5% for open space and 2% for the canal. The report underscores the significance of systematic land development in promoting sustainable urban growth, contributing to improved community living conditions and ecological balance. Through the integration of modern technologies, this study showcases the potential for innovation to reshape land development practices, leading to well-designed and accessible residential areas that cater to both present and future needs.

1. INTRODUCTION

Background

Land development means the process of planning, design, and construction used to convert raw land to serviced building parcels that are ready for construction. Land development comprises changinga landscape to better meet the demands of people who wish to live there. The land development technique is the only program that will help with sustainable urban growth with suitable infrastructure and land consolidation without financial support from the government, the majority of land disputes will be resolved, and nobody will be evicted from their neighborhoods (Oli, 2010). While development can occasionally be seen negatively because it alters the landscape, increases traffic, and affects ecosystems and habitats, land development is necessary for a community to succeed because it can increase employment, improve curb appeal, minimize the land related issues, bring neighbors together, and maintain

or raise home values (Construction and Land Development n.d.).

Using UAVs (Unmanned Aerial Vehicles) is an emerging tool for the development of residential areas. Land developers use drones to help them get accurate digital images of design concepts for new developments. Drone technology is the most cost- effective way for land developers to change their ideas and make changes before construction begins (Yunuset al., 2020). With a UAV, topographic data collection is quicker and also requires fewer human resources than with land-based techniques. Additionally, UAVs can collect data in inaccessible places too (Hermosilla et al., 2012). The establishment of control points is done using DGPS. Differential GPS (DGPS) is a system in which differences between observed and computed co- ordinates ranges (known as differential corrections) ata particular known point are transmitted to the user (GPS receivers at other points) to upgrade the accuracy of the users' receiver's position (Atabudhi, n.d.).

AutoCAD software, which has powerful drawing andvector editing functions, is used in land and planningdepartments widely but AutoCAD is weak in expressing and analyzing the relationship of spatial data whereas ArcGIS can gather geospatial data to process and express in a single model framework, aswell as handle graphic data, model, analyze, and manage the existing spatial data. Hence ArcGIS is favored by more and more GIS enthusiasts due to itsease of use while handling geospatial data(Yeh & Li,1998).

Objective

Primary Objective

- To prepare land development plan for residential purposes by systematically creating parcels of regular shapes.

Secondary Objective

- To prepare a topographic map using aerialimageries.
- To design proper building plots and roadnetworks following the government guidelines.

2. METHODOLOGY

Study Area

The study area is located near LMTC, Dhulikhel-04, Kavre. The area covered during land development isaround 5 hectares. The study area was at an altitude of around 1465m with geographic coordinates 27°37'10" N and 85°32'46" E. It is situated on the way to Dhulikhel Hospital around 200m due east of the LMTC and around 500m southeast of the junction of Kathmandu University and Land Management Training Centre (LMTC).

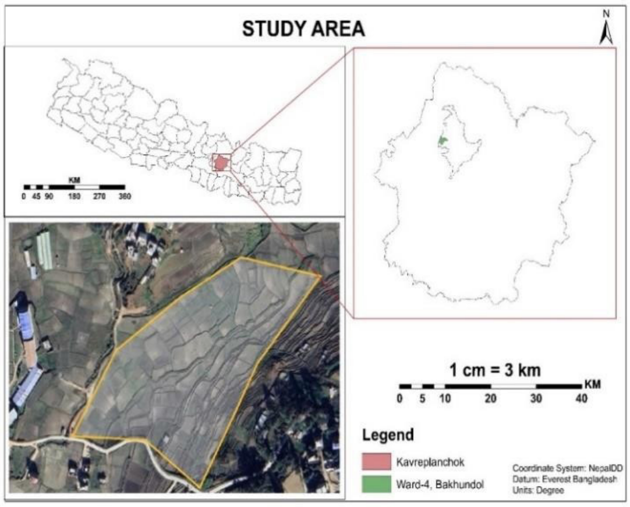

Figure 1 Study Area

Work Flow

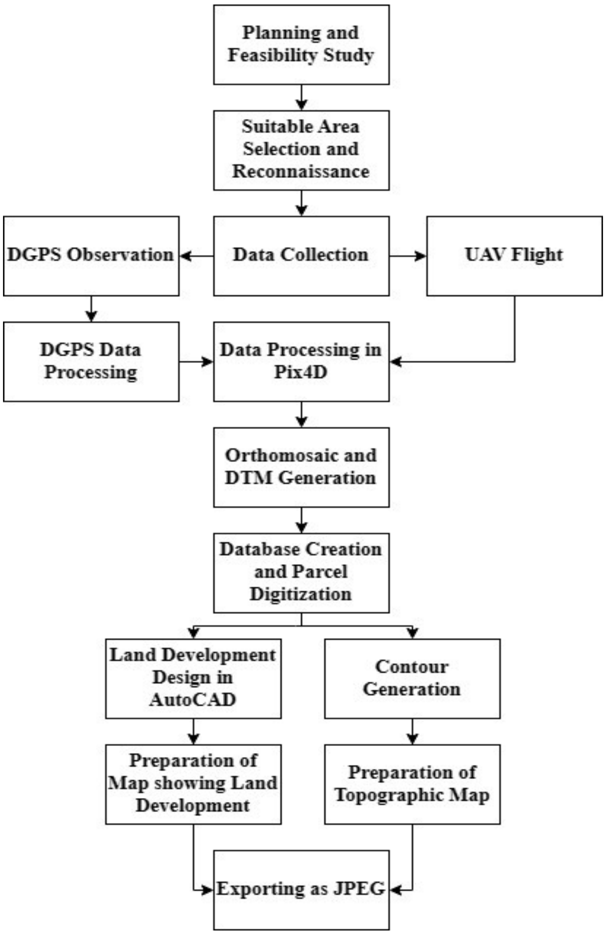

Figure 2 Workflow

Planning, Reconnaissance, Monumentation

Good planning is considered half-work done. Thestudy area, software, and instrument selection, including the choice of digital camera and UAV platform types, are all part of this phase. Determiningparameters and specifications for flight plan considering the precautions such as flight height, ground sampling distance, number of photos to be taken, storage capacity, time for battery backup,weather conditions and other parameters. Digital photogrammetric software like PIX4D was selected to process the digital aerial picture and create anorthomosaic of the study area. For better accuracy, DGPS survey was selected for the establishment of ground control points. Literature reviews of variousprojects and existing guidelines for land developmentwere studied before proceeding with the project.

Field visit and reconnaissance was done and variousfeatures such as existing roads, parcels, drainages, buildings, electric poles and so on were observed and established six control stations, well distributed in thearea.

Data Source Description

Data Used

- Ground Control Points (GCPs) were obtainedfrom DGPS.
- Aerial imageries were captured from UAVs
- Google Maps as a base map

Instrument Used

- Unmanned Aerial Vehicle (DJI Mavic Pro 2)
- DGPS (Stonex)
- Measuring Tape

Software Used

- StaticToRINEX
- Trimble Business Center
- DJI Pilot
- PIX4DMapper
- AutoCAD
- ArcGIS

Specification used for DGPS

Table 1. Specification for DGPS

Specification for DGPS	
• Working mode:	Static
• Cut angle:	15 degrees
• Time interval:	15 sec
• PDOP Threshold:	3
• Number of Stations:	6
• Observation time	
➢ For Base:	2 hr 15min
➢ For Rover:	30 min
➢ Time overlap:	10 min

Field Work

DGPS Observation

Three sets of DGPS were used. A base and two rovers were used simultaneously. Base station was kept forabout 2 hr 15 min whereas rovers were placed about30 min with 10 min overlap for better accuracy. It was made sure that the base was operating until the very end till we finished our observation. The working mode was static with a cut angle of 15 degrees and PODP threshold 3. Altogether 6 stations were studied which covered the whole area.

UAV Flight

GCP markers of size 30*30 cm were used to mark the stations in the ground exactly above the wooden pegs. The flight height was set to 70 m. For better accuracy, end lap and side lap were kept high i.e. 80% and 70% respectively. For better resolution, GSD was maintained at 1.92 cm/pixel. These parameters resulted in 163 photos being taken to cover the entire area in 7 min 7 sec flight time. The weather was clear and wind velocity was also bearable.

Data Processing and Analysis

a) First of all data acquired from DGPS (i.e. in .dat format) were converted to RINEX format using StaticToRinex software as .dat extension files are not supported by Trimble Business Center(TBC). All the converted files were imported into TBC where baselines were processed, network adjustments wereperformed, reports were generated and coordinates were extracted.

Aerial images obtained from UAV were importedinto Pix4D software. All we had to do was provide the strips of images, import the GCPs obtained from DGPS software and address the GCPs in related images. It took almost 3.5 hrs to process the images in standard quality. The software resulted in the outputs, Ortho-mosaic image and DTM.

b) Thus produced Ortho-mosaic was then exported to ArcGIS where the digitization of required area was done so that the existing condition of the ground layout could be known and could be compared with the newly designed layout after the land development. Finally, a topographic map of the study area was prepared by digitizing the Ortho-mosaic.

c) To design the new residential plots and development features, mostly AutoCAD was used. First of all, the boundary of the study area was

exported to AutoCAD from GIS. Then the design was prepared for the residential purpose. Then afterward GIS software was used to create various layers, define the coordinate system, specify the feature type (polyline, polygon, point), and apply different cartographic elements like suitable color, labels, scale, north arrow, legend and so on. Finally,a land development map was exported in JPEG format. The following factors were considered during the development of a residential plan.

- The plot's side must be perpendicular to the roadtouching it.
- Plot size must be of regular shape as far aspossible.
- Plot size must be at least 130 m^2 i.e. 4.09 Aana
- The minimum width of the plot must be greater than 6 m and length must not exceed breadth by4 times.
- Road access to the project area must be min 8m and the developed roads must be min 6m.
- The area covered by road, open space, residential plots, and serviced plots was as per the specification and guidelines of land development act.
- The area for open space must be in such a place that it should be easily accessible to every resident of the area.

3. RESULT AND DISCUSSION

Ground Control Points from TBC

Table1: Adjusted Grid Coordinates Obtained From TBC

Point ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
1000	356399.295	3055791.279	1473.216
1001	356424.541	3055888.72	1472.880
1002	356503.861	3055835.472	1476.490
1003	356471.648	3055956.338	1474.697
1004	356556.731	3055884.366	1477.751
1005	356592.031	3055991.366	1476.424

Maps

The overlay of Orthomosaic map obtained from pix4D with a base map is shown below. The Orthomosaic map has been georeferenced with the coordinates resulting from DGPS survey. As a result of georeferencing of orthomosaic, it has been overlayed over the base map perfectly.

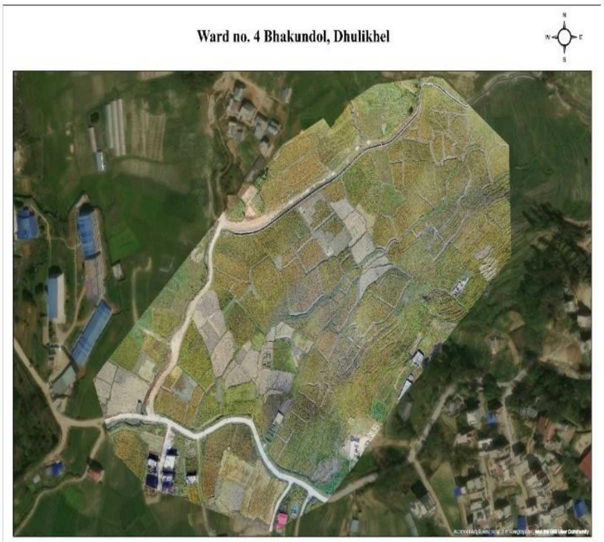

Figure 3. Overlay of orthomosaic

Using the orthomosaic as a backdrop, we digitized the existing parcels and features. Digitization of orthomosaic resulted the following map which shows the irregular parcels where there is no connectivity ofroad networks and no open space.

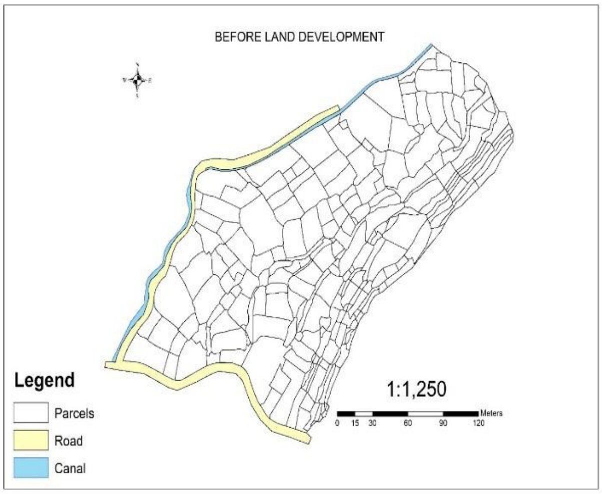

Figure 4 Existing parcels before land development

Using the contours, a topographic map is prepared ina GIS environment, which is shown below.

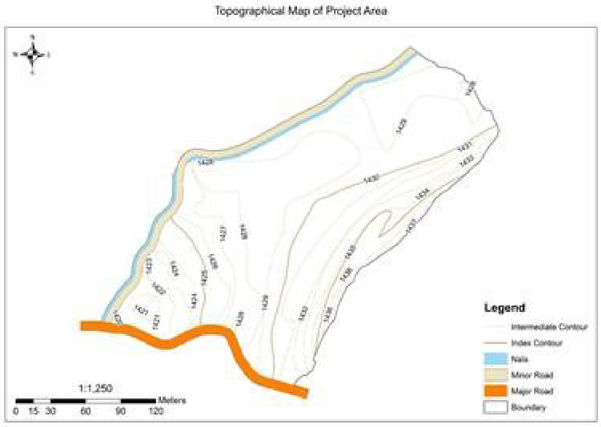

Figure 5 Topographic map of the project area

The boundary of study area is exported to AutoCAD environment. Land development plan is done using AutoCAD software where we make different layers for different features. It's quite easy to design plans in AutoCAD rather than in ArcGIS. Thus designed land development plan is later on exported to ArcGIS to get the map in desired format. The final output of project, a land development plan for residential purposes by systematically creating parcels of regular shapes is given as.

Figure 6 Final Land Development Plan

Figure 7 Before vs after land development

Project Summary

The area contained by a particular plot type along with features like road and canal is given below. Thementioned area coverage do not violate the land development guidelines. It follows the guidelines of local authority for the land development.

Table 3 Area Contained

Particulars	Description	Percentage (%)
Total Area	48045.95 m^2 (4.8 Hectare)	100
Open Space	2454.287 m^2	5
Road	12193.163 m^2	25
Service Plot	3260.588 m^2	7
Residential Plot	29308.03 m^2	61
Canal	960.919 m^2	2

Further details along with the number of each plot type as well as the width of different road types of theland development plan are given below. According to the land use regulations 2022, the government has barred the plotting of residential areas if the area of such land is less than 130 square meters (4 aana 1 daam). Hence considering this rule all the developedplots are greater than 130 square meters.

Table 4 Details of Land Development Result

Particulars	Description
Location	Ward-4, Bhakundol,Dhulikhel
Major Road	8 meter
Minor Road	6 meter
Minimum Plot Size	130 m^2 (4 Aana 1Daam)
Number of Residential Plots	157
Number of ServicePlots	9
Number of Open Space Parcels	3

4 CONCLUSION

Finally, this study meets the main objective of the project which is to prepare a land development plan for residential purposes by systematically creating parcels of regular shapes. Modern technologies suchas DGPS and UAV were used as data collection tools,which are more accurate and convenient than traditional methods. By harnessing modern technology the project has successfully created a systematic plan for residential land development thatis not only accurate but also environmentally conscious. Land development is one of the best solutions of solving problems of provision of comfortable housing and infrastructure development. Land development technique leads to an arrangement of irregular plots into regular plots which are suitable for housing and for accessibility. The rapid infrastructural developments in an unplanned way can be managed and minimized by using land development approach by using modern techniques. Land development not only helps to solve the unmanaged expansion of residential areas but also minimizes land-related issues, maintains the ecological balance, increases the value of land as well as enhances sustainable development.

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Comparative Study Using Different Techiques for Cadastral Survey in Plain Area: Total Station, RTK-GNSS & UAV

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Keywords: Cadastre, Plain Area, Total Station, GNSS, RTK GNSS, UAV, Area, Perimeter, Comparison.

Abstract:

This study evaluates various methods for mapping land boundaries in plain areas. Traditionally, Total Stations (TS) and GNSS ruled, but advancements like Real-Time Kinematic (RTK) GNSS, Unmanned Aerial Vehicles (UAVs). This project aimed to compare different ways of surveying-total station, RTK (Real Time Kinematic), and UAV (Unmanned Aerial Vehicle)-especially in plain areas. We looked at how well each method marked out parcel boundaries, focusing on RTK GNSS and UAV surveys. By checking the size and shape of parcels, we found that RTK-GNSS gave more accurate results compared to UAV. In simple terms, RTK-GNSS is better for surveying flat areas than using UAV.

1. Introduction

Land is an immovable property; beside this constraint every person depends upon it. Without land, we cannot sustain the earth. Nepal started cadastral surveying using plane table in 1923 AD from Bhaktapur district. Cadastral surveying has been in practice for over a century since its inception. It was the first cadastral surveying and mapping in Nepal. The preparation of cadastral map using plane table surveying beginner on 1999 AD and is modified to a digital cadastral system. Now, we are preparing the digital cadastral map and database using total station as a pilot project in ward number 6 of Banepa Municipality of Kavrepalanchowk district Bagmati province, Nepal from 2006 AD (Ashim Babu Shrestha, 2023).

A cadastral survey is the process of mapping, measuring, and recording the boundaries and characteristics of land parcels, including buildings and premises (FIG Statement on the Cadastre - International Federation of Surveyors, n.d). This surveying technique aims to establish an accurate and comprehensive database of real estate information, which is essential for land management, ownership registration, and legal purposes (The Importance of Cadastral Survey Information for Effective Land ., n.d). Initially, the cadastral survey was carried out with local control system and this system was applied for 38 districts, the maps thus produced are also termed as island maps. After the establishment of Geodetic Survey in Survey Department in 1973, a network of national control systems was established and so the remaining 37 districts, the surveying was based on the national control system. Therefore, the government decided to resurvey those remaining 38 districts that are not based on the national control network. At present, resurvey is in progress mainly in 9 such districts of Terai area (plain lands) including Kathmandu. Recently, a concept has been developed to prepare a parcel plan individually and to carry out the survey using Total Station Theodolites. The reason is to reduce the number of disputes, to increase the accuracy of mapping and to support the establishment of parcel based cadastral information system (Acharya, 2003). In cadastral applications, tachymeters and GNSS receivers (Global Navigation Satellite System) are commonly employed due to their high accuracy and performance in surveying object points and lines. While these traditional surveying methods excel in precision, photogrammetric applications are increasingly utilized for mapping and updating maps, particularly in larger areas. Traditional airborne images, limited by factors such as high flight altitude, resolution constraints, and cost, are less favored in cadastral surveying. However, advancements in robotic systems have facilitated the use of unmanned aerial vehicles (UAVs) as platforms for photogrammetric data acquisition. These autonomous UAVs are equipped with various sensors, including still-video cameras and LiDAR systems, enhancing their capabilities for navigation, positioning, and mapping (Manyoky, Theiler, Steudler, Eisenbeiss, 2011). Total station and RTK-GNSS are two commonly used surveying instruments for determining the coordinates of a point on the earth's surface. The accuracy of these instruments depends on various factors such as the measurement range, distance, and location of the point. According to the surveying accuracy of GNSS receivers can reach centimeter-level, which can meet the requirements of most projects. On the other hand, the total station turns out to be a more accurate equipment for short distances. However, the RTK-GNSS can reach up to 20 kilometers with greater precision(<2-5 km) (Mettatec, 2023) Journal Teknik, Sipil dan Perencanaan. (October 2019).A study indicates that for open areas, measurement with GPS Real Time Kinematic (RTK) method reaches a horizontal accuracy of 0.040 m with a total station. Ispen Safrel1, Eko Nugroho Julianto, and Nur Qudus Usman. (2018).

Another study aimed to determine the comparison of accuracy and efficiency of measuring land parcels using a total station and GPS Real Time Kinematic (RTK) method. baleid. (2020). The aim of the research is to evaluate the precision assessment between Real-time kinematic RTK GPS and TS via measuring of close traverse by applying the least square method (baleid, 2020). Total Station Surveying vs GNSS Surveying: Understanding the Differences. (n.d.). Total station surveying is known for its high precision and versatility, making it ideal for projects that require very accurate measurements.

2. Methods

2.1 Study Area

The study area was located between Kathmandu University and the Land Management Training Centre, situated in the southeastern part of Dhulikhel Municipality Ward No 4, Nepal. The study area covered approximately 32,168 square meters, with a perimeter of about 912 meters. It was near the Kathmandu University premises.

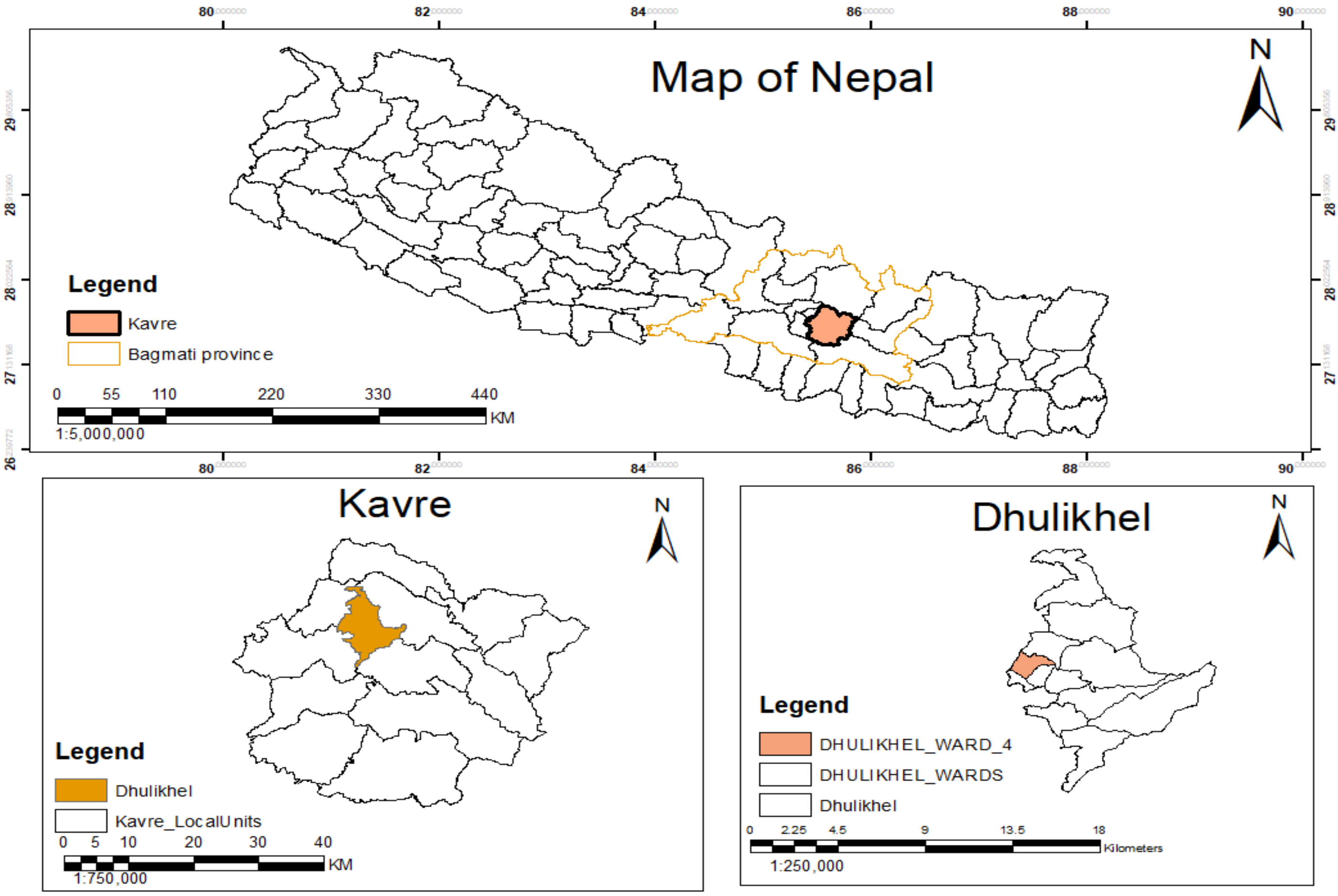
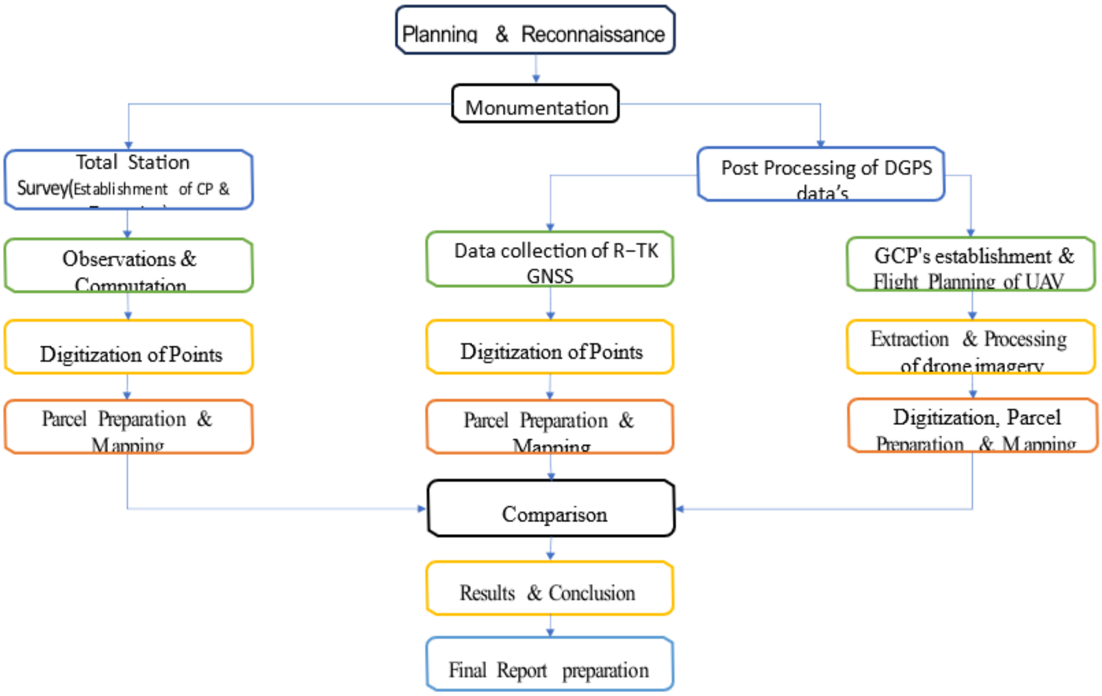


Figure 1 Map of Study Area

2.2 Methodology

The study focused on meticulous planning and reconnaissance to ensure the success of field operations. The monumentation process was crucial for establishing accurate Ground Control Points (GCPs) as reference points for surveying activities. Utilizing Total Station surveys and DGPS instruments like Trimble and Stonex, the project established control points with high precision. The DGPS processing involved post-processing methods to analyze and correct GPS data. Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS) and UAV operations were integral parts of the fieldwork, ensuring centimeter-level accuracy in data collection. Digitization processes for Total Station and RTK-GNSS data involved transferring, converting, and importing data into GIS software for parcel preparation. UAV image processing using Pix4D software enhanced the accuracy of Digital Terrain Models (DTMs) and Orthomosaics, providing detailed insights into the surveyed area. The project's comprehensive approach to data collection and processing aimed to achieve precise and reliable results for cadastral mapping and land surveying purposes.



Total Station: For data acquisition with the total station, we set up a NIKON Total Station with the specifications shown in the table below. We walked over the study area with a prism to collect the data needed to generate a cadastral map.

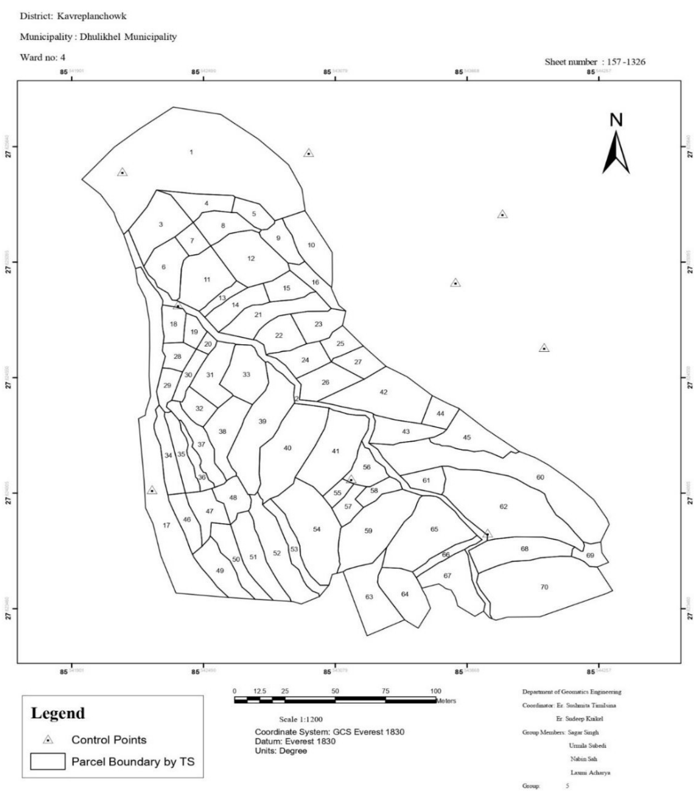


Figure 2 Cadastral Map prepared by Total Station

UAV: For data acquisition with UAV, we used the DJI Phantom, Brand DJI Type Quadcopter Functions Around flight, auto landing, automatic return Remote 2.4GHz wireless remote control. We used Orth mosaic files and started the digitization process with similar steps as Total Station. Then we generated the same number of parcels from Orthomosaic.

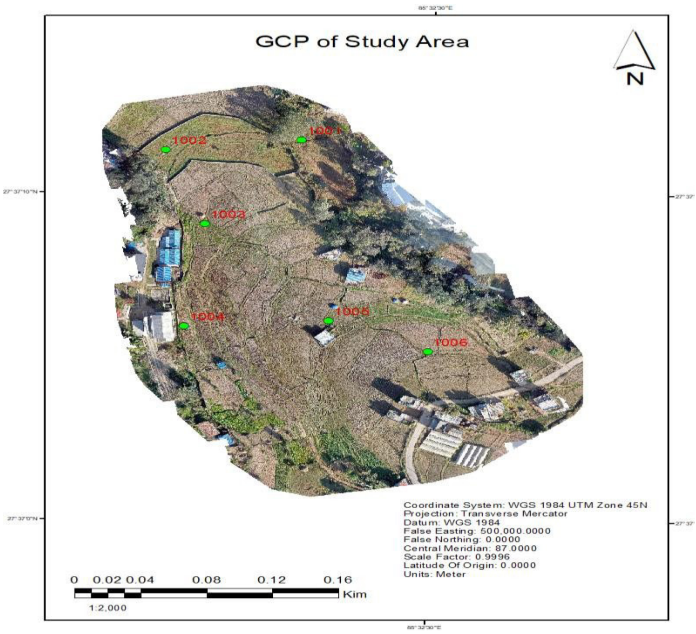


Figure 3 Geolocated Orthophoto

Figure 4 Cadastral Map prepared by UAV.

RTK-GNSS: DGPS was used to establish control points for the ground and aerial survey. One base station and two rovers were employed for the accurate establishment of control points. The DGPS used has the following specifications. Name STONEX S8 PLUS GPS Satellite Tracked GPS & GLONASS Channels 555 Signal reacquisition < 1 sec.

Then, the rover of RTK-GNSS was placed at the boundary corner of each parcel.

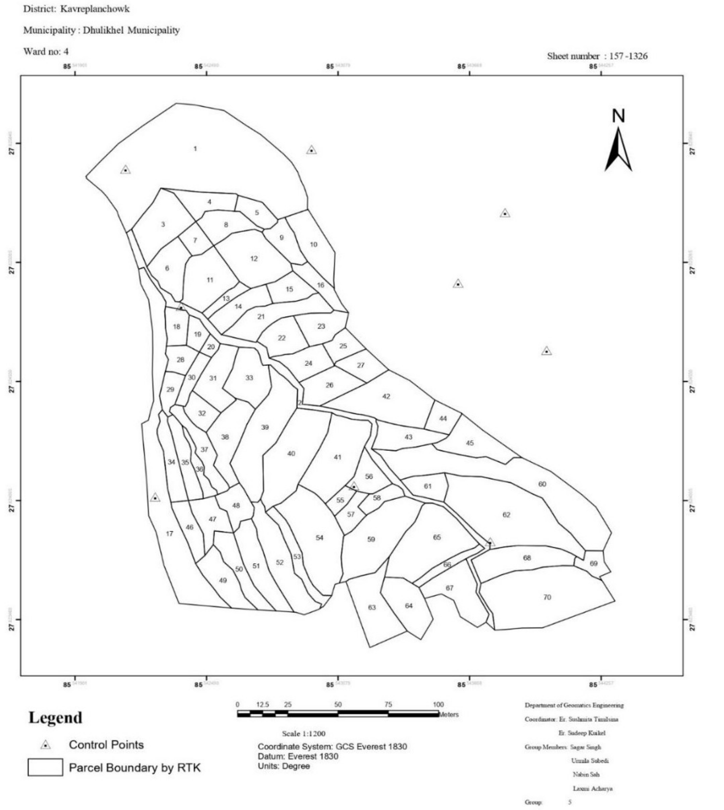


Figure 5 Cadastral Map prepared by RTK-GNSS

4. Results and Analysis

Comparison and Results

Table 1: Variation in Standard Deviation of Area & Perimeter of Total Station, RTK-GNSS, UAV

S.N.	Difference in two methods i.e., Total Station &RTK-GNSS		Difference in two methods i.e., Total Station & UAV		Difference in two methods i.e., RTK-GNSS & UAV	
	Perimeter(m)	Area(m^2)	Perimeter(m)	Area(m^2)	Perimeter(m)	Area(m^2)
Standard Deviation	0.7015	5.77475	2.32559	22.2304	2.28617	23.2586

The comparison table indicates that the variation in the standard deviation of the difference in area and perimeter between Total Station and RTK-GNSS is less compared to the variation in the standard deviation of the difference in area and perimeter between Total Station and UAV. It also shows that the variation in the standard deviation of the difference in area and perimeter between Total Station and UAV is less compared to the variation in the standard deviation of the difference in areaand perimeter between RTK-

GNSS and UAV. This leads to the conclusion that ground surveying is more accurate than aerial surveying. Total Station Survey is referenced ashighly accurate for the

study, so RTK-GNSS is more accurate than UAV after Total Station Survey.

Overlapping the Map:

Overlapping of Total station and UAV Cadastral Map.

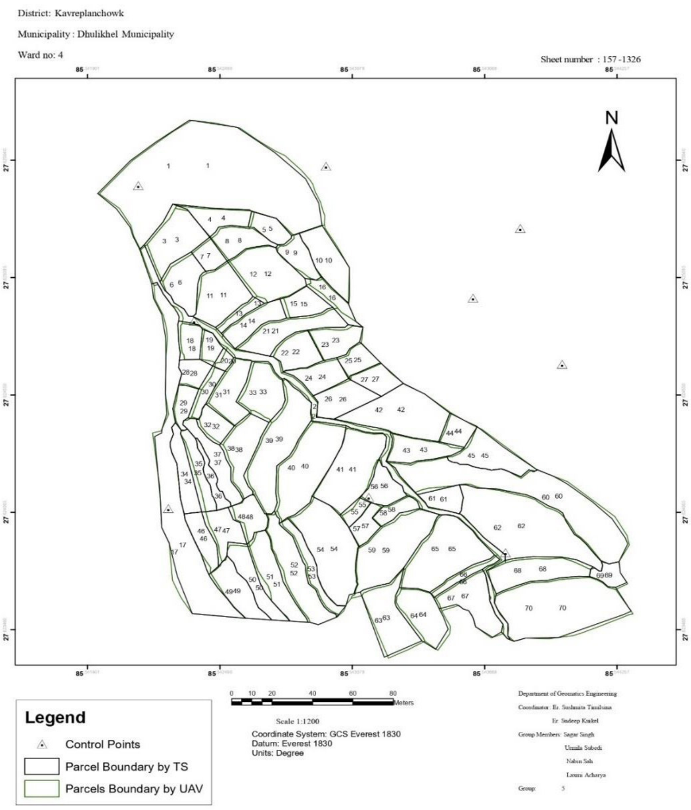


Figure 6 Overlapping area of Total station and UAV Cadastral Map

Overlapping of RTK-GNSS and UAV Cadastral Map.

Figure 7: Overlapping area of RTK-GNSS and UAV Cadastral Map

Overlapping of RTK-GNSS and Total Station Cadastral Map.

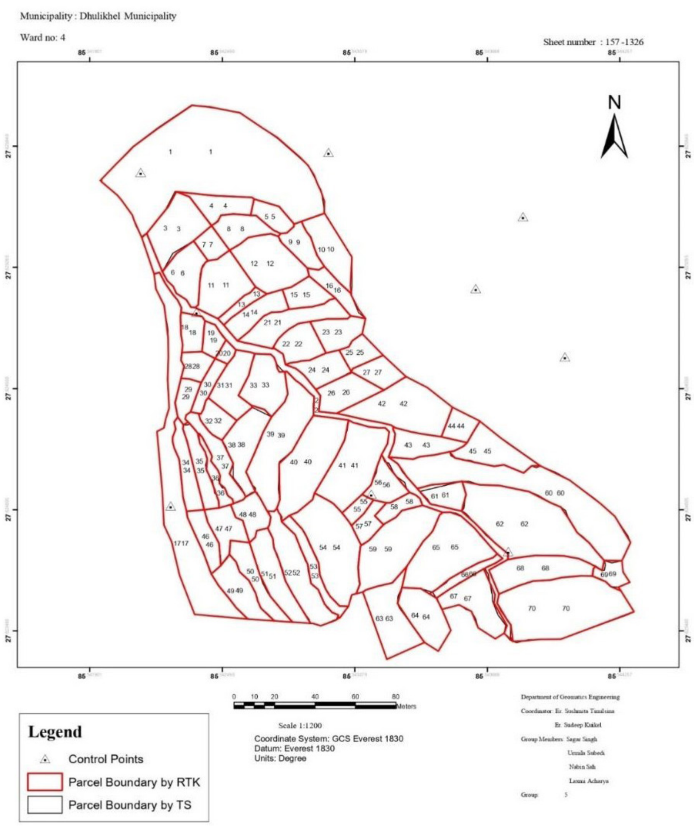


Figure 8 Overlapping area of RTK-GNSS and Total Station Cadastral Map.

Overlapping of all three Cadastral Map.

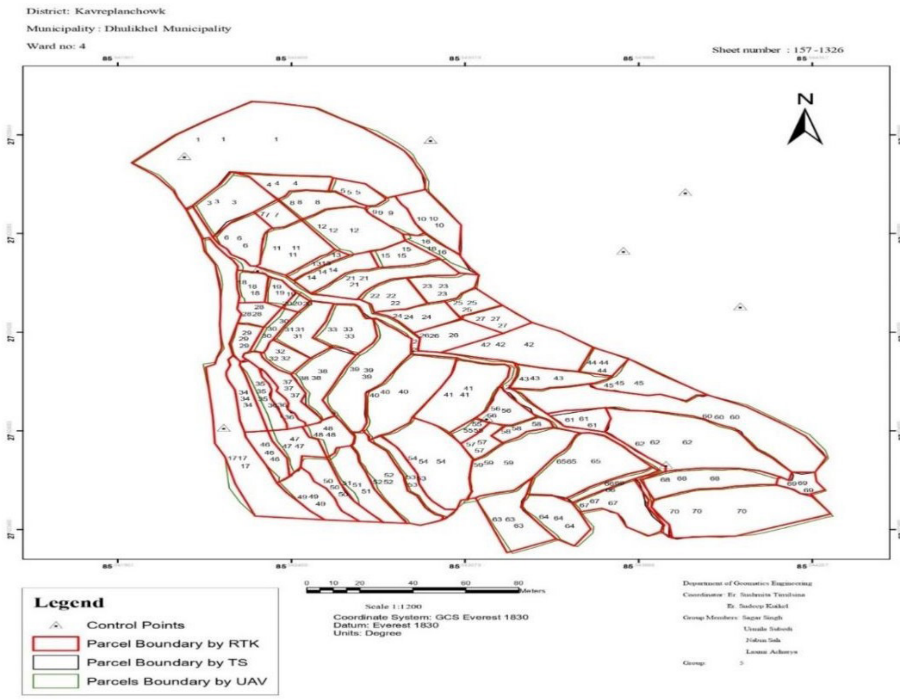


Figure 9 Overlapping Cadastral Map using UAV, Total Station & RTK-GNSS

This overlapping map of all three survey methods illustrates the variation in parcels prepared using Total Station, RTK-GNSS, and UAV. In this map, red color denotes themap prepared by RTK-GNSS, black color denotes the map prepared by Total Station,and green denotes the map prepared by UAV. According to our analysis, the cadastral map by Total Station is considered highly accurate for plain and small areas. From theabove data analysis, we conclude that RTK-GNSS is more accurate than UAV.

4.2. Limitations

This study was carried out under favorable conditions. Some of the limitations thatfaced this study area as follows:

- Accuracy was affected by weather conditions & time of the Field survey.
- Signal obstructions occurred during the RTK-GNSS acquisition.
- UAV flight limitations, and weather dependency (Flight stability affected bywind, rain, or extreme temperatures).
- Static-GNSS Post-processing complexities affecting data management.

4.3. Outcomes

The following were the outcomes of this project based on the below criteria:

Criteria	Total Station	RTK-GNSS	UAV
Accuracy	Referenced as Highlyaccurate for Study	It is more accuratethan UAV	Less accurate compared to Total Station & UAV
Data Collec-tionSpeed	Slow compared to RTK-GNSS & UAV	Faster than TotalStation	Fastest among all methods used
Operational Skills	Required Skilled Surveyors	Required SkilledOper-ators	Required SkilledOperators
Equipment Portability	Instrument portability isdifficult compared to other methods	Instrument portabilityis easy compared to Total Station	Instrument is highly portable among all methods used

Integration with GIS	Required additional steps	Seamless Integration	Required Processing Steps
Data Resolution	Point-based	Point-based	High-ResolutionImage
Data ProcessingTime	Post-Survey ProcessingRequired	Real-time or rapidProcessing	Post-Processing of image is required

5. Conclusions and Recommendations

Conclusions:

The primary objective of this project is to compare different surveying methods, namely total station, RTK (Real-Time Kinematic), and UAV (Unmanned Aerial Vehicle), specifically in a plain area. In the plain area, the comparison of parcel boundaries obtained from total station survey, RTK-GNSS, and UAV reveals the promising potential of RTK-GNSS and UAV cadastral surveys. Various analyses of parcels, including area and perimeter, were conducted using both RTK-GNSS and UAVtechniques, and the results were compared with Total Station Survey.

The comparisons indicate that the standard deviation in area and perimeter using RTK-GNSS shows less deviation in the area and perimeter of the parcels. Therefore, we conclude that RTK-GNSS is more accurate than UAV.

Recommendations

Each method has its own set of advantages and disadvantages. The most effective approach to address the limitations of one method is to offset its drawbacks by leveraging the advantages of another. This strategy ensures accomplishing tasks with higher accuracy while minimizing costs. Similarly, an integrated approach using both methods can be employed to achieve higher accuracy economically and expedite the process. Optimal results can be achieved in different surveying scenarios by adopting the following methods:

- For achieving high accuracy and precision in small areas with dense features: Utilizea total station.
- For conducting large-scale surveys in open areas with good satellite visibility: EmployRTK GNSS.
- For rapid data capture of large areas and generation of detailed imagery: UtilizeUAVs.
- Consider a combination of methods: Combine UAVs for rapid data acquisition withRTK GNSS or a total station for high-accuracy ground control points.

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Optimizing Crop Management: Geospatial Insights for Climate Smart Agriculture

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Keywords: Climate Smart Agriculture, Geospatial, Sustainable Farming, Geomatics Technology

Abstract:

Geomatics technology, integral to Climate-Smart Agriculture (CSA), revolutionizes the agricultural landscape by offering indispensable spatial data and cutting-edge tools. Its role is pivotal, as it facilitates precise monitoring across crucial parameters such as climate variables, soil conditions, crop health, and water resources. This precision empowers stakeholders with actionable insights, enabling them to make informed decisions and develop effective strategies. Moreover, Geomatics technology optimizes resource utilization by providing detailed spatial analysis. This empowers farmers to allocate inputs such as water, fertilizers, and pesticides more efficiently, thereby reducing waste and minimizing environmental impact. Furthermore, by promoting sustainable practices such as precision agriculture and agroforestry, Geomatics technology contributes to long-term resilience and ecosystem health.

1. Introduction

Agriculture is the oldest trading system and a continuous process that has been and will remain an ongoing essential activity. Contributing 4% of the world's gross domestic product (GDP) and up to 25% of GDP in the least developed nations, agriculture is also essential to economic growth (Agriculture and Food, 2024). Climate change and food security has consistently remained a critical global concern, profoundly impacting the agricultural system. Because of the hazards to human health, food supplies, and water supplies, as well as the changes in weather patterns, temperatures, and extreme occurrences, climate change necessitates worldwide cooperation. (Plingelhofer, Muller, & et.al, 2020) To cut down this problem, an approach 'Climate Smart Agriculture'(CSA) was first launched by "Food and Agriculture Organization of The United Nations" in 2010 AD. The main incentives of this approach are: increasing sustainable agriculture productivity and incomes, climate resilience and to reduce the emission of greenhouse gases.

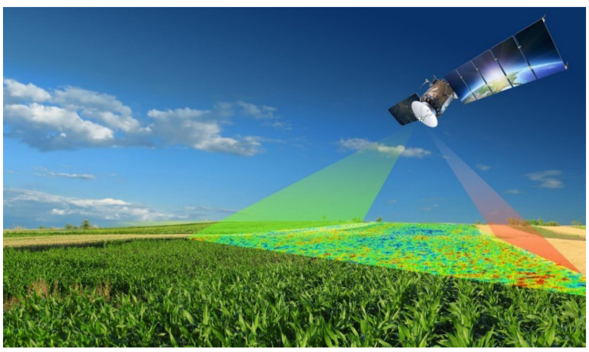

Figure 1 Geospatial Technology in Agriculture

2. Background

In today's technology-driven era, leveraging the various tools and technologies can enhance the adoption and effectiveness of sustainable farming methods. Within the Geospatial domain, the integration of geospatial software and technology has revolutionized the way stakeholders approach sustainable farming practices. Harnessing spatial data to analyze, monitor and manage the agriculture system, including tasks like crop monitoring, soil moisture monitoring, nutrient management, weed detection, and yield estimation, is the key to achieving the objectives of CSA. Agriculture emits methane and nitrous oxide through manure management, rice paddies, synthetic fertilizers, and burning residues, contributing to global warming and climate change.

Agricultural practices can be modified to reduce these emissions and promote sustainability. Agroforestry, including agrosilvicultural systems which mitigates climate change and enhances food security by creating a microclimate with tree cover that reduces humidity around crops. Innovative agroforestry addresses food security, biodiversity loss, and climate change (Agriculture, 2024).Precision agriculture technologies GPS, Sensors, Remote Sensing can help farmers and big agro-tech corporations implement climate smart agricultural practices effectively (Agroforestry Systems and Sustainable Agriculture, 2024).

Vegetation indexes essential for technology-driven sustainable farming, including the Normalized Difference Vegetation Index (NDVI) for gauging vegetation health, Normalized Difference Water Index (NDWI) for effective irrigation management, Red-Edge Chlorophyll Index (RECI) for assessing nitrogen levels, Normalized Difference Moisture Index (NDMI) for monitoring crop hydration, Normalized Difference Red Edge (NDRE) for tracking crop maturity, Modified Soil Adjusted Vegetation Index (MSAVI), and Enhanced Vegetation Index (EVI) for identifying uneven seed growth (Sergieieva, 2022).Analyzing cyclic patterns of temperature and precipitation rates is valuable for determining suitable crops for cultivation. Certain crops thrive under specific environmental conditions, while others may not.

Current agricultural practices face numerous challenges, including declining soil fertility from human activities, soil degradation, environmental pollution, yield gaps, greenhouse gas emissions, climate change-induced weather unpredictability, increased pest and disease pressure, and water inefficiency. Zhao, Liu, and Huang (2023) highlight persistent issues in Climate-Smart Agriculture (CSA), such as shortages of agricultural water resources and the impacts of climate variability and change.

3. Geomatics Innovation Technology

Geomatics innovation revolutionizes CSA through an array of sophisticated tools and techniques tailored for precise data collection, comprehensive analysis, and informed decision-making. Numerous existing and newly developed techniques and tools in geomatics domain such as Geographic Information System (GIS), Remote Sensing (RS), Global Navigation Satellite Systems (GNSS), Internet of Things (IoT), and Big Data Analytics (BDA) have become essential for global food security through effective analysis of climate and crops. Geomatics encompasses diverse data collection and analysis methods which are mentioned below:

3.1 Integration with GIS:

Geographic information systems are computer-based tools used to store, visualize, analyze, and interpret geographic data. Recently, GIS tools have been increasingly utilized in agricultural production at local, regional, and global levels. FAO estimates that geospatial information including GIS can increase crop productivity by 10 to 20% globally. (GIS in Agriculture – Geospatial Intelligence for Sustainable Farming, 2023) GIS identifies and classifies soil, providing detailed maps of soil characteristics, moisture levels, and nutrient distribution. This enables farmers to adopt precise agricultural practices, reducing the need for excessive fertilizers and pesticides. Consequently, GIS minimizes carbon-intensive processes, increases yields, and lowers greenhouse gas emissions. It also reduces farm operational costs through site-specific application of inputs, promoting agricultural sustainability in the face of climate change.

Integrating GPS/DGPS with GIS enables real-time data collection and mapping. This enhances land-use planning, promoting efficient agriculture and protecting carbon-rich areas like wetlands. It supports carbon sequestration, reduces emissions from land-use changes, prevents deforestation, and promotes sustainable land management.

3.2 Unmanned Aerial Vehicle (UAV)

UAV are employed for data collection, automated seeding and pollination without the need of human operators. The high-resolution data from UAV can then be used to optimize crop yield and minimize waste, while reducing the environmental impact of farming. UAV facilitate the monitoring of soil moisture levels and crop growth patterns, aiding in efficient irrigation management and water conservation, crucial in mitigating the impacts of climate change-induced droughts. Furthermore, UAV play important role in the assessment of land cover changes, enhancing better land-use planning and management strategies to mitigate deforestation. In recent time, Researchers are using UAV equipped with gas sensors to measure greenhouse gas emissions from agricultural activities. Real-time verification of crop types, the implementation of contour lines, and the identification of critical erosion areas are made possible through drone imagery.

3.3 Remote Sensing

Remote sensing technologies, including satellite and drone imagery, provide valuable insights into agricultural landscapes from a bird's-eye view. These images enable the assessment of crop health, soil conditions, canopy health, growth stages, yield, biomass, and water availability, aiding in decision-making processes for farmers (PHANG & et.al, 2023).These advantages result in a more effective use of resources, less wasteful use of inputs, and a decrease in agricultural emissions. By facilitating the early diagnosis of crop stress, improving irrigation management, and promoting land use planning, remote sensing contributes to the reduction of greenhouse gas emissions from crop production. Continuous data series from satellites like NASA'S Terra and Aqua satellites, ESA's Sentinel-2 satellites, and NOAA's GOES satellites monitor the crop yield. Studies also utilized the temporal data from MODIS, NOAA-AVHRR, LANDSAT, IRS, SPOT, and IKONOS (Zhao, Liu, & Huang, 2023). EOS SAT is a first ever satellite constellation created for agricultural monitoring, using remote sensing technology to cover entire farmland and forest areas in key agricultural countries (Empowering agricultural businesses with remote farm monitoring, n.d.). Landsat 8 orbits Earth every 16 days, providing essential data on crop health, nutrients, pests, and moisture, while private GIS satellites focus on specialized agriculture monitoring like fields, water, and temperature changes (Sergieieva, GIS In Agriculture: Best Practices For AgriTech Leaders, 2022)

3.4 LiDAR

LiDAR sensors have been widely used to determine the landscape and topography of agricultural land for planning and managing agriculture. LIDAR stands out due to its high-resolution 3D mapping, direct distance measurement, detailed vegetating analysis, rapid data capture, penetration through obstructions, and specific application like autonomous navigation. Feliipe Alfaya, a remote sensing specialist from Alvaz, explains the use of TrueView Lidar technology and LP360 Software for measuring and evaluating the crops for their customer, by using lidar, Alfaya is able to provide farmers with accurate information to maximize their harvest (How to Use LiDAR in Agricultural Applications, 2023). LiDAR data quantifies soil loss by using GLS point clouds to assess surface roughness in runoff areas, which 2D mapping cannot measure. This information helps farmers adopt soil erosion prevention measures by understanding terrain patterns. LiDAR's ability to detect atmospheric CO_2 aids in pollution monitoring and reduction strategies. Favored for non-destructive, light-independent remote sensing in agriculture, LiDAR data is crucial for land management.

Measurements of canopy volume, leaf area, tree area, and biomass help estimate fertilizer and pesticide needs, carbon storage, and biomass accumulation. These insights enhance photosynthesis, growth, plant health, yield potential, CO_2 sequestration, and evapotranspiration, supporting effective agronomic system maintenance.

3.5 Global Navigation Satellite Systems (GNSS)

GNSS, the preferred precision positioning method in agriculture, aids in tasks like yield monitoring, compaction sensing, tree planting, and precise weed management. Its evolving

receivers offer submeter to centimeter accuracy, with RTK-GPS ensuring centimeter precision for advanced farming efficiency (Perez-Ruiz & Upadhyaya, 2012). Nowadays, tractors are equipped with GNSS system leading significantly improved work efficiency. GNSS are pivotal in fostering climate-smart agriculture through precise positioning, timing, and navigation services. By leveraging GNSS technology, farmers can implement precision farming techniques, optimizing resource allocation for fertilizers, pesticides, and water through accurate mapping of fields and monitoring of soil composition and crop health variations. Integrating GNSS receivers with other sensors facilitates climate data collection and monitoring of carbon sequestration efforts, aiding in assessing agricultural practices' impact on mitigating climate change. Additionally, GNSS-enabled supply chain management ensures transparency and traceability throughout GNSS data aids in soil erosion control by precisely mapping erosion-prone areas.

3.6 Continuously Operating Reference Stations (CORS)

CORS in CSA are networks of permanent GPS receivers that provide real-time positioning data. They enhance farming by enabling accurate application of inputs like fertilizers and pesticides, leading to improved resource use efficiency. Additionally, CORS contributes to weather monitoring systems, improving spatial and temporal resolution of weather data for better agricultural practices. It also aids in climate monitoring and modeling, enhancing the accuracy of climate predictions. Moreover, CORS supports water management by providing accurate elevation data for efficient irrigation systems and mitigating climate change impacts on water availability. Overall, CORS plays a vital role in CSA by providing accurate positioning data that supports precision farming, weather monitoring, climate modeling, and water management efforts. By improving the precision and efficiency of agricultural practices, CORS contributes to the resilience and sustainability of agricultural systems in the face of climate change.

4. Current State of CSA in Nepal

Agriculture serves as the foundation of Nepal's economy, playing a vital role in sustaining livelihoods and driving the nations. One of the reasons Nepal continues to import a significant amount of food is due to insufficient extension of services to promote modern and sustainable farming practices. According to Acharya, Khanal and Paudel, Sustainable farming practices to achieve CSA such as plastic pond, rain water harvesting, water source protection, drip irrigation, plastic house, solar irrigation and mobile based Agro-advisory are being practiced in Kaski, Nepal. Still many farmers, particularly those in remote areas, face challenges accessing current information on modern farming techniques, climate-smart practices, resilient crop varieties, and sustainable agriculture methods. This lack of access hinders their ability to adopt more efficient and environmentally friendly farming approaches, contributing to the ongoing need for food imports in the country. Realizing the need for planned efforts to address the challenges of climate change and variability in agriculture and allied sectors, the Government of Nepal has developed a National Adaptation Programme of Action (NAPA), enacted a national Climate Change Policy in 2011 (CCP), and implemented Local Adaptation Plans of Action (LAPAs), among others Nepal is in the early stages of adopting technology, yet there are efforts to integrate Information and Communication Technology (ICT) with agriculture. Farmers' access to ICT is being improved by the MOAD's Project for Agriculture Commercialization (PACT), the Agriculture Management Information System (AMIS), and a number of other organizations (Shrestha & Khanal, 2020). GIS-powered Crop Suitability Analysis (CSA) holds promises for individual farmers and helps to optimize soil fertility, water usage, and crop management. This technological integration not only enhances agricultural efficiency but also aligns with the United Nations Sustainable Development Goals (SDGs), SDG 2 (Zero Hunger) and SDG 13 (Climate Action) which promote sustainable agriculture and food security (Ali, 2021). The adoption of geomatics technology, including LIDAR, UAVs, CORS, remote sensing, and GPS, by various organizations in Nepal is a significant stride towards modernizing agricultural practices and spatial data management. However, the process of full-scale integration is still underway, to climbing the ladder of technological advancement.

5. Conclusion

CSA has helped in mitigating climate change, food security. Many underdeveloped and developed countries has implemented this approach. The integration of Geomatics technology into CSA represents a pivotal advancement in sustainable farming practices. Through the satellite-based localization solutions, remote sensing techniques, GIS, GNSS and GPS stakeholders can make data-driven decisions that enhance in achieving the objective of CSA. The continued integration of geomatics innovations in agriculture promises significant advancements in food security, environmental conservation, and economic sustainability. It is imperative for stakeholders across sectors to collaborate, innovative, and invest in scaling up geomatics solutions to address the evolving global needs.

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Q & A

Answers collected from Geomatics Engineering Students and Faculty Members of Kathmandu University

Q How do you compare your actual experience as a Geomatics engineering students so far to the initial expectations you've had? Have they been met, exceeded or changed in any way?

As my knowledge for geomatics field was limited before, I used to think this as only a survey field but after being in it for a year, I came to know the broad field of geomatics that we may pursue our career in. So it levelled up my expectations changing my mindset and I am really enjoying it.

SAMIR BASNET | 2022

Of course there is a lot of contrast . The sudden changes from classroom to handling projects and surveying truly embarked and blasted my capabilities .
It has boosted my confidence and I feel I will make it as an excellent version of a Geomatics Engineer. I am having my expectations satisfied .

AYUSH DAHAL | 2021

Comparing my actual experience as a Geomatics engineering student to initial expectations is:
Career Preparation
Expectations: I have envisioned a clear career path in surveying, mapping, or urban planning.
Reality: Exposure to various aspects of geomatics reveal a wider range of career opportunities, including roles in environmental management, geospatial intelligence, and even emerging fields like autonomous navigation and smart cities.

PRASANNATA PRADHAN | 2022

Q What motivated your decision to pursue a career in Geomatics Engineering?

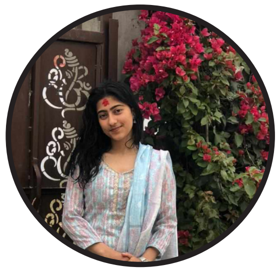
My decision to pursue a career in Geomatics Engineering was motivated by a passion for geography and technology, a fascination with mapping and spatial data, and the desire to work on real-world problems like environmental monitoring and urban planning. The field's blend of technical and practical applications, along with promising career opportunities, further solidified my choice.

AVINASH KUMAR MAHASHET | 2022

All in my early teenage years, I had planned to become an engineer and serve my nation. I half succeeded in my dreams the day I took an admission in Geomatics Engineering in Kathmandu University. The goals I had set to live my life as I wished as a teenager was to explore the unexplored, pursue a deep knowledge in maps, and finally contribute my society to become a better place which fueled me to pursue a career in Geomatics Engineering.

SAKSHAM LUINTEL | 2021

The decision to pursue a career in Geomatics Engineering is all the mixture of personal interest, future plan and also professional goal. As Geomatics engineers are demanded across various sectors including governmental field, stability of job is my main reason behind choosing this surveying engineering.



SADISKSHA GHIMIRE |2023

Q How has your career visions evolved through out these years being a Geomatics Engineering student? How do you see yourself contributing to the field of Geomatics

Within about 3 years and 3 months of entering the field of Geomatics, it's a long journey to explore the things which directly affect the real-world entity. Beginning from the basic surveying to GIS , Cartography to Photogrammetry , Saptial Database Management System, Physical Geodesy to Satellite Geodesy. Retrieving and exploring the issues related to Cadastre and its implementation to the legality and social impacts related to Land Administration.
It's a deeper diving of solving the problem with Spatial/Geoinformatics approaches and solutions.

NABIN KR SHAH | 2020

My journey through the years of being a Geomatics Engineering student has been nothing but eye opening. The reason I chose GE in the first place was due to it's immense technical scope and aspects. The broad spectrum of career opportunities is what drew me in. But now , along with the career opportunities, I can see the immense potential of Geomatics to solve the real world problems in the world. My visions have evolved form being good technically to being someone who can leverage the technology to make actual impact in the world.

PRAGYA JOSHI | 2020

During these last years, my interests have been growing in the field of Geodesy. I find the field of Satellite Geodesy very attracting and alluring. Dealing with the mathematics involved in the space is fun.

SHISIR KHAREL | 2020

Q Share with us an example of how a hands-on experience (such as field trips) that has enhanced your learning. Also, one memorable and fun experience or memory from such

I believe that field experience provides deeper insights than years of reading textbooks. For example, concepts like leveling and traversing, which we study in class, become much clearer when applied in real-world settings. Classroom learning imparts knowledge, but field trips offer practical experience, essential for competing in the professional world.
During a recent hydropower survey camp, locals assumed we were there to build a bridge and urged us to complete it quickly to ease their daily commute. This incident taught me that as a Geomatics Engineer, I have a responsibility to meet the community's expectations and help realize their aspirations.

NIKITA SHRESTHA | 2020

Accuracy and precision required in survey measurements and method of conducting surveys cannot be visualized theoritically. By involving in field visits, we learned actually how to work in real engineering survey works and the art of preparation of maps.
The most memorable experience I remember during field days is that during fourth semester survey camp, on the last day, we the whole class went to Cherdung Hill from Jiri, Dolaka. Although the journey was difficult, it was really enjoyable and fun to travel with friends.

KANCHAN ADHIKARI | 2020

The hands-on experience brought classroom concept to life. I saw theoretical knowledge get translated into practical applications.
A memory that brings smile to my face is shared meals during the field. The shared fatigue, and wear - it all dissolved in the roar of laughter shared at dining hall.The simple joy of human connection- these memories are something that has stayed with me long after the field.

ISHA YADAV| 2020

Q What role do you see Geomatics Engineering playing in addressing today's pressing global challenges? How prepared are you to address these real-world challenges as a Geomatics Engineer?

Well, geomatics engineering has a wide scope in multiple areas, we deal with variation of data. We are the creators of data be it climate related, land related or more. Not only that,we also deliver these data in an understandable form to the layman so we have a great role in addressing today's pressing global challenges.
Talking about preparedness, we are learning in every time of our lives. So we are learning to do our task.

AAGYA DHUNGANA| 2019

Geomatics Engineering plays a crucial role in addressing today's pressing global challenges by providing essential tools and technologies for collecting, analyzing, and interpreting geospatial data. Geomatics is instrumental in various applications like urban planning, disaster management, environmental monitoring, and infrastructure development. As a Geomatics Engineer and with the expertise to utilize advanced technologies like GIS, remote sensing, GPS, and spatial analysis to gather valuable information and insights for decision-making, I am well prepared and equipped with the knowledge and skills to tackle the real-world challenges.

SAILESH ADHIKARI| 2019

Let's assume that there are superheroes armed with the power of maps and geo-spatial analysis. They use their powers to face all global challenges be it GIS to know the pattern, RS to monitor environmental changes from above or advanced surveying techniques to collect extremely precise data. These superheroes are called Geomatics Engineers.
With great powers come great responsibility, I am ready to use my superpowers in making the world a better place. I am ready to use my superpowers in facing issues like enviornment conservation, disaster management, climate change and so on. We Geomatics Engineers will definitely make this world a better place.

PRADEEP UPADHYAY| 2019

Q One advice you would give to juniors to navigate college years and on how to identify their interests within the field of Geomatics Engineering?

Get involved in clubs, workshops, and internships early on to explore the intersection of IT and Geomatics Engineering. Seek mentorship from professors and industry professionals to gain valuable insights. Stay curious by attending seminars and staying updated on the latest trends in technology and spatial data. Engage in diverse projects that combine coding and geomatics to discover your true interests. Regularly reflect on your experiences and be open to evolving your focus as you find what excites you most.

GORAKH NATH PANDEY | 2019

- *participate in classes and labs*
- *join student clubs*
- *seek internships*
- *focus on research and publishing research paper*
- *attend workshops and seminar*
- *develop skills on processing data, lidar, drone, total station analysis on GIS, ENVI, GEE, Python and so on.*

KAVI RAJ MISHRA | 2019

Don't limit yourself to the course, stay updated with the latest advancements in geomatics.

ABHISHEK ADHIKARI | 2019

USE YOUR GEOMATICS BRAIN

CHALLENGE 1

FIND GEOMATICS WORD

N	O	I	T	A	T	S	L	A	T	O	T	S	E	C
V	K	U	H	F	G	M	X	G	N	T	U	D	T	Z
B	O	J	E	L	W	V	A	I	E	R	K	Y	I	U
G	S	W	O	L	H	K	A	P	V	D	R	B	L	Q
Q	N	I	D	O	B	H	G	E	I	T	H	N	L	V
H	M	I	O	K	C	A	Y	P	E	N	P	J	E	C
K	Q	Z	L	N	K	I	T	M	S	C	G	K	T	H
S	Q	L	I	L	N	K	M	E	J	N	H	T	A	G
S	T	X	T	G	E	A	U	J	N	B	M	M	S	L
A	S	U	E	I	G	V	G	D	E	A	Z	F	E	O
P	T	U	L	O	Y	L	E	K	W	C	L	J	G	N
M	V	Q	T	L	E	K	V	L	N	G	X	P	C	A
O	D	O	A	L	I	D	A	D	E	F	D	E	E	S
C	H	H	G	N	I	S	R	E	V	A	R	T	B	S

DID YOU KNOW?

The Earth isn't a perfect sphere; it's slightly pear-shaped. So technically, your "round the world" trip is more of a "pear-shaped the world" trip!

Early mapmakers used to fill unknown areas with drawings of dragons and sea monsters. Maybe they were the original fantasy cartographers!

DID YOU KNOW?

There's a real place in the Pacific Ocean called the "Point Nemo," the oceanic pole of inaccessibility, which is closer to space stations orbiting Earth than any human habitation.

The phrase "off the map" might take on a new meaning if you live in the town of Dildo, Newfoundland. Yes, it's a real place, and yes, people often can't believe it's on the map!

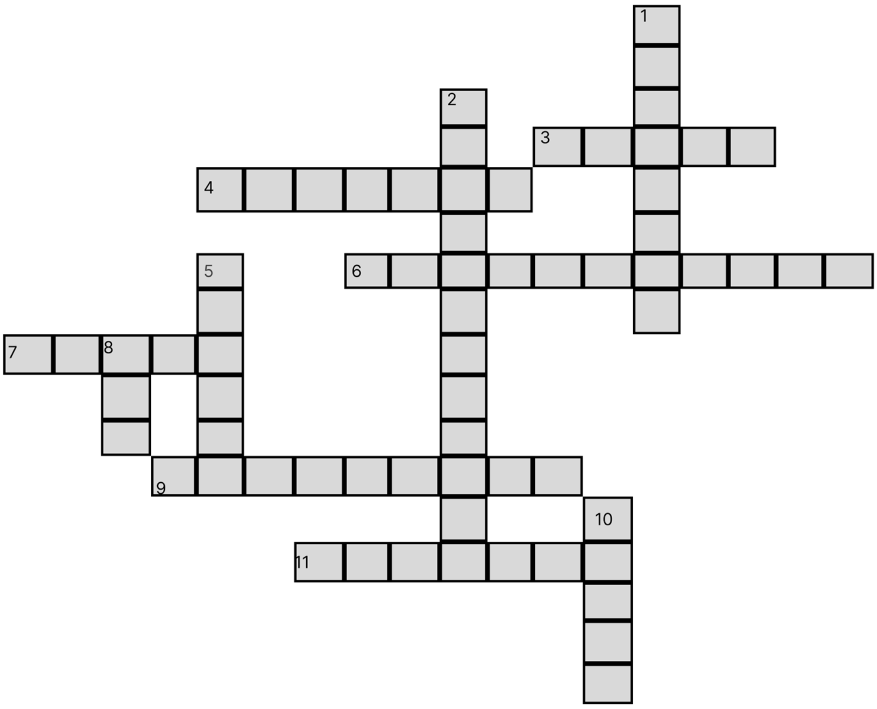
DID YOU KNOW?

A cartographer once inserted a fake town called "Agloe" into a map to catch copycats. It eventually became a real place, recognized by mapmakers and locals alike!

Antarctica has its own McDonald's, making it the southernmost Mickey D's on Earth. Talk about a Happy Meal with a view!

CHALLENGE 2

Solve Crossword Puzzle



ACROSS

3. The ruler for rooftop rulers.
4. Horizontal map coordinate.
6. Art and science of map-making.
7. Remote sensing technology using laser pulses.
9. Earth's egg model.
11. Earth's natural lines of elevation.

DOWN

1. Where property lines waltz on paper.
2. Surveyor's reference marker
5. Your piece of the property puzzle.
8. Digital representation of land elevation.
10. Tool for reflecting signals in surveying.

DID YOU KNOW?

If you're ever lost, just remember: you can always blame the GPS! It's estimated that GPS errors cause over 3 million wrong turns per day worldwide.

In 2013, a glitch in Apple Maps directed drivers to a remote Australian desert instead of a city, leading to an unintended adventure for many!

DID YOU KNOW?

In the 1970s, a prankster group of geographers added a fake mountain, "Mount Richard," to maps of the Rocky Mountains. It stayed there for years before anyone noticed!

10. Did You Know! The shortest place name in the world is "Å" in Sweden and Norway. It's a good thing GPS doesn't charge by the letter!

CAPTURED MOMENTS | 2018 BATCH

6th semester Survey Field | Jiri ,Dolakha

CAPTURED MOMENTS | 2019 BATCH

4th semester Survey Field | Jiri ,Dolakha

CAPTURED MOMENTS | 2020 BATCH

6th Semester Survey Field | Pokhara, Kaski
4th Semester Survey Field | Jiri, Dolakha

CAPTURED MOMENTS | 2021 BATCH

4th semester Survey Field | Bajrabarahi , Makwanpur

CAPTURED MOMENTS | 2022 BATCH

3rd Semester Survey Field | Kathmandu University
2nd semester project Demonstration

BATCH 2019

BATCH 2020

BATCH 2021

BATCH 2022

BATCH 2023

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