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Cover Page

Inauguration Program of International Workshop on "Land Use Planning and Land Administration: Integration and Decentralization".

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EDITORIAL

It gives me and my team immense pleasure to present you the fifth issue of 'Journal of Land Management and Geomatics Education'. The publication of this journal has played a significant role in sharing the advancements and achievements in the geospatial sector to professionals, academicians, students and all those who are concerned with this domain. It's a big part of our institution that, we believe, will help the readers to gain some perspectives about geomatics field and enhance their knowledge on the domain to a great extent. For this purpose, we have been very conscious about improving the content and quality of this academic piece. We have requested and included articles from wide range of theme such as environment, climate change, disaster management, land administration and diverse topics such as remote sensing, Global Positioning System, UAV, Surveying and Mapping, etc. In addition, special effort has been given by our team of guest editors for maintaining the standard of those articles. In this edition of journal, we have included most of the papers presented in the international workshop recently organized by the Centre.

The major highlights of this journal are UAV technology, application of machine learning algorithms for geospatial problem solving, land banking initiatives for sustainable land management and identification of land market impact factors in Nepal. Further, it also includes the economic implications of land use planning.

Getting the journal published was not an easy journey. Therefore, I would like to express my sincere gratitude to all those direct and indirect helping hands that made this attempt possible. On behalf of editorial committee, I would kindly like to thank the authors for their contribution on this issue. Similarly, I am very grateful to the advisory committee for their valuable suggestions and the editorial team for their constant dedication and effort. I express my sincere gratitude to Er. Bhagirath Bhatt and all the members of editorial committee for making their efforts in publishing this issue. Lastly, I express my warm regards to all our readers for being big source of motivation for us to publish this great piece of knowledge.

We will be back again with the next issue of this journal in the upcoming year!

A big congratulations to our institution in its 55th anniversary!

Thank you!

Ramesh Gyawali
Editor in Chief
July, 2023

Executive Director's Message!

It is with great pleasure that I present the fifth issue of the "Journal of Land Management and Geomatic Education" as a special issue, commemorating the 55th Anniversary of the Land Management Training Center (LMTC). On this auspicious occasion, I would like to extend my congratulations to the entire LMTC family, who have been associated with this esteemed institution in various capacities, and express my heartfelt gratitude to those whose contributions have played a significant role in shaping LMTC into the esteemed institution it is today. Personally, I am proud to have the opportunity to present subsequent issues of the journal since its inception. In the first issue, I highlighted the historical evolution of the center, along with the significant achievements made thus far and the new initiatives undertaken in that year to develop the center as a "Center of Excellence." In the second issue, I showcased our outstanding achievements through innovative work over the years. The third issue focused on the resilience and determination that allowed us to achieve even higher levels of success despite the impact of the global COVID-19 pandemic. In the fourth issue, I emphasized some of the innovations at LMTC, such as the issuance of the "Land Management Training Center (Operation and Management) Directives, 2022," the establishment of a Continuously Operating Reference Station (CORS) on the center's premises to receive real-time data from the Global Navigation Satellite System (GNSS), the establishment of Sun Dail, the installation of a calibration laboratory, and the improvement of the museum and physical facilities. It was a proud moment for LMTC to receive ISO 9001:2015 certification in that year.

In this fifth issue, I am filled with pride as I reaffirm our continued devotion and commitment to enhancing the center's capacity, quality, and scope, in order to achieve the highest level of excellence. The multifaceted trainings offered to government employees, ranging from local to federal levels, have reached new heights in terms of quality, scope, and effectiveness. It was a historic moment to organize the "Survey Literature Festival" for the first time in Nepal's surveying history. Additionally, we recently hosted the "International Workshop on Land Use Planning and Land Administration: Integration and Decentralization" for the second time at LMTC, which took place from February 16-17, 2023. This special issue is dedicated to that event. Furthermore, we are proud to announce the renewal of the Memorandum of Understanding with Kathmandu University for the fifth time, which enables us to offer academic courses in Geomatics Engineering and Land Administration.

I would like to reiterate that the Center is determined to continually improve the quality of our training programs. Our courses are delivered by passionate and dedicated faculty members and trainers who possess extensive knowledge of both national and international issues and are highly qualified from renowned national and international universities. We are thrilled to see the high motivation and interest of young and energetic officers in joining our institution. One of the strengths of LMTC is our capable workforce, which is well-equipped to conduct various training courses in the field of Geomatics, land administration, and management. It is also a proud moment to mention that we have been recognized for meeting the quality requirements of international standards.

Our primary goal is to establish this journal as a highly esteemed publication for professionals and academics in the fields of land management and geomatics. The majority of the papers published in this journal, including the keynote speech by the Registrar of Kathmandu University Prof. Dr. Achyut Wagle, were presented at the aforementioned international event and have undergone a rigorous peer review process led by esteemed geomatics academics and professionals, including Dr. Rishi Raj Datta, Dr. Dev Raj Paudyal, Dr. Arun Kumar Pratihast, Dr. Subash Ghimire, Dr. Reshma Shrestha, Mr. Uma Shankar Panday, and Mr. Niraj Manandhar. We strive to maintain the highest standards of quality and integrity in our publication.

I would like to express my sincere appreciation to my colleagues, the members of the Advisory Committee, and the Editorial Committee for their invaluable contributions in producing this issue. Furthermore, I extend my deepest gratitude to all the reviewers for their invaluable efforts in reviewing the papers and guiding us in improving the journal's quality. I would also like to thank all the authors for their valuable professional contributions. I am confident that this support and professional contribution will continue in future issues.

Lastly, I extend special thanks to Mr. Ramesh Gyawali for facilitating the overall publication process and to Er. Bhagirath Bhatta for their tireless efforts in meeting the stipulated publication timeline.

I must emphasize that we are still in need of high-quality papers. Therefore, I once again encourage my colleagues from the Center, as well as professionals in the fields of Land Management and Geomatics, to contribute quality articles to the journal in the future.

We look forward to receiving your critical feedback on our efforts.

Happy reading!

Ganesh Prasad Bhatta
Executive Director
Land Management Training Centre
July 10, 2023

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The Land-use Planning and its Economic Implication*

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Background

The rationale of land-use planning is almost axiomatic. The world population is expected to reach near to 10 billion by 2050, while the landarea of the earth is fixed forever. It is a common knowledge that only 29 per cent of the earth surface is land. There is a scientific consensus, out of which only 20 per cent is hospitable. A back-envelop calculation shows that average per capita land available in 2050 would be about 1.5 acre or about 11 ropanis; including the land for agriculture, forest, conservation and habitat, among others. Therefore, human race has no alternative to wiser planning to meet ever increasing unlimited needs with finite land resource available in any country or geographical domain we may name.

The Land-use Planning has literally hundreds of definitions to suit different context and purpose. There is equally rich academic and applied literature available. But all these concepts and definitions of land-use planning, land development and land management essentially converge on very rationale of both, optimizing utilization and maximizing productivity of any given land area in particular, and the entire land surface of the planet in general. The concept and practice of land-use have very rich heritage of thousands of years across civilizations,and it embodies historical, social, cultural, political, invariably deeply emotional, and sometimes religious and, of course, economic paradigms.

Apart from food as the indispensable basis of living that the land only can provide, it also gives the sense of entitlement, belongingness and identity, wealth and future security, national sovereignty, and ecosystem services for the entire humanity. The fixed amount of hospitable land available on the surface of the earth as against continuously rising

population globally makes the science and art of the land-use planning not only increasingly important, rather inevitable so as to enable the mother earth to unfailingly feed the human race, provide shelter and, at the same time, sustainably save the 'blue' planet in a habitable shape for the infinite posterity.

This brief paper looks into several scenarios, with examples primarily from Nepal, on the pattern and practices on use of land, emerging trends in land management, land use planning and their socioeconomic implications in the light of seemingly competing objectives of higher productivity and demand for land-based products versus equitable distribution of land and long-term sustainability of its use.

Land Resource of Nepal

Geographical feature of any country is the predetermining factor for any form of land use or land development plan. Nepal contains some of the most rugged and difficult mountain terrain in the world. Roughly 75 percent of the country is covered by steep hills and high mountains. From the south to the north, Nepal can be divided into four main physical belts, each of which, generally, stretches east to west across the country. These are, first, the Terai, a low, flat, fertile land adjacent to theborder of India; second, the forested Siwalik (Chure) foothills and the Inner Terai zone, rising from the Terai plain to the rugged Mahābhārat Range; third, the mid-mountain region between the Mahābhārat Range and the Great Himalayas; and, fourth, the Great Himalaya Range.

The high mountains or the Himalayan region, that comprises about 27 percent of the country's land surface, is perhaps the least studied geographical area of the world, after Antarctica, widely known as 'data white spot.' Although the most attractive highest peaks of the Himalayasincluding Mt Everest (8848.82m), Kanchanjunga (8,586m), Lhotse (8,516m) lie in the range, detailed data and knowledge about exactdynamics of the glacial movement and activities, high Himalayan ecology and even geological structure is very scanty, to say the least.

The Hilly region comprises approximately 48 percent of Nepal's land area between the Mahabharat and Siwalik ranges enclosing some of the vibrant valleys like Kathmandu, Pokhara and Surkhet. But area of gainful cultivation in this belt is also limited and subsistence farming makes life of people difficult. Accessibility to quality transport, communication, and education and health services still remains a major challenge in this belt as well.

The Terai flatland including some Doons or inner valleys like Chitwan and Dang is the most fertile part of the country comprising 23 percent ofthe total land area. But it

*Keynote Speech Presented at the International Workshop on Land Use Planning and Land Administration: Integration & Decentralization is a narrow strip stretched east to west with width ranging only from 25 to 32 km. During last few decades, migration from mountains and hills to Terai has dramatically altered the population geography of Nepal, thereby impacting on every aspect of land classification and land use planning at the both ends of origination and destination of the population movement.

Nepal has its own constraints with regard to land records and required data to make the land classification and land development plansoptimally rewarding for the economy, and the society at large. The most reliable source of information about Nepal's land is a 45- years old Land Resource Mapping (with images) completed in 1977 with the support of the Canadian government. According to the data of Forest Research and Training Center (2019), 44.47 percent of Nepal's land is forest area,

28.68 percent is bare surface that is not commonly used, 21.88 percent isarable, 2.6 percent is grassland, 1.22 percent is wetland and 1.15 percentis covered by housing.

Historical perspective

Nepal has its own long history of land management in terms its categorization, tenure and taxation systems, land development, dedicateduse along with emergence of the concept of the planned development and the land-use planning. These practices, on use of land if not land-useplanning, have evolved with many unique features often specific to the ecological and geographical belts, according to nature and quality of theavailable land, across diverse cultures and communities and, along with need and objectives of the use of the available land.

Some form of land administration and land use planning was there even during the Vedic period. Kautilya's *Arthashashtra* (300 BC) states, 'Land, the most important natural resource, was primarily, in the public sector, with the state holding all virgin land, forests and water resources. Arable land, however, was both in the public and the private sectors. Crown lands were either directly cultivated by the Chief Superintendent of Crown Lands or leased out to tenants. Land was granted either in perpetuity or for a limited period, on a tax-paying or on a tax-exempt basis.' Several ancient documents reveal that in Buddhist era community/collective or 'sangha' ownership was practiced which was considered judicious. So, complements the idea of संघम् शरणम् गच्छामि .

During the reign of Kirats (800 BC-300AD), there was a provision to give certificate of land ownership called *Lekhya* and owner had to pay tax or *kut* proportionate to the agricultural production. During the Lichhavi period (450-750 AD), the land tax was collected from an office called *Adhikaran* and the land administration was decentralized to the village *panchali*. When Kathmandu Valley was ruled by Malla kings, King Jayasthiti Malla (1382-1396 AD) surveyed the land he ruled and authorized to sell and mortgage it. King Ram Shah (1606-1636) of Gorkha introduced productivity-based land measurement on the basis of toil like plough and spade and on the basis of amount of seed used like *mato-muri*, *bijan*, *mana*, etc.

A land record system of *Lal Dhadda* or red book (1814 AD) and *Moth Dhadda* or record compilation office were set up in 1822 AD for systematic survey records and also to collect the revenue on the basis these records. After the enactment of the Civil Code (1853 AD), systems for land valuation, land survey and collection of land tax were brought in practice under a dedicated office; *Tehsil*.

A *Mal Adda* (land office) was created in 1895 AD and, in 1902, it was merged with *Tehsil* set up to pay salaries to employees and collect taxes.In the same year, the *Madhesh Mal Sawal* (land rule related to Madhesh) was implemented. Land registration and land tax collection were started in the Terai through landlords and *patwaris* (record clerks) and, landlords and *mukhiyas* (village headman) in the hills. Perhaps for the first time in Nepal's history,

In 1903 AD, Rana Prime Minister Chandra Shamsher classified the land into 4 categories- hallmark, secondary, wetland and dry or pastureland *(abbal, doyam, sim and chaahaar)* and varied rate of taxes were imposed accordingly. Related legal, institutional, and operational arrangements also gradually evolved since.

A prominent Nepali Scholar Mahesh Chandra Regmi (1929-2003) who wrote a seminal four volume research work 'Land Tenure and Taxation in Nepal' (University of California Press, 1963) has identified seven landtenure system adopted in the annals of Nepal's checkered history.

1. Raiker - The state ownership of land that gave rise to a system of private ownership and landlord-state nexus on managing the lands of this tenure.
2. Birta - Originated from land grants to individuals for livelihood.
3. Guthi - Grew out of land endowments to religious and philanthropic institutions. It is a form of institutional landownership designed to protect the government's power to confiscate the land from the private/community ownership.
4. Jagir - Stemmed from assignments of lands to government employees and functionaries in lieu of emoluments/salaries.
5. Rakam - A system where cultivators were required to be provided with paid labour on an unpaid compulsory basis to meet government requirements.
6. Kipat - The communal authority superseded any claim that the state might extend on grounds

of internal sovereignty or stated landlordism kept ownership rights in Kipat lands by virtue of membership in a particular group or a location in particular area/Eastern Nepal.

7. Communal ownership of land - The practice was confined to certain community of Mongoloid origin in The Hills.

Nepal's extensive land reform, that began with enforcement of Land Reform Act 1964, has dominated philosophical underpinnings of tenancy rights with the slogan, 'land to the tillers' (जसको जोत, उसको पोत)and lowering the ceiling on the size of private ownership of land. The ceiling on the size of entitlement for housing, agricultural andcommercial farming were set differently across different geographical belts and it was gradually tightened. It instantly resulted into a land fragmentation spree by the large-holding landlords. They transferred the ownership to all kiths and kins as quickly as possible. Or, they convertedit into commercial farming schemes that had higher ceiling compared to individual ownership. This effectively ended the prospect of having a reasonably feasible size of land for a large-scale commercial agriculture.The 4th amendment of the Act in 1996, once and for all, ended the tenancy rights on the land, another major reason of land fragmentation inNepal.

Law and institutions

The legal and institutional arrangements evolved very slowly. They were often transitory, fragmented, and atomistic. The eighth five-year plan of 1992 proposed the creation of employment through the utilization of land, the ninth plan proposed for a land-use plan and the tenth plan madearrangement for a national geographic information system. The firstNational Land Use Plan was launched in 2001 and a Land Use Council was established to implement the Plan. The national budget for fiscal year 2011-12 proposed a land-use plan by classifying the land into six categories. But, needless to say, none of these policies or plans evercame into full implementation. Over the period of last two decades, when out-migration of youths and remittance earning became new economic phenomena for Nepal, area of fertile land is now increasingly being left fallow.

The government implemented the Land Use Policy in June 2022. It took three years for this regulation to be introduced since the enactment of the Land Use Act in 2019. The objective of the Act is set as 'to gain maximum and sustainable benefit through classification, proper utilization and effective management of the land'.

The Policy has classified the land in ten categories namely: 1. Agricultural, 2. Residential, 3. Commercial, 4. Industrial, 5. Mines and Minerals, 6. Forest, 7. Rivers, Streams, Lakes, Wetlands, 8. Public Use, 9. Cultural areas and Areas of Archaeological Importance and 10. Others (as decided by the Local Land Use Council). The Act provides for Land Use Councils to be set-up at all three levels of the government – the federal, provincial, and local.

The review on actual efficacy of the implemented provisions of the past Acts and Regulations on the ground level is yet to emerge. However, it is apparent that current classification is based on the existing use of theland and it fails to adopt the prospecting and scoping strategy, for example for planned urban development, establishment of large industrial districts and creating large agrarian and conservation areas by reclassification of the land. This reduces the potential to utilize land as a key resource for future economic development of the country.

Some practical bottlenecks have also been experienced. According to thedirective issued by the government as part of the implementation of the Policy debarred the transaction of the land before classified by the Local Land Councils. Without the recommendation from the local governments with specific mention of the land category, the Land Registration Offices refused to withhold the transfer of ownership and collateralize the same with the bank and financial institutions. The borrowers from the banking system faced difficulties for long.

The local governments while recommending must now distinguish whether the land in question is being used for agricultural or non- agricultural purpose. But, most of the local levels are yet to develop theirown land use plan. Often, they lacked technical competence to classify itobjectively and they are prone to local social and political pressures to classify the land as per the demand of beneficiary than reflect the actual use.

According to a provision in the Land Use Regulation, the Ministry of Land Management should make the original map with the classification available to the local levels and they needed to follow the same while recommending the status of use of the land for transactions or records. Even if the local level wanted to modify the classification, it should first be sent in writing to the ministry itself for approval. Such policy confusions and overlap of authority have only added to mismanagement, more arbitrary classification of the land and impacted on the implementation of the land related policies. The municipal authorities seem compelled to recommend most of, thus far, agricultural farmland also as nonagricultural one. It is evident that all haphazard fragmentationof the fertile farmland as the housing plots is pervasive nationwide and sold in parcels even without basic urban infrastructure.

Modern principles, experiences and practices of land management indispensable for agriculture and food security, orderly urbanization and environmental sustainability have not been followed. Lack of systematic data and information, ideally in digital form, is proving to be a daunting impediment.

Land Economics of Nepal

Economically, land is arguably the most attractive investment instrumentin Nepal. Bank finance is invariably linked to immovable property, i.e land and/or building on it. Land-based financial transactions are becoming increasingly speculative in Nepal as other investment andasset creation tools, such as financial derivatives, bond markets, information technology enterprises, etc., are not yet sufficiently developed or beyond easy reach and comprehension of a common investor. Excessive speculation has fueled the land prices, particularly of the land in urban and southern plane, to an irrationally astronomical extent.

The role of the land as the major contributor to the economy is incumbent on its direct productivity. Agricultural and forest products, ecological services, surface connectivity and habitats are its direct products. As mentioned, the proportion of arable land in Nepal is very small and its fertility also varies across the geographical regions. Nepal has harnessed only limited economic benefits from the forest resources.

The current arrangement to assign the responsibility of land classification to the local levels is largely ad-hoc, thus, has lot of caveats. Main worry is availability of skilled manpower, measurement and survey equipment and sustainable record and documentation system at the municipal offices responsible for the task. As such, land development could be a too tall a task to ask from them. Pervasive conflict of interest is often ruling the roost in every aspect of land use planning, land administration and land development.

The land fragmented as such into very small parcels has been the main Achilles heel to the commercialization of agriculture; rendering it unableto take benefit of the economies of scale in productivity. Actually, the large enough quality land plots required for organized and commercial agriculture is not available anywhere in the country. According to the Ministry of Land Management, the land has been divided into 30 millionplots under the entitlement of about 13.5 million land owners. A nationalor regional model of agricultural expansion and urbanization has never been established in history. The practice of developing land for a specific purpose did not exist. As a result, neither agriculturalproductivity increased, nor did good cities and planned settlements develop.

The benefit of land-based ecological services are best optimized only if the human disruption on the natural ecosystems could be minimized, soilfertility is prevented from salination and erosion and, flora and fauna are protected. But sadly, we are moving in opposite direction. Nonetheless, Nepal fortunately still has about 45 percent of her land covered by forestof different density and vegetation. Apart from its obvious contribution to the environmental sustainability, the gains from carbon trading have only just begun and are relatively nominal.

In Nepal, perhaps like everywhere else in fundamentally agrarian economy, the land-ownership is viewed with emotional and spiritual value in addition to social status, livelihood security and property-based wealth. Nepal's rights-based inheritance laws and customs have led to excessive and accelerated fragmentation of the land. People are desperate to own a piece of ancestral land, even if it is an unassumably small and they effectively have no active use of it. The emotional attachment to the ancestral land, apart from its economic utility, remains strong in our social milieu. Therefore, all aspects of land management should not be treated purely as a technical matter and any process to this end should embody the capacity to address human sensibilities inherent in it.

Nepali politics has historically evolved mainly through movement against feudalism and authoritarianism. Therefore, the benchmark narratives on exploitation or equality basically emanate from the pattern of land ownership and utilization. The fulcrum to test the extent of the prevalence of feudalism and also the principles of freedom orexploitation in politics is actually the pattern of land ownership and distribution of its productivity. The issue of land distribution to landless squatters and the vote-bank politics on them is as live as before.

Over fragmentation of land has virtually left thousands of cultivable plots of land unproductive. Lately, increasing amount of land is being left fallow for several reasons including outmigration of active age population and degeneration of farm-work culture.

This has given rise to the debate of Nepal having a land bank to address these problems. Its institutional structure was also proposed once. Butthe priority of different government regarding the proposed land bank also seems to be greatly varied. The concept of the land bank was promoted very aggressively in the previous year but the current political leadership seems to have only a lukewarm response to it. Lack of political consensus on such a serious national issue defeats the twin objectives, making the land a basis of economic prosperity and, making the land management future-oriented and effective.

Conclusion

To conclude, let me touch upon a few historical, technological andeconomic contexts of Nepal that should provide some meaningful reference for Nepal's future of land use planning, use of land and reapingeconomic benefits from land not only by the present but future of humanity.

What has deeply touched me is that throughout history, until the invasion of cement buildings and tarred roads in our virgin lands, Nepal's main hinterland put the land use planning in practice in the form of perched settlement on the hill-top, pasture and grassland on sloppy hill-chicks and, intensive farming at foothills and valleys. Also, the then rulers built forts and palaces on the hill tops.

Such practice had desirable effects in many ways. Most infertile and impossible-to-irrigate type of land was used for residential purposes. The human and animal excreta flowing top-down from settlements continuously replenished the soil fertility and humidity and, the soil nutrients slowly reached to the fields at low-lying areas. These fields were the most fertile and had better irrigation possibilities, therefore, were deliberately left uninhabited as agricultural land. This was the mostsustainable use of resources by any modern standards. Also, routine up and downhill journey of the people to travel between the work and homeprovided much needed exercise to their body. Now, when we claim to have knowledge and technology for scientific land-use planning, our most fertile lands are covered with unplanned concrete jungle.

Nepal, and any other country for that matter, needs to invest in several forms of modern technology to continuously improve the data quality onland. Use of satellite imaging for survey of multiple facets, analysis of big data so obtained, use of AI and cloud computing to optimize the results need large investments. Digitization of historical records andinformation, and align the related data of cadastral survey and ownership/ tenure with the land use planning is indeed a herculean task. Nepal certainly has taken some much needed initiatives but the progress has been very tardy. The political class is yet to understand the future of land management, land development and land use planning is largely dependent on our ability to make best use of rapidly evolving disruptive technologies. And, there must be readiness to spend for fastertechnological adoption in the sector, mainly from the public coffers.

The most compelling economic growth model in contemporary economic science, the intergenerational growth model, is in fact fully congruent to the land economy with intergenerational ownership of property. The land is a unique but ubiquitous platform to realize the goalof sustainable development. Conservation of natural endowments like soil and water versus the economic growth and physical infrastructure development are often seen as mutually exclusive and, more often than not, competing interests of the governments, policy-makers and planners. The land-use planning and management are caught up betweenthese two seemingly opposite-pole debates. It should no longer be the case. The conservation should in practice be development and the all developmental activities must incorporate the component of conservation, among others. The upcoming laws, institutions and practices must embrace this complementary approach in vision, plan, investment and implementation aimed at maximizing the economic benefits and social well-being from the land resource for now, and more for the future.

Thank you !

Land Management Training Centre Dhulikhel

February 16, 2023

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LAND BANKING INITIATIVE IN NEPAL FOR SUSTAINABLE LAND MANAGEMENT: UNFINISHED AGENDA OF DECENTRALIZING LAND USE PLANNING AND LAND REFORM*

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ABSTRACT

In Nepal, the idea of land banking appeared first in the report prepared by High Level Land Reform Commission (HLLRC) in 1994. After almost two decades, the Government of Nepal (GoN) revived the project of land banking to be carried out in co-ordination with local levels. This time it has specific objectives of controlling land fragmentation, enhancing agricultural productivity, assuring food security, providing equal access to land resources to farmers, low-income/poor groups, creating new job opportunities in agriculture sector for youths in post-COVID 19 scenario, and planned urban development. Since mid-1960s until now, there have been series of attempts for land and agrarian reform, which seems unfinished with few achievements. It can be guided by approaches of redistributive land reform and adoption of appropriate model of land banking that would guarantee optimum use of land resources. With the very concept of land banking in center, this paper aims to study how it can be designed as a planning tool for decentralizing proper implementation of land-use plan and long-sought land and agrarian reform in Nepal. The paper is based upon study of international best practices on land banking with case studies from The Netherlands, The Philippines, and USA. While the Government of Nepal seems carefree with multiple ad-hoc land commissions ineffectually setting the policy agenda of land-use planning and land reform, findings of the paper suggest decentralized land banking model at local levels in Nepal for the purpose of agricultural as well as urban land pooling for sustainable land management.

KEY WORDS: *Land banking, Land use planning, Land and agrarian reform, Land administration, Sustainable land management*

1. INTRODUCTION

Land is definite and land use planning is one of the major constraints in land and agrarian reform. It may seem that land resources are characteristic of socio-economic goods only, however, right to land has been a point of departure for several political transformations and pursuit of democracy around the globe. Until now, land reform remains problematic in socio-economic planning for developing countries while developed countries have an advanced model of spatial planning to deal with land management. In this context, as a tool for urban planning, a land bank was established in South Africa as Land and Development Bank of South Africa (LADBSA) in 1912 (Gaikwad, 2012). Gaikwad also suggests that Louisiana Land Bank (LLB), established around 1916, is supposed to be the first of its kind in the USA. Since then, this concept of land banking model has been adopted in Central and Western Europe and in the Philippines for urban development and agricultural reform as well.

In Nepal, the idea of land banking appeared first in the report prepared by High Level Land Reform Commission (HLLRC) in 1994. A decade after the publication of this report, in fiscal year 2005, budget was allocated for establishment of land bank in Nepal with support from World Bank as well (CSRC Nepal, 2020). However, the government stepped down followed by criticism that the land bank would not address the issues of agrarian reforms and problems of existent farmers, agricultural workers, and landless/homeless people in Nepal.

Again, after almost two decades, the Government of Nepal (GoN) revived the project of land banking to be carried out in co-ordination with local levels. This time it has specific objectives of controlling land fragmentation, enhancing agricultural productivity, assuring food security, providing equal access to land resources to farmers, low-income/poor groups, creating new job opportunities in agriculture sector for youths in post-COVID 19 scenario,

*Presented at the International Workshop on Land Use Planning and Land Administration: Integration & Decentralization and planned urban development (MoLCPA, 2020)

Land reform has been considered as one of the important issues in political economy. In fact, the uprising against imperialism during mid-20th century was largely inspired by the concept of land tenure. However, there is still a dilemma in adoption and/or implementation of scientific land reform based on equal access to land in developing countries. In this context, the GoN introduced the concept of land banking as a tool for implementation of scientific land and agrarian reform.

In Nepal, there are over 70 different policies, acts, rules and regulations related documents on land governance. However, there are plenty of institutional bottlenecks for properly addressing the issues of unequal distribution of or access to land resources, land fragmentation and migration crisis in hand. Furthermore, due to insufficient understanding of the concept itself among the general public, it seems critical that introduction of land banking would contribute towards sustainable land management and land and agrarian reform in Nepal.

The objective of this study is to perform critical assessment of relevance of land baking in Nepal in terms of sustainable land management from the perspective of integrated land use planning and decentralized land administration approach based upon literature review of related topic and selected case studies. This study looks forward to criticize the establishment of land banking in Nepal whether it would be relevant or not, in the context of proxy capitalistic market and unstable government. In light that there are low chances of land banking being properly adopted in Nepal, this study will also provide some recommendations for effective implementation of the concept.

The underlying problems in this study are poor land management and poor land administration, which have been hindrance for realizing scientific land and agrarian reform in Nepal. This phenomenon is prevalent due to existing insecure land tenure and traditional or exclusive land use planning practice.

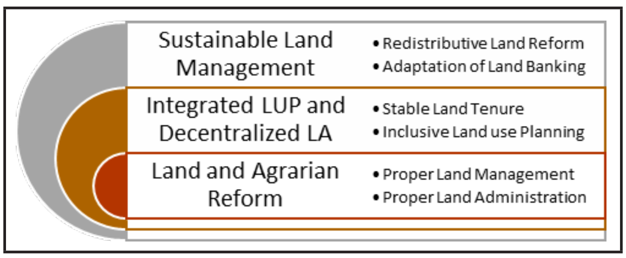

Figure 1. Conceptual framework of the study (Author's construct).

In this context, in order to resolve the research problem, the conceptual framework of this study is constructed based upon the concept of redistributive land reform. It suggests the principle of sustainable land management with land banking as a tool for integrated land use planning and decentralized land administration that considers stable land tenure and inclusive land use planning to pathway of desired land and agrarian reforms in Nepal.

The research methodology of this study is mainly based upon relevant literature review of land banking concept itself, several topics/subjects closely related to land banking, such as land reform, land development, agrarian reform, sustainable land management, fit-for-purpose land administration, etc., and cross-sectional case studies in land banking from different countries including from Asia, Europe, and North America. This study is essentially based on comparative studies. Learnings from case studies are established to recommend proper institutional framework, and balanced social and commercial mandate for land banking practice for its success in Nepal.

Understanding the concept of land banking initiative in Nepal has tried to justify or define its purpose in terms of land and agrarian reforms. The study is comprehensive to the extent of examination and justification of the guiding principles of land banking initiative in Nepal. The research is limited to the study of applicability of such type of framework for the nation-wide scenario for regional analysis. Since the land banking practice in Nepal is not implemented in its complete form yet, and it is in conceptual form, the study has taken policy analysis approach.

2. LAND BANKING INITIATIVE IN NEPAL

2.1 Outline of Land Banking in Nepal

Although it was not an entirely a new concept, the term land bank or land banking is found to be first cited in Nepal in the HLLRC report in 1994 only. The commission had put forth the idea of land banking originally as an approach for land reform in order to provide access to land for poor people. It also intended to arrange for compensation for land holdings exceeding the maximum allowable size announced by the then government, the amount for which would be collected on installments from beneficiary households (CSRC Nepal, 2020). Sadly, these objectives were never realized or discussed adequately.

However, after a decade, the term land bank appeared strategically once again in National Agricultural Policy (NAP) of Nepal in 2004. It found its place in the Tenth Five Year Plan (2002-2007) of Nepal. NAP 2004 had proposed some policies (out of which establishment of land bank was one) to avail special facilities for target groups such as farmers having less than half a hectare of land and lacking irrigation facilities, farmers belonging to marginal classes, and agricultural workers. It was stated that a land bank shall be established and arrangements shall be made with the participation of the local bodies to provide information services relating to the availability of agricultural lands to those who wish to buy/sell such lands for agricultural operations, as well as to provide credit facilities to the needy ones (MoALD, 2004). Further, special credit facilities would be provided through the land bank at concessional rates to the target groups in order to enable them to purchase lands for agricultural production.

Later in the fiscal year 2005, a total budget of 25,579,809 USD was allocated to establish a land bank in Nepal. The initiative was taken by the World Bank with contribution of 17,053,206 USD towards the total estimated budget (CSRC Nepal, 2020). The World Bank had proposed market-led approach for the establishment of land bank in Nepal, which would be based on the principle of willing buyers and willing sellers. This modality of the land bank would be guided by a demand-driven approach with self-selected beneficiaries with voluntary participation by landlords and full cash payments at market values (Gaikwad, 2012). However, once again, despite promising developments, the GoN decided not to go for action to establish a land bank in Nepal pertaining to possible setbacks that it would not assure rehabilitation or properly address the land right issues of landless/homeless people and marginal classes.

Back again, yet after another decade in 2014, Ministry of Agriculture and Livestock Development (MoALD) formulated Agriculture Development Strategy (ADS), 2014 that spoke about piloting a land leasing corporation to facilitate land leasing of unutilized lands. Similar to the concept of land bank, establishment of land leasing corporation referred to the idea of a land leasing company that would provide intermediation between owners of land and prospective leaseholders of land. Such intermediary company would assure land rights of the owners and facilitate long-term leasing of land by private individuals, co-operatives, or private enterprises (MoALD, 2014).

In fiscal year 2020, the GoN allocated a budget of 4,263,300 USD for establishment of land bank in 300 municipalities in co-ordination with local level governments (CSRC Nepal, 2020). It triggered a debate whether establishment of land bank is essential in Nepal or not, if yes, what kind of modality should be adopted. While people have been confused with the initiative of the GoN, Ministry of Land Management, Co-operatives and Poverty Alleviation (MoLCPA) made public its brief concept regarding operation of proposed land bank in detail. The concept itself seems concise in terms of idea of land banking, but essentially lacks integration of land use planning and decentralization of land administration.

2.2 Existing Legal and Institutional Frameworks

In National Land Policy (NLP), 2019 of Nepal, it is indicated that a detailed concept regarding land bank will be prepared and implemented (MoLCPA, 2019). Also, it is directed in The Fifteenth Plan (2019/20-23/24) of Nepal that the concept of land bank will be implemented mobilizing co-operatives for large-scale farming (NPC, 2020). Land use Act (LUA) 2019, primarily based on Land-use Policy (LUP), 2015 of Nepal, has also mandated the GoN to establish land banks in local levels as required to successfully implementing land use classification in order to optimize land use for increasing agricultural productivity (HoRN, 2019). LUP 2015 has suggested protection of arable lands by checking on non-agricultural use of arable lands or keeping land fallow following rampant fragmentation. It has recommended discouraging the trend of keeping lands under conditions of non-use or under-use, misuse and excessive use with provision of penalty in doing so (MoLCPA, 2015). Moreover, these legal instruments related to the concept of land banking in Nepal were originally inspired by NAP 2004 and ADS 2014. Presented below is a table showing information on key legal and policy instruments related to land banking in Nepal in chronological order:

Legal and Policy Instruments	Implications on the Concept of Land Banking
NAP 2004	Proposition of willing buyers and willing sellers modality
ADS 2014	Suggestion of land leasing corporation
LUA 2019	Optimization of land use through land bank
NLP 2019	Detailed conception of proposed land bank

Table 1 : Chronological order of legal and policy instruments related to land banking in Nepal (Author's Construct).

Apart from abovementioned legal and policy instruments, there are some specific laws and programs, which are not directly associated with the socio-economic aspects of land banking, but are similar in nature of land reform, land administration, and land management practices in Nepal. To mention, such laws and programs include Land Acquisition Act (LAA) 1977, Land Pooling Program, Freed Bonded Laborers Rehabilitation Program (FBLRP), and Government Land Lease Strategy (GLLS), 2014. These existing regulations and projects seem already complimenting some conceptual aspects of the proposed land banking system.

The LAA 1977 was introduced in Nepal with an objective of acquiring land for public and institutional purposes. The act was required for acquisition of land for construction of physical infrastructures or projects in the interest of general public subject to payment of compensation as decided by the GoN (MoLCPA, 1977). Likewise, Land Pooling Program was also started in Nepal during 1990s, which is still ongoing across the nation. The program was guided by Town Development Act, 1988. With technical support from the ADB, 350 Ha of land and nearly 16,000 serviced plots have been developed in the Kathmandu Valley alone during past 30 years (Faust, Castro-Wooldridge, Chitrakar, & Pradhan, 2020).

Another program is FBLRP, which was initiated by the GoN almost a decade ago as a part of land reform strategy in order to provide access to land to the agriculturally bonded laborers in Nepal that were declared free. The program is still ongoing in different parts of the country. The GoN provides subsidy to selected beneficiaries through local land revenue office for buying land, housing, and reconstruction. For this purpose, the GoN has established a proxy financial subsidiary (considered as land bank) within Agricultural Development Bank of Nepal (MoLCPA, 2011).

Accordingly, the GoN has also authorized GLLS 2014 with motive of protecting and optimizing land use of government and public land by leasing it to willing individual or institutions or businesses. The intended lease period is 5 years for short term, 20 years for medium term, and 30 years for long term with possibility of renewal. There is provision of free lease for building physical infrastructures of local government. It has set minimum annual lease amount, i.e. 0.25% of total land value, for agricultural purposes, and maximum annual lease amount for commercial complexes, i.e. 1.50% of total land value (MoLCPA, 2014).

As designated in the Brief Concept Regarding Operation of Land Bank in Nepal by the GoN, the bank will be operated and managed by the local level led by elected mayor or chairperson. Its administrative leadership will be bestowed upon the Chief Administrative Officer (CAO) of the local level. A separate Land Bank Unit (LBU) will be established under the authority of local level to carry operations of land bank. The Land Management Division under Ministry of Land Management, Agriculture and Co-operatives of province government will act as provincial agency of land bank. It will co-operate, assist, and co-ordinate with the LBUs at different local levels under its province. Similarly, the Land Management Division under MoLCPA of federal government will be the central authority of land bank. A Land Bank Co-ordination Section will be established under the Land Management Division of MoLCPA, which will co-operate, assist, and co-ordinate with the LBUs at different provinces and local levels across the country (MoLCPA, 2020).

Furthermore, specific roles and responsibilities of federal, province, and local governments has also been delineated in the concept of land bank proposed by MoLCPA. The federal government will formulate mother policies, laws, directives, and model working procedures regarding operation, management and promotion of land bank. It will inspect, monitor, and evaluate all the land banks in operation across the country. The federal government will co-operate and co-ordinate as required with province and local governments in terms of operation of land bank. It will arbitrate or facilitate issues related to land use concerning land administration in two or more than two provinces. Likewise, the province government will have the responsibility of co-operating and coordinating with federal and local governments in terms of operation of land bank. It will have jurisdiction over the issues related to land use concerning land administration in two or more than two local levels (MoLCPA, 2020).

Financial means and budgetary provision for land banks will be the responsibility of province and federal government. They will have the responsibility of providing incentives and packages of agricultural equipment, fertilizers, seeds, and pesticides to those who want to engage in agricultural activities by taking land from the land bank. The federal government will also create an online database of up-to-date land information from land banks at different provinces and locals levels. Major responsibilities regarding detailed operation and management of land bank including preparation of guidelines for selecting suitable land, prioritization of beneficiaries, definition of banking services fees, lease duration, compensation, and implementation of land use plan, etc. have been assigned to local levels (MoLCPA, 2020).

In addition, MoLCPA has recognized different stakeholders related to land banking services. Based on the potential actors who can to contribute to development of land banking system, and prospective beneficiaries to land banking services, the different stakeholders can be categorized into government institutions or bodies related to land sector, non-governmental organizations working on fields associated to land sector, specific target groups from the general public, and private sectors.

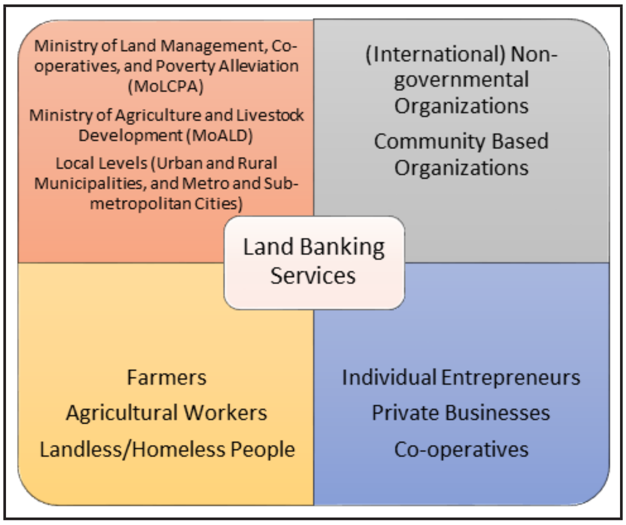

Figure 2. Stakeholder matrix of land banking services suggested by the GoN (Author's Construct).

Major stakeholders from government include MoLCPA, MoALD, and participating urban and rural municipalities and metro and sub-metropolitan cities. Likewise, stakeholders from non-governmental organizations will be various organizations such as community based organizations working on advocacy for land rights to low-income and marginalized groups. Stakeholders from specific target groups including farmers, agricultural workers, and landless/homeless people will be the most important stakeholders. Similarly, other important stakeholders from private sector have beneficiaries as individual entrepreneurs, private businesses, and co-operatives willing to take land from the land bank for agricultural purposes. However, the GoN suggested institutional framework has missed important stakeholders from Ministry of Urban Development (MoUD).

3. CASE STUDIES ON LAND BANKING

3.1 Land Banking in The Netherlands

Land banking practice in The Netherlands dates back to 1930s, which started with land reclamation from the shallow seas. Large pieces of agricultural land were obtained from heath land during the 50s and 60s, and from 1960s onwards, the Dutch government aided farm restructuring process by promoting the withdrawal of unproductive agricultural holdings (Damen, 2004). In 1946, a state foundation called Foundation for Land Management (SBL), which was later renamed as Bureau for Land Management (BBL) was established to deal with the compensation of land. The objectives of SBL/BBL were to consolidate land in rural areas for improved land use and management, management of revolving land fund, and facilitation for land leasing including its sale and distribution as well.

As suggested by Damen, there are some valuable lessons from land banking experience in The Netherlands, one of the important lessons being that land banking assists largely in successful realization of land development projects. However, the land banking agencies should not try to control the land market. Another important aspect to learn is that land banking can guide multi-sectoral spatial planning in rural areas.

3.2 Land Banking in The Philippines

The Land Bank of the Philippines was established in 1963 with the endorsement of agricultural land reform code. It was created to support the procurement and subsequent distribution of agricultural land for division and resale to small landholders, and for purchase of the landholding by the agricultural leaseholder (Yedra & Ducusin, 2007). Later in 1973, the bank was granted exercise to expand lending to non-agricultural activities and commercial activities in order to support land reform function and credit assistance of the bank to small farmers. The bank was also excused from national and local government taxes.

The Philippine government has not yet concluded the implementation of agrarian reform due to budgetary constraints and fiscal deficits. Even though the economy has shifted from agriculture-dependent to service-oriented, the land bank continues to support the majority of poor in rural areas, who rely on agriculture and agriculture-based activities for their livelihood (Vogel & Llanto, 2006). Whilst there persists challenges of decreasing productivity and lack of infrastructure in traditional agriculture sector, the land bank is looking forward to diversifying its lending portfolio to attract SMEs, rural infrastructures, and agriculture-based businesses.

3.3 Genesee County Land Bank, USA

The Genesee County Land Bank, in City of Flint (Michigan), USA, was created in 2004 in response to a tax-foreclosure cycle in Genesee County. Through the land bank, the County has been enabled to acquire vacant land from the foreclosure process, and to determine the best possible use of such land (Harrison, 2007). The land bank acquired almost 6% of the land of the City of Flint and assisted thousands of families during the foreclosure. Under the initiative of the bank, vacant buildings are re-developed, and other properties owned by it is managed by a non-profit housing authority. Harrison suggests some features of Genesee County Land Bank that could be taken as best practice in terms of co-operation and co-ordination among the local government, non-profit organizations, and the local community in agreeing regarding proper land use of available land in the area. It emphasizes on mutual support and dialogue between relevant stakeholders for acquiring land, land rights, access to finance for housing, and land management and development.

Furthermore, in recent days, the idea of land value capture is also gaining popularity with the concept of land banking. It is an approach in which the value of land increases with public investment, and the local community benefit from it. It has also been considered a tool to tackle socio-economic and environmental challenges of regional and urban planning (German & Bernstein, 2018). Large domain of land banking co-operated with charges on building or land rights, special assessments, impact fees, land value taxes, and exactions are some of the instruments of land value capture.

4. AGENDA OF LAND USE PLANNING AND LAND REFORM

The land cover data of Nepal shows that the significant (more than half) part of the country, i.e. 51.60%, is covered by forests including shrub land, and grassland and pasture. Exactly 28% of the land is categorized as agricultural land, out of which is 7% of the agricultural land remains uncultivated. Further, water bodies including wetlands, river systems, lakes, and streams, etc. occupy 2.60% of the land. Moreover, 17.80% of the land is categorized as others, which includes built-up area or settlements occupying 1.15% of the land, landscapes with bare soil, rock, ice, and unmanaged land, etc. (MoALD, 2020). In recent days, agricultural land is being left unused due to the alarming trend of out-migration of economically active youth workforce from Nepal (Maharjan, Kochhar, Chitale, Hussain, & Gioli, 2020). Unfortunate it is, but designated land use guidelines by LUP 2015 is also not being respected by different stakeholders in land sector leading to complicated consequences on land use planning.

Land is considered as one of the most important assets and source of production in Nepalese economy. It is obvious that access to land largely ensures access to food, housing, and livelihood as well. In Nepal, more than 80% of people live in rural areas, and almost 75% of these people are highly dependent on agriculture. Moreover, for nearly 66% of Nepalese people, agriculture is the main source of income. Yet, around 26% of such agricultural households do not have land for farming, i.e. they do not have proper access to land or land rights. Particularly, the small farmers have inadequate land such that their families are vulnerable to food insecurity (MoLCPA, CSRC Nepal and UN Habitat, Nepal Country Office, 2018).

Furthermore, large numbers of private land holdings remain uncultivated since most of the cultivable or fertile land in rural areas of Nepal is held by less than 5% of elite groups, who do not engage themselves in agriculture. Less than 20% of women in Nepal have land ownership, and 41.4% and 36.7% of marginalized groups respectively in Terai and Hills are landless or they do not have access to land. There are more than 1 million landless people in Nepal. The National Living Standards Survey (NLSS), 2011 of Nepal showed that the bottom 20% of Nepalese households barely own 3% of agricultural land whilst the topmost 7% of households occupy 31% of it. Almost half of the Nepalese rural households own half a hectare of land or less occupying less than 20% of cultivable area. In general, 70% of Nepalese farmers own less than one hectare of land area. There are 5% of households who do not own any land, and work as bonded labourers or agricultural workers on other's land. The average size of agricultural landholding is 0.7 Ha in rural areas of Nepal (CBS, 2011).

4.1 Land and Agrarian Reform in Nepal

In Nepal, until 1950, land used to be the property of state, which had two types of land tenure system, i.e. Raikar and Kipat (Regmi, 1976). According to Regmi, Raikar was state-owned land while Kipat was land with community ownership. Under the Raikar system, the state used to grant land to individuals or communities in the forms of Birta, Guthi, Jagir, and Rakam. Birta was land granted or distributed by the state to individuals, and Jagir used to be the land given by the state to government employees in recognition of their service. Similar in nature, Rakam was land provided by the state to individuals as a remuneration for their contribution. Guthi, which still exists in practice, is the land assigned by the state to institutions with charitable, religious, and philanthropic functions (Nepal, Khanal, Zhang, Paudel, & Liu, 2020). After 1950, with democratization in Nepal, Raikar denoted individual or private property with absolute land rights pertaining to certain tax or revenue to government. Eventually, these land tenure under Jagir, Birta, Rakam, and Kipat systems were abolished respectively in 1951, 1959, 1963, and 1968 (Adhikari, Land Reform in Nepal: Problems and Prospects, 2008).

At present, according to the MoLCPA, the land administration system in Nepal deals only with the formal or statutory land tenure system, which consists of land that has been formally registered in the national cadastre. Out of the total agricultural land available in the country, only 75% of such land is formally registered in the cadastre with secured tenure. This means 25% of the total arable land and built-up area belongs to non-statutory or informal land tenure without spatial recognition, which is roughly estimated to be around 10 million physical land parcels. This also includes illegitimate land occupancy of government and public land, and private lands as well, which are legally owned by other people or institutions (MoLCPA, CSRC Nepal and UN Habitat, Nepal Country Office, 2018)

The accounts of land reform in Nepal started with the ledger of Land Act in 1964. In 1963, the government had established Nepal Resettlement Company with an objective to distribute land to landless people. The Land Act 1964 had set a maximum ceiling for land holdings of individual household in different parts of the country, and such excess land after the maximum ceiling was appropriated and brought under state ownership again. The land was supposed to be distributed among landless/ homeless people, and low-income and marginalized groups. However, such popular measures of redistributive land reform substantially failed in achieving its purpose due to several reasons (Adhikari, Land Reform in Nepal: Problems and Prospects, 2008).

Furthermore, in Nepal, land concentration has been declining, and there is a small portion of bigger landholdings. Over 50 years, the holdings larger than 2 hectares (which is not considered a big area for commercial farming) have diminished to 23.6% in 2011 compared to 60.6% in 1961. This implies that adequate land cannot be obtained from the land ceilings for redistribution unless the ceiling is set at 2 hectares or less (Adhikari, Agrarian Relations, Institutions, and Land Reform in Nepal, 2019). The pattern exhibits the trend of defragmentation of land for non-agricultural purposes. This is so sad to witness that uncontrolled urbanization and encroachment of agricultural land has been deteriorating food security, displacing employment or people dependent on agriculture, and pushing them into poverty (Dhakal, 2011).

In Nepal, since mid-1960s until now, there have been series of attempts for land and agrarian reform, which seems unfinished with some achievements. For example, abolition of compulsory labour and increase in daily wages of agricultural workers can be remembered as one of the good initiatives, however, they still don't have access to land or land rights. The government had committed to redistribute around 180,600 Ha of tenanted land to 541,802 registered tenants, which but remains unrealized due to random conflicts and disputes (Wily, Chapagain, & Sharma, 2009).

Besides some successful programmes on land, housing, and reconstruction for small number of groups, the target groups including farmers, agricultural workers, landless/ homeless people, and low-income and marginalized groups do not have either relaxed access to finance or programmes from which they could directly be benefited. Land and agrarian reform, scientific land reform as it is emphasized, has always been one of the most important agendas of Nepal's major political transformations, which is but always left behind. Numbers of HLLRCs have been formed at different point of time, but their recommendations have never been implemented due to lack of political will, one of which was the concept of land banking itself. Sometimes, poor land administration and information system in Nepal is cited as one of the managerial impediments to efficient land and agrarian reforms (Adhikari, Agrarian Relations, Institutions, and Land Reform in Nepal, 2019).

4.2 Decentralizing Land-use Planning for Sustainable Land Management

While looking at the cross section of legal and institutional frameworks and development of land and agrarian reform in Nepal, integration of land-use planning and decentralization of land management and land administration is always missing out. For instance, the so called new Land-use Regulations (LUR), 2022 enacted by GoN asserts on devolution and division of power to provincial and local governments in terms of proper implementation of recommended land-use plans. However, the aspect of governance for decentralized land-use planning is left out in land management and land administration system. LUR 2022 has simply classified land-use areas into agricultural, residential, commercial, industrial, mines and minerals, forest, rivers, streams, lakes and watersheds, public usage, cultural and heritage importance, and other viable areas (MoLCPA, 2022), which is again based on traditional land-use categories as already narrated in LUP 2015, NLP 2019, and LUA 2019.

Coming back to the concept of land bank proposed by GoN, it has range of target groups, such as landowners who are unable to properly use their land, and farmers and agricultural workers who readily have the required labor and skill, but do not have ownership or access to land. It also targets co-operatives, businesses or firms, rural unemployed youths, returnee out-migrants, and agriculture industrialists. The main goal of proposed land bank is to stop land degradation and bring back uncultivated lands to production chain to increase agricultural productivity (MoLCPA, 2020). As the bank is supposed to create an inventory of unexploited land, collect such land as credit from willing sellers, and provide it to willing buyers for fixed period with certain terms, the dire necessity of decentralized land-use planning goes unaddressed in the existing land management and land administration system. Likewise, as mandated by modality of operation of the bank, an effective mechanism would be required in land administration apparatus in order to create database of idle government and public land and land recuperated form river/streams in local levels, and provide it to willing buyers for fixed period with certain terms defined by the respective local government. Such objectives are far to be achieved towards sustainable land management in lack of integration of land-use planning and decentralization of existing land administration system.

As suggested by (Liniger, Studer, & Gurtner, 2011), sustainable land management practice is mainly based on four principles, i.e. policy and institutional support for development of incentive mechanisms for income generation at the local level, participatory approaches motivated by land users, integrated use of natural resources on farms and at the ecosystem scale, and multi-level/multi-stakeholder involvement and partnerships at different levels. Relating above principles to concept of the land banking, with decentralized land-use planning, the use of land resources can be maintained sustainably for all stakeholders. Land bank with such sustainable land management practice and decentralized land-use planning would contribute to minimization of land degradation, rehabilitation of degraded areas, optimal use of land resources, conservation of ecosystem and bio-diversity, coping with or mitigating climate change, and most importantly, ensuring food security and livelihoods of farmers, agricultural workers, landless/homeless people, and low-income and marginalized groups.

In Ukraine, to some extent, land development was guided, and land fragmentation was controlled with implementation of sustainable land management practices (Kuryltsiv, Hernik, & Kryshenyk, 2018). Similarly, in the context of Nepal as well, the lingering issues of land reform referred to as scientific land reform can be addressed with putting sustainable land management into practice. It can be guided by approaches of redistributive land reform and adoption of appropriate model of land banking that would guarantee optimum use of land resources, especially for increasing agricultural productivity, and simultaneously improve livelihoods or living standards of specific target groups with equal access and rights to such land resources.

Realization of decentralized land-use planning for sustainable land management as discussed is only possible given the proper land administration and information system. This requires up-to-date and interdisciplinary or multi-dimensional concept of land administration in order to realize sustainable land management in practice including redistributive land reform. In this context, the concept of Fit-for-Purpose Land Administration (FFPLA), developed internationally from research and knowledge of various individuals and institutions working in land sector, has been recognized by different countries. It basically supports towards efficiency and inclusiveness of national land administration system. The Nepalese land administration system also needs to adopt and implement the concept of FFPLA in order to facilitate sustainable land management practices.

The FFPLA approach is composed of three key components: spatial, legal, and institutional frameworks. The spatial framework is related to mapping and proper documentation of land parcels or cadaster and the associated land rights. The legal framework is related to recording and security of land rights, which is believed to be more flexible compared to conventional cadastral system. The institutional framework is related to service delivery apparatus or bureaucracy of designated institutions associated to land administration (MoLCPA, CSRC Nepal and UN Habitat, Nepal Country Office, 2018). Integration of land-use planning and decentralization of land management and land administration in above framework could help establish appropriate land bank, and to systematically guide land and agrarian reform in Nepal.

As an example, in rural parts of Nepal, there exists a practice of lease holding land for agricultural purposes among the villagers. The lease holders are either people with insufficient land or with enough land as well. There is another practice, in which landless people or low-income and marginalized groups work on other's land, and they share half of the production with landowners. These practices might contribute to sustainable land management, however are discriminative and informal, out of the radar of land administration system and formal economy, with insecure land tenure. Adoption of proper model of land banking with the concept of FFPLA can help resolve these kind of problems in land administration and management in Nepal.

5. CONCLUSIONS

The long-debated concept of land banking recently introduced by the GoN in Nepal is substantial in terms of its goals and objective, however, it seems essentially ambitious regarding increasing agricultural productivity in absence of pre-requisite infrastructures including necessary tools and equipment, access to markets, and telecommunication services, etc. It has also focused exclusively on traditional land use mostly limited to agriculture again. The proposed institutional arrangements bestow major responsibility of implementation of land banking services upon the local government despite inadequate capacity of local levels in carrying out such complicated programmes in terms of human resources or technical expertise.

Moreover, the legal framework of land banking is derived from much conceptual policies, strategies, and laws. The institutional framework is again entirely drawn from the organizational structure of MoLCPA and its divisions, which might be linked to insufficiently defined scope of the proposed land bank. There exists some functional conflict among municipal bylaws or building codes, laws related to land management, and the unclear capacity of land banking in addressing issues of land development. The proposed institutional set up for establishment of the land bank is dominantly administrative with less than required financial structure for its operation.

The concept of proposed land banking practice has failed to address one of its supposedly most important motives, i.e., land and agrarian reforms in Nepal. The previous initiatives including one from the World Bank were also backed off due to criticism over implications of land banking on land reform. It was debated that the willing buyer-willing seller model of land banking would not benefit the farmers, agricultural workers, landless/homeless people, and low-income and marginalized groups. Nonetheless, it has stated that the optimum use of land will be guided by LUP 2015 and LUA 2019, still the implementation of these regulations is vague itself. It emphasizes on providing incentives and access to finance and necessary agricultural materials, tools, and equipment to needy people from specific target groups, such programmes but have been barely realized in the past.

It is more than important that the significance of land banking is adequately justified in terms of its central theme and idea. In this context, adoption of land banking process in Nepal with appropriate model can contribute to decentralization of land-use planning with proper land administration and management. Defining land banking through the concepts of sustainable land management and fit-for-purpose land administration can be a point of departure for its proper formulation. Also, learnings from the experience of other countries can help in developing the suitable model of land banking.

The concept of prospective land banking in Nepal should be reformulated with inclusivity of modern land use planning issues such as the repercussions of rural-urban migration and urban real estate as well. In fact, addressing urbanization can be a separate aspect apart from traditional aspects of agriculture. The land bank should have the scope of financing rural infrastructures. There should be an adequacy of trained and motivated technical expertise at local levels for efficient implementation of land banking process.

The GoN should immediately prepare a separate Land Bank Act with sufficient consultation among different possible stakeholders including interdisciplinary government institutions not limited to MoLCPA and MoALD only, non-governmental organizations working on land sector, related experts, and the general public. The land bank should be formed such that it can at least sustain its administrative outlays. Rather radical it may sound, the operation of land banks can be transferred or handed over to the community after some period instead of making it more quasi-government organization. Similar to this proposition, there is practice of community land trusts in the USA, which function as land banks.

In regard to the issues of land and agrarian reforms, land banking can be used as a tool for agricultural land pooling, just as it is used for urban land pooling. Before the federal structure of Nepal, there were town development committees in existence in different municipalities, which had some acquired land. The land was used for range of purposes including institutional establishments, rehabilitation of landless/homeless people, agricultural development, and urban expansion as well. The land bank can revitalize the functions of previous town development committees.

The most important recommendation would be to launch a pilot project of land banking on few selected local levels instead of starting the programme nationwide, which the GoN has decided to do so. This will save substantial amount of resources for the GoN, which can be used for further research in constructing appropriate model of land banking in Nepal for decentralization of land-use planning, and guiding land and agrarian reform in a successful way.

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A BRIEF HISTORY OF ADVANCES IN GEODESY WITH NATIONAL CASES

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ABSTRACT

By looking into the advancement of geodesy from past to present- theories and technologies of geodesy can be distinctly divided into classical and modern geodesy. Modern geodesy stands upon the achievements/foundations of classical geodesy however, modern geodesy has come very far away at present and classical geodesy has become almost obsolete. Three pillars of modern geodesy are the geometry of the Earth, Earth's rotation, and Earth's gravity field, these are the basis to study Earth's system. 4 major space geodetic techniques: Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), and Global Navigation Satellite System (GNSS) are used to observe three pillars of geodesy. In addition, modern geodesy takes help from airborne and terrestrial-based modern geodetic techniques. Modern geodesy studies Earth's geometry, its gravity field, and its orientation in space, outputs the reference frame and has very wide applications including the world's critical issues such as the environment and climate change. As modern geodesy provides observations with a high spatial and temporal resolution with unprecedented accuracy and precision with global coverage with a capacity to measure and monitor minute changes due to several geophysical processes, the importance of modern geodetic infrastructure has been realized. Hence developed countries such as Australia, Europe, etc have already modernized their reference system and frame enabling modern geodetic services and products. As the classical geodetic infrastructure and its products and services have become obsolete, nations around the globe are gradually modernizing their reference system and frame, products, and services.

KEY WORDS: *Geodesy, History, Advances, Modernization, Reference System, Reference Frame, Space Geodesy, Nepal*

1. INTRODUCTION

Geodesy – the science and technology of determining the shape and size of the Earth, whose origin dates back even before 625 BC. From the flat Earth model proposed by Thales of Miletus in 547BC, the spherical Earth model notion prevailed by the Pythagorean school in 500BC, the radius of the Earth computed by Eratosthenes of Alexandria in 194BC to the ellipsoidal Earth model and the concept of geoid after 17th century(Vanicek, 1986), geodesy has now entered into space-based modern geodesy.

After scientific instruments started to develop in the 16th century, telescopes, theodolite, and tape came into the scene. Using these instruments methods of astronomical observation and triangulation were developed to precisely measure the position, determination of distance and angle, and then the position of each feature on Earth's surface. The appearance of Radio Detection and Ranging (RADAR) and Electronic Distance Measurement (EDM) after World War I (WWI) made large distance measurements convenient. The successful launch of the first satellite in 1957 and the appearance of the hydrogen maser (atomic clock) – led to the birth of space geodesy.

After 1960, the integrated use of the concept of RADAR, satellite, and atomic clock led to the development of the Global Navigation Satellite System (GNSS), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS), Satellite Laser Ranging (SLR), and Very Long Baseline Interferometry (VLBI). USA and Russia developed their satellite-based navigation systems: navigation system using timing and ranging (NAVSTAR) GPS and global navigation satellite system (GLONASS). France built the DORIS. Different nations built the SLR. Detection and processing of radio signals from very distant quasars led to the VLBI technique.

GNSS and a network of non-stop running ground-based GNSS receivers formed the continuously operating reference station (CORS) network – which has multipurpose benefits. The scale of geodetic surveys/works expands from being only national to regional to global due to the global coverage of satellites orbiting the Earth. As space-geodetic observation begins to provide global measurement at very precise and accurate and at a very high spatial and temporal resolution, it made it possible to measure and monitor the Earth's internal and external dynamic processes and quantify minute changes thus appearing. Hence geodesy now describes the Earth as dynamic replacing the old notion of static Earth.

Modern geodesy has contributed in terms of both application and precision. Applied geodesy has wider applications in positioning and navigation: ocean navigation, aircraft navigation, aircraft landing, car navigation, precision agriculture, autonomous navigation, space weather (ionosphere), tsunami warning, earthquake deformation, surveying and mapping, weather forecasting, airborne Light Detection and Ranging (LiDAR), Synthetic Aperture Radar (SAR), glacial flow. While precision geodesy focuses on precision timing, levelling, satellite orbit determination, volcanic hazards, hydrology, seismic hazards, geodynamics, and sea level (*SGP Applications*, 2018).

Modern geodesy has a societal contribution because of its contribution through environmental geodesy and climate geodesy for climate change. There has been a global alliance to conduct global geodetic activities.

Developed countries have developed modern geodetic infrastructure integrated with GNSS, DORIS, SLR, and VLBI. The classical terrestrial reference frame is topocentric and ellipsoid based while the modern terrestrial reference frame is geocentric with Earth Centered Earth Fixed (ECEF) cartesian coordinates and is time-dependent. The classical vertical reference frames are referenced to Mean Sea Level (MSL), and levelling network-based while modern vertical reference frames are built by precise and accurate geoid and GNSS observation. Countries like Australia, New Zealand, Europe, Japan, Canada, USA have modernized their reference system and frame. As geodesy is global by nature, developing countries like ours gradually building modern geodetic infrastructure.

This article is a brief account of history and advances in geodesy. Section 1 of this paper provides an introduction to geodesy. Section 2 provides a classical definition of geodesy followed by elaborative paragraphs. Section 3 presents the history beginning from the era of Eratosthenes to the use of modern scientific technologies such as satellites and atomic clocks. Section 4 puts light on modern geodesy, discusses both methods and technologies and how it overcomes the limitations of classical geodesy and advances ahead. The first part of section 5 talks about the modernized National Spatial Reference System (NSRS) and its components. The second part presents the works of developed nations such as Australia, Japan etc towards modernized NSRS and ends with the context of Nepal. Finally, section 6 concludes the paper.

2. DEFINITION OF GEODESY

The classical definition of Geodesy given by German Geodesist Friedrich R. Helmert is stated as "Geodesy is the science of measurements and mapping of the Earth's surface" (Torge, 2001). Geodesy does so by defining a reference system and realizing such a system through a reference frame. A reference system is an abstract concept while a reference frame is the mathematical and physical manifestation of the reference system. Geodetic observations, and the position of either celestial objects or any point on the Earth's surface, below or above are referenced to such a reference system. The definition of the reference system and establishment of the reference frame is the principal output of Geodesy.

The definition of the reference system and establishment of the reference frame requires the knowledge of the orientation of Earth in space, the figure of the Earth, and highly precise and accurate geodetic observations. In the past, traditional geodetic observation techniques such as astronomical observation, triangulation survey, gravity observation, and geodetic/precise levelling were used to determine the orientation and figure of the Earth. But in modern times space-based and satellite-based geodetic observation techniques are employed for this purpose.

The figure of the Earth refers to both the shape and size of the Earth. The shape of the Earth's surface is a consequence of the gravity field (Torge, 2001). Geodetic observations we made are influenced and referenced to the gravity field of the Earth. For example, the vertical axis of theodolite is made coincident with direction of vertical or plumb line. To determine the figure of the earth; computing and analysing geodetic measurements necessitates a good understanding of the Earth's gravity field. Hence Geodesy makes a study of Earth's orientation in space and Earth's gravity field, makes highly precise and accurate geodetic observations, and outputs the celestial reference system and frame used for positioning both celestial objects and terrestrial reference system and frame for positioning the Earth's surface's features and phenomena.

Modern geodesy is characterized by the advent and proliferation of space-based and satellite-based geodetic techniques. Before the era of modern geodesy, concepts, tools, services, and products of classical geodesy was mostly used. Even today rest of the world except for most developed nations such as Australia, Japan, Europe, and a few others, are using the reference system and frame defined and established by classical geodesy. Though slowly as satellite-based geodetic techniques are becoming easily available, at low cost, with high precision and accuracy, efficient data collection, nations are intending to modernize their classical geodetic infrastructure.

Geodesy models the Earth as ellipsoid and geoid. An ellipsoid is a rotating ellipse about its minor axis, flattened at the pole and protruding out at the equator. Measurements from triangulation, arc measurements, deflection of verticals, and gravity observation revealed that Earth's shape is best approximated by an ellipsoid as the Earth is flattened at the pole and protruded at the equator. The quantity of flattening is also determined from the above-mentioned data. Thus, an ellipsoid is used as a reference surface for horizontal positioning of the Earth's surface's features using the curvilinear coordinate system: latitude, and longitude.

Such an ellipsoid must best fit the surface of the Earth, thus different nations have defined their ellipsoid to best fit their surface. For example, the Everest1830 ellipsoid, the flattening and semi-major axis of this ellipsoid are decided in such a way that it best fits the Earth surface of the Indian sub-continent while the Geodetic Reference System 1980 (GRS80) ellipsoid best fits the global Earth surface.

A network of monuments is established on the Earth's surface and precise coordinates are assigned to them. These precise coordinates are referenced to such best-fit ellipsoid. Such a network is called the reference frame used for positioning works.

Likewise, the equipotential surface resulting from Earth's gravity field is called a geoid, taken as a reference surface for heightening purposes. The geoid is realized through MSL, tide gauge estimates of MSL, and benchmarks (BMs) whose heights are determined relative to MSL. Several BMs are established in a distributed manner, a network of such BMs is called a vertical control network. Several vertical data exist around the world, for instance, Nepal used MSL defined at the Bay of Bengal as its vertical datum.

A network of highly precise and accurate horizontal control points referenced to best-fit ellipsoid is called a horizontal reference frame. The network of BMs referenced to MSL is called a vertical reference frame, this is how Geodesy fulfils its responsibility of providing reference frames for positioning. Such frames are used for various surveying and mapping activities, monitoring of subsidence of the ground, deformation of Earth's surface etc. Such reference frames are used by geodynamics, geophysics, geography, oceanography, hydrography, and other geosciences for positional information.

3. HISTORY OF GEODESY

1. **Eratosthenes, Radius of the Earth, and Spherical Model of the Earth**

   In past, by looking into and making observations of celestial bodies such as the sun, moon, planets, and stars – that science are called astronomy and it is considered one of the oldest science – humans began to explore, learn, and collect evidence of shape and size of Earth (Vanicek, 1986). Astronomy was the basis for Geodesy (Vanicek, 1986). Thales of Miletus, known as the founder of trigonometry, described Earth as a disc floating in an infinite ocean (Vanicek, 1986). Later in 580-500 BC, Pythagoras and his school developed and prevailed on the notion of a spherical shape Earth and as time goes by this concept of spherical Earth got established. The major evidence that Earth is spherical was shown and proved by Eratosthenes of Alexandria. He computed the radius of the Earth which was -7% less than the presently accepted value of the radius of Earth (Torge, 2001). He is considered the founder of geodesy.

2. **Improvement of the Radius of Earth**

   From the 15th century onwards, geodesy began to advance with the help of scientifically made observations to determine more improved and accurate shapes and sizes of the Earth (Vanicek, 1986). Advancement and availability of precise instruments and methods led to scientific, precise, accurate, and easier geodetic observations. Snellious and Tycho Brahe carried out the first triangulation in the 17th century (Torge, 2001). In 1670, French J. Piccard measured the meridional arc through Malvoisine-Paris-Amiens with the help of a triangulation network and obtained the radius of the Earth +0.01% of the present value (Torge, 2001). This was the first improvement of the radius of Earth after Eratosthenes (Vanicek, 1986).

3. **Flattening of the Earth**

Jean Richer noticed one-second pendulum operated in Paris when operated in Cayenne, needed to be shortened to maintain the same one-second period (Torge, 2001). This gave hint that gravity increments while moving from the equator to the pole indicating Earth is not spherical. The major evidence that Earth flattened at a pole and bulged out at the equator came from Newton in 1687 (Torge, 2001). Newton proposed, based on his laws of gravitation, an ellipsoid in rotation as the figure of the Earth (Torge, 2001). Arc measurements by Snellious, J. Piccard, and Cassini led to the Earth is flattened at the Poles (Torge, 2001). In 1735-43 French academy of sciences conducted two famous survey expeditions, one at the equator, Peru led by Pierre Bougar and another at the nearby pole, Lapland led by Alexis C. Clairut. Geodetic observations from these expeditions calculated the value of Earth's flattening thus proving Earth's shape as Ellipsoid. Alexis C. Clairut demonstrated that gravity measured at two different places could be used to derive the flattening of the Earth. Thus, finally Earth's shape as an ellipsoid was established.

4. **Astronomical Survey and Triangulation: Bread and Butter of Geodesists**

Arc measurements and triangulation were extensively used to compute parameters; semi-major axis and flattening, of ellipsoid Earth from 1750 to 1950 (Vanicek, 1986). Triangulation became the only and easier geodetic surveying method to establish the network of controls point at a local and national level. Observations from arc measurements provided the basis for defining and establishing the best-fit ellipsoid of any region. This best-fit ellipsoid is used as a horizontal reference surface to compute the positional coordinates of any points on Earth. Such points are established with higher precision and accuracy and have coordinates referred to as ellipsoids. These networks of control points were used for the mapping of various purposes such as topographical, cadastral, engineering and others. Triangulation, astronomical observation for latitude, longitude, azimuth, and precise levelling were dominant works of geodesy (Vanicek, 1986).

5. **Deflection of Vertical**

Later it was noticed that coordinates from triangulation referenced to ellipsoid and the coordinates from astronomical observations at the same point were found to deviate which gave suspicion that even the ellipsoid could not be a true figure of the Earth. Such deviation called deflection of vertical found to have significant value in mountainous regions. Based on this evidence Carl F. Gauss, Pierre-Simon Laplace, and Friedrich Bessel gave an improved definition of the figure of the Earth. The improved definition separates the actual physical surface of the Earth, geoid, and ellipsoid; the geoid is the mathematical surface and the ellipsoid is the reference surface (Torge, 2001).

6. **RADAR, EDM, First Satellite and Atomic Clock**

Before 1950 all geodetic problems such as the shape and size of the Earth, the gravity field of the Earth, and the reference surface required for horizontal and vertical control networks were completely based on terrestrial geodetic observation. But then the philosophy, methods, and techniques of geodesy got revolutionized because of 5 major reasons; one: the invention of RADAR, two: the introduction and use of the computer, three: the introduction of EDM, four: the introduction of radio interferometry and the five: most significant and the major; the use of satellite (Vanicek, 1986) and the atomic clock (H. P. Plag & Pearlman, 2009) as well. The first satellite Sputnik launched on October 4, 1957, marking the era of modern geodesy and the use of artificial Earth satellites, space and atomic clocks led to 3D and 4D geodesy.

4. MODERN GEODESY

1. Space Geodetic Techniques

The advent of space-age and atomic clocks gave rise to space-based and satellite-based geodetic observation techniques such as DORIS, GNSS, SLR, VLBI, Orbit analysis, Altimetry, Interferometry Synthetic Aperture Radar (InSAR) (H. P. Plag & Pearlman, 2009). Introduction of NAVSTAR GPS after 1980; GNSS system of USA, GPS being extensively used for surveying and mapping works (Seeber, 2003). The use of GPS completely changed the perspective of surveying and mapping (Seeber, 2003).

2. GNSS

Since GPS has global scale coverage, widely spaced ground-stationed GPS receivers with continuous observations of high-orbiting navigation satellites made it possible to define and establish high-accuracy global terrestrial reference frames. A GPS survey was also used for the establishment of the geodetic control network of national and regional scales. This led to the connection and transformation between classical horizontal networks to modern geocentric reference systems. The geoid is being developed and determined relative to the GRS80 ellipsoid (Torge, 2001). Later other GNSS systems such as GLONASS of Russia, GNSS of Europe (GALILEO), BeiDou Navigation Satellite System (BDS) of China etc. appeared as satellite positioning systems in several parts of the world. Observations from such GNSS systems directly gave the 3D coordinates of any points, above the Earth's surface in combination with geoid which made possible the concept of 3D geodesy otherwise traditionally there used to be separate horizontal and vertical reference surfaces (Torge, 2001).

3. Power of Space Geodetic Techniques

These space-based and satellite-based geodetic observation methods along with terrestrial and airborne geodetic observation methods gave results with unprecedented accuracy; high spatial and temporal coverage; high resolution, parameters observed, latency and quality (H. P. Plag & Pearlman, 2009). Because of these technological advancements, geodesy got completely revolutionized. These satellite-based geodetic observations gave the basis for measuring, monitoring, modelling, and analysing the quantum changes of Earth's surface land/ice/oceans because of the internal and external Earth's dynamic processes.

4. Dynamic Earth

Earth's internal dynamic processes include plate tectonics, earthquakes, Earth tides etc. while external dynamic processes include glacier melt, sea-level changes, atmospheric loading etc. (H. P. Plag & Pearlman, 2009). These dynamic processes affect the mass distribution and angular momentum of Earth thus consequently changing the Earth's gravity field and Earth's rotation (H. P. Plag & Pearlman, 2009). Because of a proper understanding of these dynamic processes and their consequences, the static view of the Earth is no longer tenable. So fixed coordinates of points on Earth's surface as in traditional geodesy could not be true. Again, the principal goal of geodesy is to define and establish an accurate, precise, timely reference system and frame to which positions of points on Earth's surface are referred to. The definition and establishment of such reference system and frame must then continuously study and incorporate geodynamics, gravity field, and rotation of the Earth and their changes over time.

5. Modern Definition of Geodesy

The idea of dynamic Earth led to an extended and modern definition of geodesy which can be stated as "geodesy is the study of geometry; orientation and gravity field of the Earth; and its rotation with their changes over time"(H. P. Plag & Pearlman, 2009). Modern geodesy views Earth as an Earth system approach rather than static. Figure 1 shows the 3 pillars of geodesy: geometry, Earth orientation, and gravity field;

geodesy's principal output which are reference frames; and positioning and applications of geodesy.

4 major reference frames are celestial, terrestrial, gravity, and height reference frames as shown in Figure 3. Earth orientation parameters connect the terrestrial reference frame to the celestial reference frame. A gravity reference frame and height reference frame are required for the study, measurement, and modelling of the gravity field (Figure 2). The products related to the gravity field such as the static and temporal gravity field of the Earth; gravity data, and geoid models are tied to gravity and height reference frames. These products are also crucial to make these reference frames precise and accurate turn.

All these reference frames are utilized in a combined way to measure, monitor, and modelling of the geometry of the Earth. Surface deformation models, ocean topography models, sea level change, station position and velocities, tide gauge records, and sea surface heights (see Figure 2). All these phenomena are tied to reference frames. Precise and accurate reference frames help to model the Earth's geometry with more precision and accuracy. These precise and accurate products are used to make reference frames precise and accurate in turn.

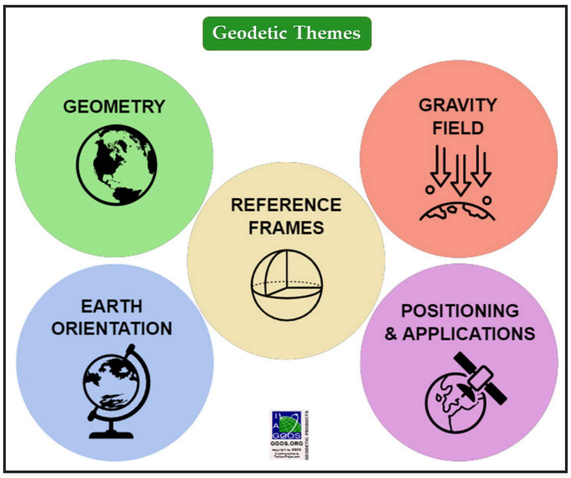

Figure 1: Three pillars of geodesy: Geometry, Earth Orientation, and Gravity Field. Reference frames are the major output of geodesy. Three pillars of geodesy and reference frames have very wide applications. (Source: Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG) website) (Global Geodetic Observing System, 2021).

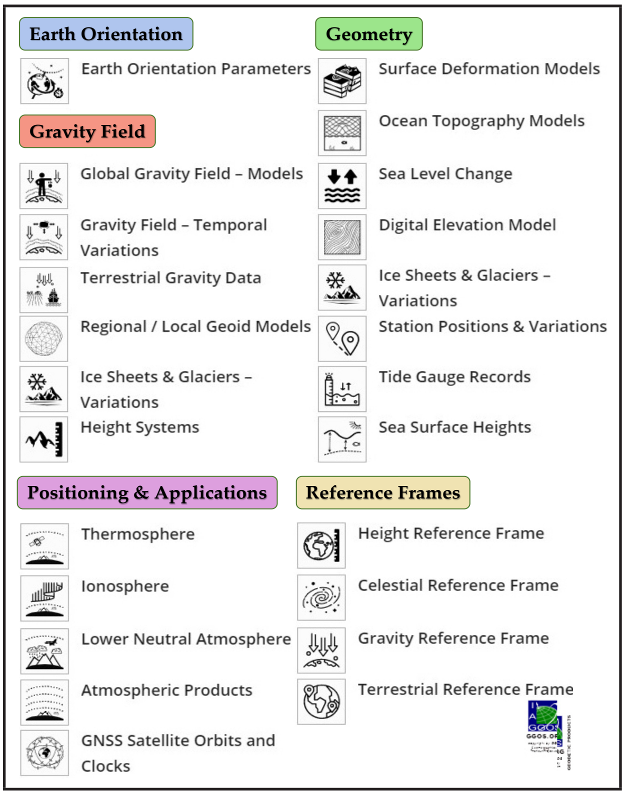

Figure 2 List of geodetic products (Source: Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG) website) (Global Geodetic Observing System, 2021).

6. Time-Dependent ITRF

Changes in the surface of the Earth's land/ ice/oceans because of Earth's processes are continuously monitored using dense ground-based stations taking continuous observations to satellites in space nowadays. Changes in the gravity field of the Earth and its rotation caused by Earth's processes are also continuously measured through satellite and space-based geodetic observations. Thus, the highly accurate reference system and frames such as International Terrestrial Reference System (ITRS) and International Terrestrial Reference Frame (ITRF) were defined and established. The first realization of ITRS was ITRF89 in 1991(*IERS - IERS - ITRF*, 2013). Since then, 12 newer ITRF versions have been released. Recently ITRF2020 has been released (*ITRF | Itrf2020*, 2022), the most precise, accurate, stable geometric reference available now.

5. ADVANCES In GEODESY

Most countries in the world have modernized and are about to modernize their national spatial reference system (NSRS). They left old, less accurate and less precise NSRS which was formed by traditional and terrestrial geodetic techniques. The major limitation of such reference systems is that they are not compatible with modern-day surveying and mapping technologies. Traditional NSRS is distorted due to geophysical phenomena. Some distortions have been accumulated due to various adjustments. Thus traditional NSRS has become obsolete.

1. Modernized NSRS as a solution

Space and satellite-based geodetic techniques, improved understanding of Earth system and Earth processes, ability to measure minute changes, ability to acquire high spatial and temporal resolution data, high computing capability and requirements of modern technology-enabled users necessitate the modernization of NSRS.

2. Component of NSRS

NSRS consists of data, reference systems, reference frames, working surfaces, infrastructure, models, and standards (*Zero Is Priceless: The Importance of Geodesy | Intergovernmental Committee on Surveying and Mapping*, 2020). Datum includes horizontal datum, vertical datum, and 3D Cartesian coordinate datum. Reference frames are the physical realization of abstract reference systems. Before space and satellite-based geodetic techniques, triangulation networks were reference frames. But nowadays VLBI, SLR, DORIS, GNSS CORS, gravity stations etc. with their highly precise 3D ECEF coordinates and other associated values constitute the physical realization of national, regional, and global reference systems. For example, World Geodetic System 1984 (WGS84) is the reference frame of NAVSTAR GPS's reference system. ITRFs are the realization of ITRSs. In Nepal 68 first-order triangulation stations can be said as the reference frame of the Nepal Datum. As for vertical positioning, nations have used MSL as a reference surface for height since a long time ago.

3. Geoid: Key Component of Height Reference System and Frame

Geoid has been used as a reference surface for height. GNSS survey is very convenient nowadays. The geometric height obtained from GNSS can be transformed into orthometric height using a geoid model. Getting the orthometric height of any point with the help of GNSS and geoid is termed GNSS-levelling. GNSS levelling is characterized by fast, accurate, and accessible to difficult terrain while precise levelling is tedious, time-consuming, weather and time window dependent. Precise levelling is almost impossible on difficult terrain. Several countries have developed accurate geoid models and started using GNSS-levelling.

4. Geodetic Infrastructure, Models, and Standards

Geodetic infrastructure includes monuments, benchmarks, survey markers, CORSs, stations of space and satellite geodetic techniques, tide gauges, gravity stations etc. Models include earth gravity models (e.g. EGM2008), geophysical models such as Plate Motion Models (PMM), deformation models and others. Standards may include standards published by the International Earth Rotation and Reference System Service (IERS), International Association of Geodesy (IAG), International Union of Geodesy and Geodynamics (IUGG) or standards published by the National Mapping Agency (NMAs) etc. which is required for consistency, efficiency, easiness of positioning and other geospatial works throughout nations.

5. International Trend on Modernization of Geodetic Infrastructure, Services and Products

In this subsection, we provide the modernization done by developed countries on geodetic infrastructure, products, and services. Two major geodetic infrastructures: terrestrial reference frame and modernized vertical datum have been adopted leaving the classical geodetic horizontal and vertical datum.

1. Australia

Australia had been using the Geocentric Datum of Australia 1994 (GDA94) as its horizontal datum since 2000 and the Australian Height Datum (AHD) as its vertical datum since 1971. Recently it has modernized its spatial reference system (SRS) which is precise, accurate and meets the needs of users. The result of SRS modernization is Australia now uses a two-frame approach, which is the Geocentric Datum of Australia 2020 (GDA2020) and Australian Terrestrial Reference Frame 2014 (ATRF2014). GDA2020 is a 3D static datum, aligned to ITRF2014 at epoch 2020.00, realized through 109 GNSS CORS of the Australian Fiducial Network (AFN). It replaces the former GDA94 and available since October 2017. ATRF2014 is a time-dependent reference frame, that incorporates Australia's PMM, and coordinates of features in ATRF2014 change with the time as modelled by PMM. ATRF2014 was made available on 1 January 2020 (*Upgrades to the Australian Geospatial Reference System | Intergovernmental Committee on Surveying and Mapping*, 2020).

For heightening purposes, Australia has been using Australian Height Datum (AHD). Australia has developed a geoid called AUSGeoid. GNSS users in Australia could get AHD heights from ellipsoidal heights using AUSGeoid with an accuracy of 6-13cm (*Australian Height Datum | Intergovernmental Committee on Surveying and Mapping*, 2020) . But since, 1 January 2020, Australia has had another reference surface of height called Australian Vertical Working Surface (AVWS), which incorporates Australian Gravimetric Quasi Geoid (AGQG), ellipsoidal heights from GNSS can be transformed to AVWS heights with the accuracy of 4-8cm (*Australian Vertical Working Surface | Intergovernmental Committee on Surveying and Mapping*, 2020). Users who require accurate heights over long distances could use AVWS. In addition, AVWS overcome the biases and distortions present in AHD (*Australian Vertical Working Surface | Intergovernmental Committee on Surveying and Mapping*, 2020).

2. China

In July 2008, China replaced the older Xi'an Geodetic Coordinate System 1980 with the Chinese Geodetic Coordinate System 2000 (CGCS2000). CGCS2000 is geocentric, aligned to ITRF97 at the epoch 1 January 2000.0. China has a national GPS control network 2000 (GPS2000) consisting of 2500 stations in 2003. CGCS is realized through 28 IGS and CORS stations, a GPS2000 network, and an astrogeodetic network (Yang, 2009).

3. Japan

Japan began to use the Japanese Geodetic Datum 2000 (JGD2000) in April 2002 as its modern NSRS. This Japanese NSRS consists of JGD2000 Horizontal, JGD2000 Vertical, and GISGEO2000 geoid models (Matsumura et al., 2004).

JGD2000 Horizontal is aligned to ITRF94 at the epoch of 1 January 1997, replacing the old Tokyo Datum, geocentric and of world standard. JGD2000 is realized through 1300 GNSS Earth Observation Network System (GEONET) CORS stations and VLBI stations (Tsuji & Matsuzaka, 2000). GEONET is maintained by the Geospatial Information Authority of Japan (GSI) and consists of 1300 CORS at an average of 20km spacing. Data from GEONET mainly serve crustal deformation monitoring and GNSS surveys in Japan. Data from GEONET are open for public and private uses in Japan (Tsuji & Matsuzaka, 2000).

Japan has been using the orthometric height system JGD2000 vertical, earlier the height system was based on normal orthometric heights. JGD2000 vertical consists of the latest nationwide levelling survey, maintained in a levelling database called "LAGSAS", available since April 2002 (Imakiire & Hakoiwa, 2004). GNSS users in Japan use the GSIGEO2000 geoid model to convert ellipsoidal heights to orthometric heights. This GSIGEO2000 geoid is adopted into JGD2000 Horizontal and JGD2000 Vertical. GSIGEO2000 is computed from land gravity data, marine gravity data, and GPS-levelling survey data (Matsumura et al., 2004).

4. **United States of America (USA)**

United States of America (USA) has planned to modernize its existing horizontal and vertical datum and adopt modern NSRS since 2008 (National Geodetic Survey; National Oceanic and Atmospheric Administration, 2019). USA is planning to replace its current horizontal datum North American Datum 1983 (NAD83) with North American Terrestrial Reference Frame 2022 (NATRF2022) and replace its current vertical datum North American Vertical Datum 1988 (NAVD88) with North American Pacific Geopotential Datum 2022 (NAPGD2022) by 2022-2025 (National Geodetic Survey; National Oceanic and Atmospheric Administration, 2017a). NATRF2022 is geocentric, aligned to ITRF2020, and uses the Intra-Frame Velocity Model (IFVM2022) as a plate motion model. NATRF2022 is realized through National Oceanic and Atmospheric Administration (NOAA) CORS Network (NCN) (National Geodetic Survey; National Oceanic and Atmospheric Administration, 2017a). Similarly, NAPGD2022 is a geopotential datum defined using GNSS data and gravity field. It consists of geopotential fields, geoid undulations, deflection of verticals, and surface gravity models. The geoid model adopted in NAPGD2022 is GEOID2022. NAPGD2022 is referenced to ITRF2020 (National Geodetic Survey; National Oceanic and Atmospheric Administration, 2017b).

As we see, Australia, Japan, and China have left their older/existing NSRS and adopted the modernized NSRS in the first decade of the 21st century. USA will soon adopt modernized NSRS by 2022-2025. Many other countries such as South Korea, Countries in Europe, and countries of South America have modernized NSRS. Countries of Europe have defined and established European TRS 1989 (ETRS89) and European Vertical Reference Surface (EVRS). Countries of South America established and use Geocentric Reference System for Americas (SIRGAS).

6. **Advances & Future Strategies for Nepal**

Several geodetic activities took place in Nepal. The official recorded history dates to 1924-27 when astronomical survey, triangulation survey and continuation of the Great Trigonometrical Survey (GTS) for 1":4Mile topographic map preparation (Oli, 2007). Nepal datum was built in 1984. Vertical datum uses the MSL of the Bay of Bengal as a reference surface. Recently, Nepal measured the height of Sagarmatha in 2020. A detailed history of geodetic activities in Nepal can be found in our previous review paper (KC & Acharya, 2022).

As activities of modern geodesy, In 1992, SD and University of Colorado (CU) together built geodetic network of 29 GPS stations spread around Nepal to create the dynamic Nepal datum. SD and CU run CORS stations to monitor the surface deformation starting from 1991 to 2000. Later, the Department of Mines and Geology (DMG) and EarthScope Consortium (previously UNAVCO) collaboratively run the CORS network in Nepal.

Nepal Academy of Science and Technology (NAST) also operates more than 10 CORS stations. Universities such as Kathmandu University (KU) and Tribhuvan University (TU) also run CORS for their scientific purpose. China Earthquake Administration runs an array of CORS at the borderline of Nepal and China. At present, SD established two new CORS in Bara and Mahottari districts. SD already has two CORS at the SD premise and Nagarkot Geodetic Observatory.

Similarly, DTU-Space and SD performed the airborne gravity survey in 2010, SD did the LiDAR survey of Western terai in 2021. Again, detailed information on modern geodetic activities in Nepal can be found in (KC & Acharya, 2022).

Nepal is in a tectonically active zone. Gorkha earthquake hits Nepal seriously. Our surface has deformed significantly in the horizontal and vertical directions due to these phenomena. This is the right time to build a modernized NSRS. Nepal should work on a geocentric terrestrial reference frame and geoid-based modernized vertical datum.

A geocentric national terrestrial reference frame ties various datasets from various spatial data producers within a country. Topographic and cadastral mapping products would be tied to this NTRF. Existing dataset based on classical NSRS can be converted to modernized NSRS using transformation models. Datasets from modern surveying technologies such as LiDAR, UAV, RTK etc would be referenced to this NTRF. In this way various dataset can be integrated– this is how robust NTRF serve its purpose.

6. CONCLUSION

Geodesy has evolved from classical geodesy to modern geodesy, terrestrial observations to space-based and satellite-based observations, static view of the Earth to dynamic Earth, national scale to regional and global, from low to high spatial and temporal resolution, to unprecedented accuracy and precision.

After classical geodesy has served society well, modern geodesy has been providing highly accurate, stable, and accessible reference systems and frames to society. Geodesy has widened its applications to various areas and has been key science for environment conservation and climate change. Realizing the importance of modern geodesy and the socio-economic benefits of modern geodetic infrastructure, gradually countries are modernizing their NSRS.

In the context of Nepal, Nepal has an excellent performance in the case of building classical geodetic infrastructure, however, Nepal is lagging in terms of modern geodetic infrastructure namely geocentric national terrestrial reference frame (NTRF) and modernized vertical datum.

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PERCEIVING, PRESERVING AND PROMOTING INDIGENOUS LAND USE ROLE MODEL WITH DRONE MAPPING IN NEPAL*

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ABSTRACT

It is important to consider Nepal's unique landscape and lifestyle when planning and implementing land use projects. To achieve this, the study uses drone technology to capture high-resolution images, producing an orthomosaic and classification of same results land use maps, which identify significant indigenous living styles and promote their preservation in the development of suitable land use plans. The drone images were collected for three regions: Chepuwa (Mountain Region), Mastamandu (Hilly Region), and Nayaroad/Newroad (Terai Region). The resulting orthomosaic had a resolution of 3.08 cm/pixel for Chepuwa, 3.22 cm/pixel for Mastamandu, and 2.60 cm/pixel for Nayaroad. The images were classified using a random forest classifier with 50 decision trees in Google Earth Engine. The resulting land use maps had an overall accuracy of 0.78, 0.91, and 0.94, with kappa coefficients of 0.73, 0.89, and 0.92, respectively, for the Mountain, Hilly, and Terai regions. The study successfully identifies significant indigenous living styles, such as the donkey's trail in Chepuwa, houses surrounded by manure and farmland in Mastamandu, and large farmland surrounded by dispersed houses and access roads in Nayaroad. Additionally, the study examines factors such as built-up resources and style, agricultural practices, vegetation types, socio-economic interactions, fresh landslides, and hazards. In summary, this research utilizes drone-based products to understand the landscape and lifestyle of Nepal, and supports land use plans for nearby communities. By incorporating indigenous land use practices, the study promotes sustainable development that meets the local community's needs and preserves the region's unique characteristics.

KEY WORDS: *Drone Mapping, Random Forest Classifier, Land use planning, Indigenous land use practices, Google Earth Engine*

1. INTRODUCTION:

The long-standing relationship between human beings and land has been vital in shaping our understanding of how we interact with social and environmental systems (Long, 2022). The study of land use systems provides a deeper understanding of this relationship and how it relates to socio-economic development (Grainger, 1995). Nepal is currently facing rapid urbanization, new town development, and the implementation of strategic plans by the Ministry of Urban Development, which suggests a severe transition in land use, is expected (Dahal and Timalsina, 2017). This transition, starting from pre-settlement natural vegetation and ending with intensive agriculture, urban areas, and protected recreational and ecological lands (Foley et al. 2005), poses a significant threat to indigenous knowledge and practices. One of the main reasons for this depletion is the lack of documentation and presentation of traditional practices and their consideration in shaping land use policy for the future.

As Nepal shifts from an agriculture-based economy to an industrial service-based economy (Di Clemente et al. 2021), it is crucial to ensure that development and environmental protection go hand in hand to mitigate any adverse environmental impacts (Aryal et al. 2023). Nepal can learn from its indigenous peoples and their traditional practices to improve its ways of interacting with the environment. For instance, participatory park management, which involves indigenous peoples and addresses the livelihood issues of indigenous communities, has ultimately succeeded in its efforts toward wildlife conservation (Nepal, 2002). 103 different caste and ethnic groups have been identified based on the 2001 census data, the Nepal Living Standards Survey (NLSS) grouped these into just eleven broad categories:

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Brahmins, Chhetris, Terai middle castes (particularly Yadav), hill Dalits, Terai Dalits, Newars, other hill indigenous peoples (other than Newars), Terai indigenous peoples (particularly Tharu), Muslims and other groups/ minorities (LAHURNIP & IWGIA, 2014) Indigenous peoples are residing on different geographic belts with traditional life styles are closely attached with ecosystem, biodiversity, natural resources, and environmental from ancient period of time (Lama ,2021). Much of the interest in indigenous knowledge has focused on natural resources and the environment, which was reflected in the emergence of the concept of indigenous environmental knowledge (Dove, 2006).

Increasing rate of infrastructure development and urbanization in Nepal is going to benefit from researched and updated land use planning based on indigenous knowledge. However, the attitude of both government and general public towards the acceptance of plans and policies related to land management is a problem which is evident from the fact that these are short of adequate participation and feedback from general public and local stakeholders (Chand, 2019). Unmanned aerial vehicle (UAV), commonly known as drone is being used for land use and land cover classification (Hassan et al. 2011), (Kalantar et al. 2017), monitoring and mapping of urban vegetation regions (Feng et al. 2015), rangeland (Rango et al. 2009) and agriculture (Chen et al. 2020). It helps in land use analysis for documenting local lifestyle to build tourism too (Prasenja et al. 2018). Drones capture imagery at higher spatial resolutions than satellite imagery, which can facilitate mapping at greater detail (Gray et al. 2018). Also, the imagery and videos by drone is easily understood by local people (Kleinschroth et al. 2022), increasing their participation in decision-making processes. This ultimately ensures the success of land use projects from planning to implementation.

Despite the increasing use of drones for mapping and data acquisition, there is a lack of research on how drone mapping specifically can be used to understand the landscape and lifestyle of indigenous people in Nepal, and how this information can be used to understand, protect and foster good land use practices while ensuring the participation of local people in land use policy preparation and new urbanization projects. The objective of this research is to explore the potential of using drone mapping to quickly gather data, comprehend the landscape, and way of life of indigenous people in Nepal. The aim is to facilitate smooth and successful land use transitions by perceiving, preserving and promoting good land use practices of indigenous people. Additionally, this research will investigate how raw products like drone images and processed products like orthomosaic, Digital Elevation Models and land use maps can be utilized to enhance the participation of local people in land use policy preparation and the implementation through participatory mapping.

2. STUDY AREA:

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

In this paper, three selected sites representing different topography of Nepal using drone imagery: Chepuwa in the Mountain region, Mastamandu in the Hilly region, and Nayaroad in the Terai region are studied. These sites were chosen for their unique landscape and lifestyle characteristics, which must be considered when planning and implementing land use projects in Nepal. The goal of the research is to use drone-based products to better understand the landscape and lifestyle of these localities, in order to support land use plans for nearby communities.

Chepuwa as the name suggests is the hidden beautiful village in the mountain region in Bhotkhola Gaunpalika-02, Sankhuwasabha, Province 1, the nearby ridges completely cover the settlement zone making it invisible from nearby places just like other typical mountain villages of Nepal. The elevation of Chepuwa is around 2000 meters above sea level (masl). Bhote are the native residents here. The village wasn't connected to motorable roads till 2021; donkeys were used to transport goods. But, today Koshi Highway is in the making, close to the village probably 2 Kilometer (Km) away, only tractors travel on the same road till now. Nevertheless, this village surprises the outsider by its immense beauty and well managed galli or pathways that run through an integrated settlement zone which is also, rare in the mountain regions because of the undulated terrain.

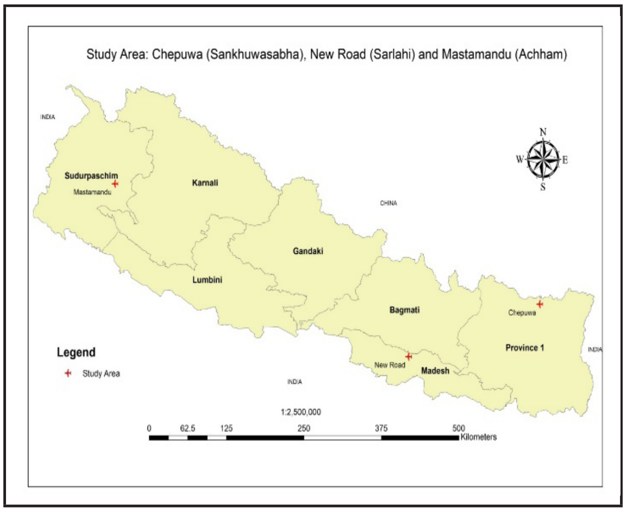


Figure 1: Study area- Chepuwa, Mastamandu and Nayaroad

Mastamandu is a ward number-4 village in Sanphebagar municipality in the hilly region in Sudurpaschim Province. The village is connected with a motorable gravel road. The integrated settlement structures built with local resources are the main attraction here. The elevation of Mastamandu is around 1000 masl. The area is populated with Brahmins, Chhetris and hill dalits.

Nayaroad which was formerly known as Dungrekhola VDC lies in Bagmati Nagarpalika-02, Sarlahi. The elevation of Nayaroad is around 110 masl. The area is predominantly populated by people of Madhesi ethnicity, who are mainly engaged in agriculture. The caste system is also prevalent in this region, and the residents include a mix of different castes such as Yadav, Patel, Sada, Musahar, and other sub-castes. Agricultural land here is surrounded with roads that can be used to access each plot, scientific farming can be done as tools and instruments can reach the land easily here. Further, the east-south Bagmati Canal passes through the southern part of the region providing the irrigation facility. One of the distinct settlement styles at this area is the buildings are dispersed and are built in outskirts whereas the farmland in mountain and hilly regions surrounds the settlement zone in the center.

3. METHODOLOGY

The overall workflow of the research is as defined by following steps:

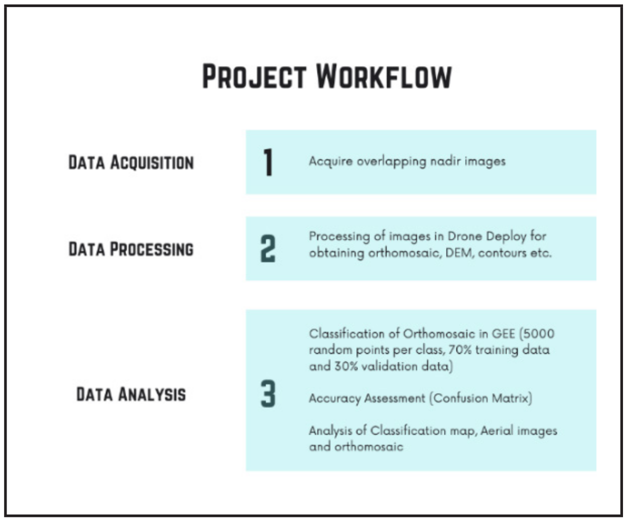


Figure 2: Workflow of the project

3.1. Data Acquisition: The raw images were captured by DJI mavic 2 pro which has 1” CMOS sensor with 20 megapixel Hasselblad camera. The aircraft weighs 907 g thus, falls below 2 Kg category drones that can fly for an average 25 Minutes in Nepal’s terrain and environment. Overlapping images were acquired flying manually with a DJI Go 4 app in Chepuwa because of terrain and threats of predator birds capturing 389 images in one flight on 7th February 2021. The images for Mastamandu were captured in an automated mission by the help of pix4Dcapture app with 80% overlap resulting in 728 images in two flights on 24th November 2022. Similarly, 512 overlapping images for Nayaroad were captured in a manual flight with a DJI Go 4 app again because of threats of predator birds on 30th March 2021.

3.2. Data Processing: Acquired images were processed with the help of drone mapping software called DroneDeploy. The software is a commercial photogrammetry tool that relies on its own proprietary processing algorithm. Orthomosaic of 3.08 cm/pixel Ground Sample Distance (GSD) with 12.33 cm/pixel GSD for Digital Elevation Model (DEM) covering 73.7 hectares area for Chepuwa, orthomosaic of 3.22 cm/pixel GSD with 12.86 cm/pixel GSD for DEM covering 85.2 hectares area for Mastamandu and orthomosaic of 2.6 cm/pixel GSD with 10.40 cm/pixel GSD for DEM covering 93.5 hectares are produced. The results of processed images are as shown below:

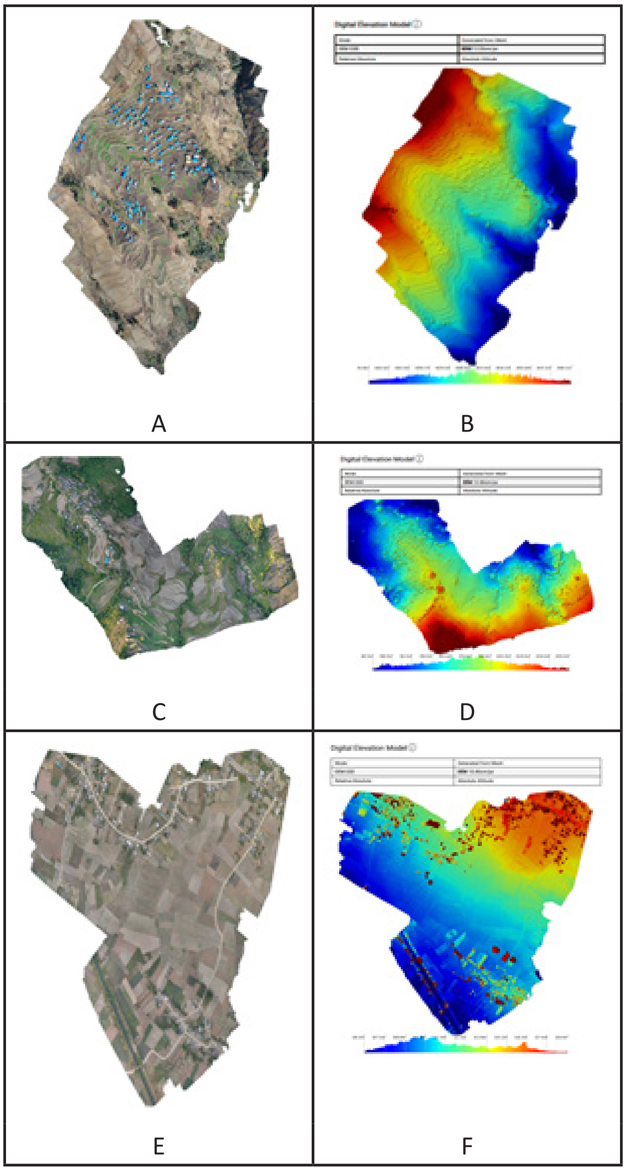


Figure 3: A- Drone orthomosaic for Chepuwa, B- DEM for Chepuwa, C- Drone orthomosaic for Mastamandu, D- DEM for Mastamandu, E- Drone orthomosaic for Nayaroad and F- DEM for Nayaroad

3.3. Data Analysis: Data analysis was done by classification of various land utilizations at research locations and also by analyzing aerial photographs using elements of interpretation of colors, shapes, patterns and sizes. Image classification is computer assisted interpretation of images (Eastman, 2003). The overall objective of image classification is to automatically categorize all pixels in an image into classes or themes. Aerial photograph analysis is done with photo key approach, in which photomorphic appearance in the image is used as the main foundation in the differentiation of various object appearances (Danoedoro, 2009).

4. RESULTS AND DISCUSSION

4.1. Land use and land cover classification map: Land use and land cover (LULC) is a critical aspect of understanding the state and dynamics of the Earth's surface. LULC is shaped by human activities and physical environment (Pandey et al. 2019). LULC depicts agriculture land; forest; water bodies; settlement zones etc. i.e. natural environment as well as artificial construction in it. By analyzing LULC maps, planners can identify areas that are suitable for particular land uses, such as agricultural land (Pramanik, 2016), residential areas (Madurika and Hemakumara, 2017), or protected wilderness areas (Polasky et al. 2008). They can also identify areas that are vulnerable to natural disasters such as floods (Ouma and Tateishi, 2014), landslides (Hong, Adler, and Huffman, 2007) (KC et al. 2022), or wildfires (Carmo et al. 2011). Therefore LULC map can be used to develop plans and policies that optimize land use and minimize risk.

Among different classifiers, a random forest classifier is supposed to be more effective in analyzing all types of images even with stronger noise (Ge et al. 2020). Therefore, random forest algorithm is selected for supervised classification of LULC. The classification was done using Google Earth Engine (GEE) which is a cloud based infrastructure, user-friendly platform to perform sophisticated spatial analysis, classification and validation with support of various training algorithm and classifiers (Gorelick et al. 2017). Even it has been used for land use classification of steep terrain of Fanjingshan National Nature Reserve (Tsai et al. 2018).

For this research paper LULC map has been prepared to understand human-environment interaction. For Chepuwa, Mastamandu and Nayaroad area, five classes has been defined namely “Buildings” for settlement zone as higher resolution image being able to differentiate individual buildings easily, “Trail/Road” for use of land for transportation, “Tree” for forest zone as individual tree canopy also can be segmented from drone orthomosaic and “Cultivation Land” for agricultural field even the land status either ploughed, organic fertilizer sprayed, irrigated or not and crops being grown can be distinctively visible. Final land use class defined is “Water body” which is not present in mountain region’s site Chepuwa being the drier area thus; “Barren Land” has been defined to map the drier and unused land. Whereas, water bodies are clearly visible at Masatmandu and Nayaroad; both have an irrigation pond or canal to facilitate agriculture.

The classification of drone orthomosaic was done ensuring an even sampling of training and validation pixels across the classes, selecting 5000 random points (pixels) per class (n = 25,000 points) from within the training polygons. These points were merged into a feature collection to be mapped across the images to extract digital number statistics for each category followed by splitting the points into 70% training and 30% validation data and use of Random Forest algorithm with 50 trees for classification in GEE (Bennett et al. 2020). The resulted LULC maps (Figure 3, 4 and 5) and accuracy assessment result is as tabulated below in Table 1.

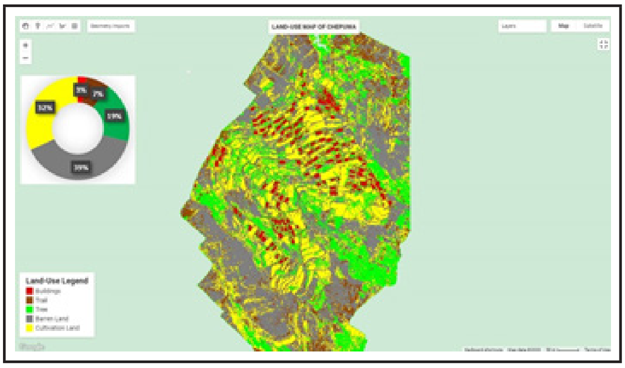


Figure 4: LULC map of Chepuwa, prepared in Google Earth Engine

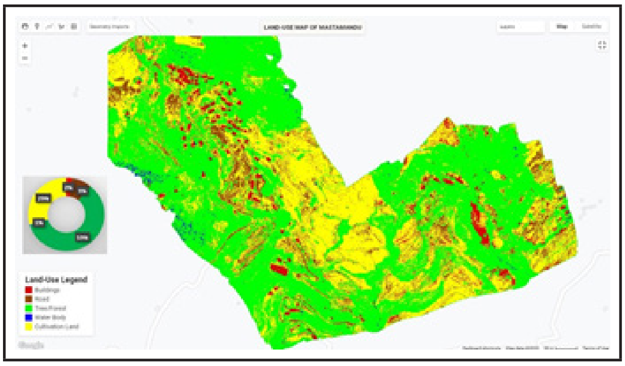


Figure 5: LULC of Mastamandu, prepared in Google Earth Engine

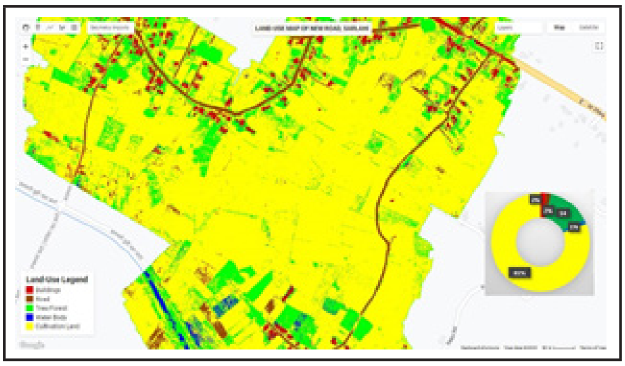


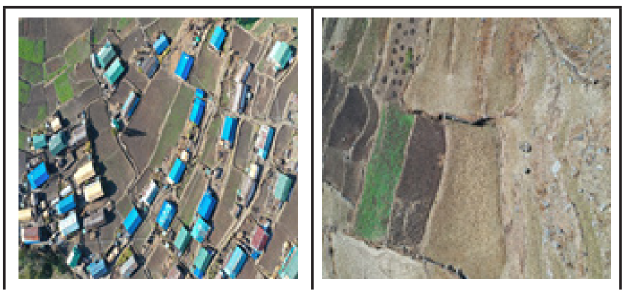
Figure 6: LULC map of New Road, prepared in Google Earth Engine

Particulars (Simple Random Forest classifier output)	Study Area		
	Chepuwa (Mountain)	Mastamandu (Hilly)	New Road (Terai)
Overall Accuracy	0.78	0.91	0.94
Kappa Coefficient	0.73	0.89	0.92

Table 1: Accuracy assessment from random forest classification (50)

4.2. Aerial photograph analysis: One of the main objectives of the paper is to study the lifestyle of people from the aerial photographs. Some key information that can be extracted in order to understand interaction of people with the environment living is defined below:

4.2.1 Chepuwa: Most of the roof tops are made of galvanized sheet; some of them are covered with a knitted roof made of Nigalo (Drepanostachyum falcatum) commonly known as Himalayan bamboo are used for many purposes from roofing to making goth (shed for livestock). Being not connected to the road, donkeys are the mode of transportation of goods, the galli are wider here and the nigalo fence covering the whole field area is also visible in the aerial images, keeping livestock away from the agriculture field. Changes in snow-cover dynamics directly affect biodiversity at high elevations. Chepuwa's climate is drier; the effect can be seen in agriculture fields there, also the boulder mix soils can be one of the causes for people leaving their land barren. The local spray organic fertilizer produced from livestock waste. Firewood and local micro-hydro are the main energy sources here. If observed closely, the chimney in some house is visible too in photos which are also supported by the fact that the villagers here use improved Cooking Stoves (Sudharieko Chulo). The integrated settlement by the people with improved land use knowledge in their own cultural aspect is something worth learning.



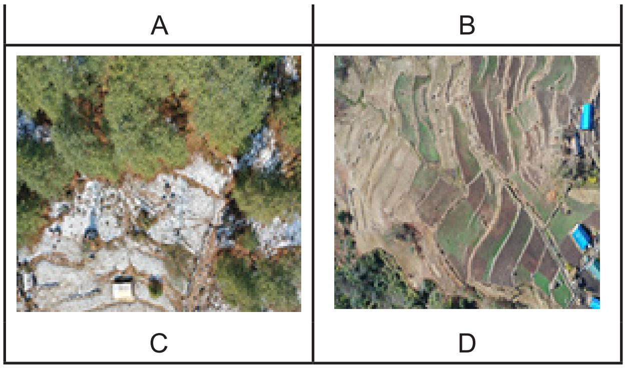
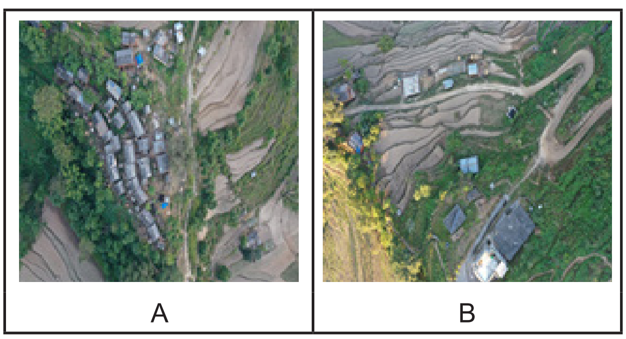


Figure 7: A- Houses roof tops with galvanized sheet and some covered with knitted roof made of Nigalo, foot-trail network with fencing and even Chimneys of sudharieko chulo visible, B- Dry soil and organic fertilizer being used in field, C- Snow covered higher elevation and D- Cultivation land and barren lands

4.2.1 Mastamandu: Most of the roof tops are made of slates, some of them are built with concrete roof and galvanized sheet. Also, mud-plastered walls made with stone are painted with red-ochre (raato maato in Nepali) and white-ochre (seto maato in Nepali). Green spaces are an immense part of the community: banana, bamboo, bhimal, mango, fig (bedu), sallo, asuro, banj, pipal tree etc. are abundantly found here. People are involved in agriculture and livestock farming. Manures are stockpiled around every house and are sprayed over fields. Straws are dried and stockpiled in trees. Irrigation ponds are being made and tunnel farming is also being practiced, vegetable farming is on rise which typically was not a culture of Achham. Mainly hydroelectricity and solar panels in hospitals facilitating the hospital during the electricity outage are main sources of energy here. The integrated settlement zone that was built by its own cultural value is itself appreciable with less development cost during installation of electricity and drinking water. Because of aforementioned traits, the village can be studied as a role model for land use policy and development works around the locality.



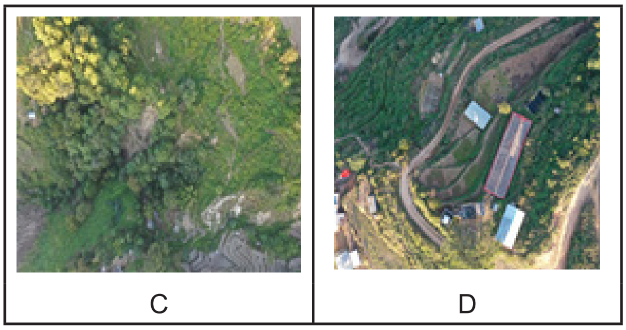


Figure 8: A- Houses roof tops mostly using slates, walls painted with seto and rato mato, surrounded by manure, B- Solar panels, some concreted buildings and small irrigation ponds, use of manures in farmland visible, C- Landslide and D- Tunnel farming

4.2.3 Nayaroad: Most of the roof tops are made of tiles made of muds, houses are surrounded with livestock especially buffalo, fresh mud works, dunks and manures support the fact people making their own Biomass Briquette (used as fire woods) and organic fertilizer. East-south Bagmati Canal is main irrigation source, further people uses electric motor and pipes in their plots to facilitate water. Farmland is in the middle of entire settlement area, well surrounded with access roads from where tools and tractors can reach each plots easily.

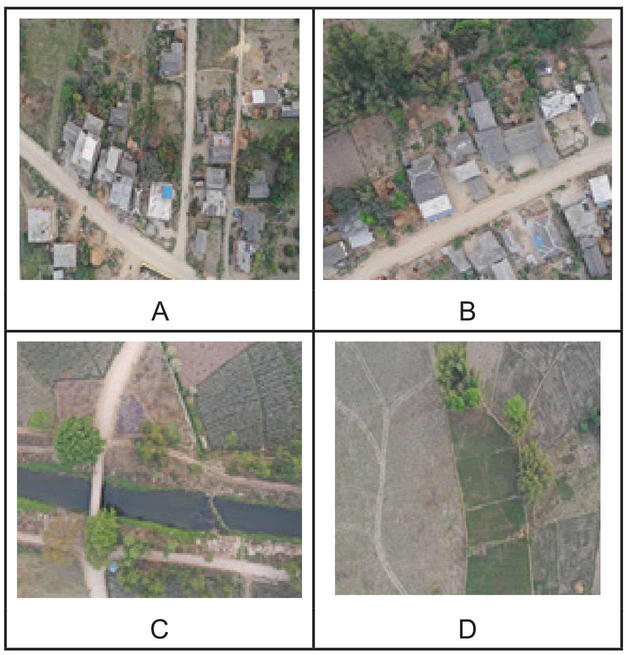


Figure 9: A&B- Houses roof tops mostly using tiles, surrounded by fresh mud works, dunks and manure, C&D- Farmland, canal and pipeline for irrigation, all plots accessible to tractors and tools as suggested by wheel marks in agriculture plots

5. RECOMMENDATION FOR FUTURE

Although this paper successfully highlighted how drone products can be utilized to study both the landscape and lifestyle of people giving a quick overview to the planner and the local Government on locality's land use practices so that they can make informed decisions on making suitable land use policy for nearby localities. But, land use transition, trend and change detection is only possible when we have temporal orthomosaics. Since the study is based on data taken at one point of the time, taking imagery at different times and comparing them with the baseline data is sure to give us an idea on how transitioning is occurring. Further, we can also have ideas on different vegetation and crops that are being cultivated in the regions from orthomosaics of different seasons. Also, we can extract such information from the people in a participatory mapping session where we can ask people on types of crops they grow and other necessary social aspects that are important for the study. Similarly, using hyperspectral sensor and thermal camera in drone platform add further details for more detail processing and analysis. One of the finding of this work is the increase in classification error with increase in elevation or increase in classification accuracy with decrease in elevation is something worth investigating further with drone data of various region. As, suggested by the data, overall accuracy is 0.94, 0.91 and 0.78 with kappa coefficient 0.92, 0.89 and 0.73 for Terai, hilly and Mountain region respectively. Beside, drier and boulder mixed soil confusing the system in differentiating various land use type, terrain and slope might have contributed in generating errors too.

6. CONCLUSION

Use of drone for studying human environment interaction thus, understanding the different land use practices for finding the role model at three topographical division mountain (Chepuwa), hills (Mastamandu) and terai (Nayaroad) has been concluded getting the idea on general landscape and lifestyle of locality there. Drone based orthomosaic of 3.08 cm/pixel for Chepuwa, 3.22 cm/pixel for Mastamandu and 2.60 cm/pixel for Nayaroad along with their raw images, land use map with overall accuracy at Terai 0.94, Hilly 0.91 and Mountain 0.78 and kappa coefficient 0.92, 0.89 and 0.73 respectively are helpful for understanding the built-up resources and style, agricultural practices, vegetation types, socio-economic interaction, fresh landslide and hazards etc. While other drone based products like DEM and their derived products like contours, slope aspect, topographical maps, land use zoning etc. provides deep insights for planning and development works. Drone based mapping products are for everyone whether you are a technical person or a layman. This ensures a fruitful conversation between people, government and planner. Informed decisions and suitable land use policy are more likely to be made with mutual understanding with drone baseline data whose implementation success is highly likely. This way not just indigenous knowledge on land use is preserved and promoted but can be used to guarantee success of land use projects in Nepal.

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REUTILIZATION OF ABANDONED AND FALLOW AGRICULTURAL LAND IN NEPAL: LENSING THROUGH THE VEDIC WISDOM PERSPECTIVE*

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ABSTRACT

TThe Vedas are universally honored as the earliest literatures of universe which basically includes the comprehensive source of wisdom including laws of nature. This paper simply tries to present the agricultural wisdom expressed in different vedic literatures and its relevancy in the present context with reference to reutilization of abandoned and fallow agricultural land. Going by the vedic literature, it is quite evident that agriculture sector was the key source for livelihoods of the people (कृषिमूलं हि जीवनम्। ऋग्वेद). Vedic farming system considers farm as living, dynamic and spiritual entity to be managed with its natural tunes for sustainable agricultural development. Vedic hymns praise and respect the nature including land as mother (माता भूमि: पुत्रो अहं पृथिव्या:). In recent years, rural Nepal has gone through the complex process of transition involving outmigration, increasing trend of urbanization and commercialization. The shift has posed new challenges for the agrarian economy in the form of land underutilization and abandonment in the rural areas. It has created the situation of exploitation resources including land in the urban areas resulting ecological imbalance, environmental pollution and food insecurity. Vedic civilization believes that the exploitation and abuse of the nature and natural resources for our short sighted gains and immediate pleasure is unfair and unethical. It emphasizes on the wise use of natural resources including land. The vedic wisdom of respecting the nature with due consideration of land use planning is well relevant even in modern agricultural farming system. Due attention needs to be given to follow, replicate and extend the best agricultural land use practices described in vedic literatures in line with the current land utilization and management policies.

KEY WORDS: *Vedic, Wisdom, Farm Land, Nature*

1. Introduction

Going by the Vedic literature, it is quite evident that Bharatkhanda and Himavatkhanda, including Nepal and India, had ancient wisdom on agricultural development since the beginning of human civilization. Vedic civilization has been contributing in the field of agricultural land management since ancient times. The agriculture awareness of vedic seers, right from the vedic periods, was remarkable and praiseworthy as Agriculture has been treated as source of prosperity and sustenance (कृषिमित्कृषस्व। वित्ते रमस्व वहु मान्यमानः ॥ ऋग्वेद) (Vaidik Sukta Sangraha, 2076 BS). Vedic wisdom continued from the time immemorial which arose in the course of many centuries and has been extended and handed over one generation to another by verbal communication initially.

In recent years, rural Nepal has gone through the complex process of transformation involving outmigration, increasing trend of urbanization, commercialization and change in population dynamics. This shift has presented new challenges for the agrarian economy in the form of land underutilization abandonment. The total agricultural land of Nepal is around 28 percent out of which 7 percent is uncultivated (MoALD, 2020). Some studies have shown that over thirty percent of total cultivated land is abandoned due to which a negative impact on food and nutrition security has been seen. Different studies have shown that a combination of agro-horti-silvicultural model for fallow and abandoned land utilization would be the best solutions owing to its impact on food and money supply in the rural economy as well as long term impact on environment particularly on soil and water conservation (Dahal et.al, 2020).

Ancient vedic texts like Vedas, The Mahabharata, Ramayana, Upanishads, Bhagavad Gita, Kashyapiya-krishi-paddhati and Krishiparasara, Puranas and Smriti contain the earliest messages for utilization and management of land through plantation of fruit trees. We can take the example from sloka from Mahabharat that those who plant fruits for social welfare are blessed in the afterlife (पुष्पिताः फलवन्तश्च तर्पयन्तीह मानवान् । वृक्षदं पुत्रवत् वृक्षास्तारयन्ति परत्र च ॥) (Mahabharat, 2018).

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Nepal has made increasing efforts to formulate and adopt policies appropriate to land management. Vedic wisdom agricultural land management can work as a guidance for policy formulation and implementation as well. This paper simply tries to present the wisdom of agricultural land management and utilization expressed in different vedic literatures.

1.1 Objective of the Study

This paper simply attempts to document the agricultural wisdom expressed in different vedic literatures and its relevancy in the present context of reutilization of abandoned and fallow agricultural land in Nepal.

2. Methodology

This paper is mainly based on review of vedic literatures and current policies and practices of reutilization of abandoned and fallow agricultural land. The information for this study is derived from the review of agricultural land management related vedic literatures supplemented by the experiences of author working in the agricultural sector of Nepal as a follower of vedic civilization.

3. Result and discussion

3.1 Agriculture in Vedic Literatures

Vedic literatures clearly mention that agriculture was considered prestigious among all occupations (कृषेरन्यत्र नो धर्मो न लाभः कृषितोऽन्यतः । न सुखं कृषितोऽन्यत्र यदि धर्मेण कर्षति ॥) (Shastri, 2073 BS) . Different dimensions of agriculture are expressed in vedic literature very strongly. As food is the basic need of human being and for which a developed agricultural system is most essential (अन्नो वै प्राण । वेद) (Juganu, 2013)**.** Vedic seers have also given top priority of food crops production. All creatures (life) come into being from Anna (food), and this food arises with the help of rain. Through yagyas we get rain, thus yagya gives rise to activity or karma (अन्नाद्भवन्ति भूतानि पर्जन्यादन्नसंभवः । यज्ञाद्भवति पर्जन्यो यज्ञः कर्मसमुद्भवः) ॥ (Ramsukhadas, 2078 BS).

The entire agricultural operations were given a spiritual belief respecting the nature (एनामि कृषिस्ततनाम विश्वाः पनाष्मोजो अस्मे समन्वितम्...ऋग्वेद) (Vaidik Sukta Sangraha, 2076 BS). The concept of respecting the nature with due consideration of ecological balance is well relevant even in modern agricultural farming system. In due course of time there is the change dynamics of agricultural practices. A little bit elaborative explanation on agricultural practices are found in Yajurveda showing the advancement in farming system. Atharvaveda also well explains the agricultural occupation as a prestigious occupation (कृष्टराधिरुपजीवनीयो भवति ।। (Vaidik Sukta Sangraha, 2076 BS). While talking with the animal husbandry, domestication, caring and use of cattle (cow, bull), horse, sheep and goat are well mentioned in the vedic literatures (Prapannacharya, 2072 B.S).

Krsihiparashara has discussed the importance of agriculture in elaborative forms. It says that even a learned scholar who is expert in all the four Vedas, who recites Shastras and is intelligent, when is overcome by Alakṣmī, is reduced to dishonour caused by begging for food with folded hands (चतुर्वेदान्तगो विप्रः शास्त्रवादी विचक्षणः । अलक्ष्म्या गृह्यते सोऽपि प्रार्थनालाघवान्वितः ॥) (Shastri, 2073 BS). People even having surplus of gold, silver, jewels and garments have to solicit farmers as earnestly as a devotee would pray (सुवर्णरौप्यमाणिक्यवसनैरपि पूरिताः । तथापि प्रार्थयन्त्येव कृषकान् भक्ततृष्णया ॥) (Shastri, 2073 BS). People in spite of having gold ornaments in their necks, ears and hands have to suffer from hunger in absence of food (कण्ठे कर्णे च हस्ते च सुवर्ण विद्यते यदि । उपवासस्तथाऽपि स्यादन्नाभावेन देहिनाम् ॥ (Shastri, 2073 BS).

Food is life, food is also the strength, food is everything. Basically, food comes from grains and grains cannot be available without agriculture. Therefore, leaving everything else one should endeavour for agricultural practices (अन्नं हि धान्यसंजातं धान्यं कृष्या विना न च । तस्मात् सर्वं परित्यज्य कृषिं यत्नेन कारयेत् ॥ (Shastri, 2073 BS) . Farmers have improved and cultivated diverse varieties of crops and domesticated animals over generations. This has been important for food security and in providing clothing, healthcare and shelter. Vedic seers and Sages with divine insight glorify agricultural activities as the basis of sacrifice and as life giver of living beings (यज्ञनामपि चाधारः प्राणिनां जीवदायकम् । कृषिकर्म प्रशंसन्ति मुनयो दिव्यचक्षुषः।) (Juganu, 2013).

3.2 Vedic Farming System and Agricultural Land Management

Vedic culture has attached great respect to natural elements including earth as a mother. Integrated farming system with due respect of ecology and ecological balance is the major approach of agriculture. Ecology is mainly concerned with the interrelation of living organism with their environment. Bhumishukta of Atharvaveda is one of the important source of ancient wisdom on the relation of human being to his environment and his duty is to conserve it. Some mantras illustrate the importance of Yajnas for rain, agriculture, air, environment, all living creatures and their interrelationship (कृषिश् च मे वृष्टिश् च मे... औद्भिद्यं च मे यज्ञेन कल्पन्ताम् ॥) (Vaidik Sukta Sangraha, 2076 BS). Agriculture, animal husbandry and forestry were the major components of farming system described in the vedic literatures.

The major agricultural practices described in vedic literatures are soil and land management with village settlement, integrated farming system with due consideration of ecology, crop cultivation inclusive of plant protection measures and agricultural technology, irrigation system management, animal husbandry, agroforestry management and meteorological observation in relation to farming system (Kaphle, et.al., 2022)

Methods of farming have also been discussed in vedic literatures. There is some sort of similarity between method of farming mentioned in Atharvaveda and modern method. In sathapatha brahmana, a vedic texts, the whole process of farming has been described in four word- Karsana (preparation of the field), Vapana (Sowing seeds), Lavana (Reaping the harvest) and Mardan (Threshing). Ploughing was regarded as an important process in cultivation. Prayers were offered for the ploughshare to plough the field properly and for tillers to practice properly (शुनं सुफाला वि तुदन्तु भूमिं शुनं कीनाशा अनु यन्तु वाहान् I) (Vaidik Sukta Sangraha, 2076 BS). Cultivation of a wide range of cereals, vegetables, and fruits was common, and animal husbandry was the important means for their livelihoods.

Land management and utilization was done for the the natural inclination of people towards agriculture to please gods and be encouraged with special effort as it sustains life of all living beings (कृषिप्रवृत्तिं सर्वेषां देवानां प्रीतिदायिनीम्। यत्नतो रक्षयेयुस्तां जीवानां जीवनप्रदाम्।।) (Juganu, 2013). Agricultural land utilization trough plantation of fruit crops is based on religious inspiration. We can take the example from sloka from Mahabharat that inspire for plantation to utilize the agricultural land (अतीतानागते चोभे पितृवंशं च भारत । तारयेद्वृक्षरोपी च तस्माद् वृषान्प्ररोपयेत् ॥ तसमात्तडागे वृक्षा वै रोप्याः श्रेयोर्थिना सदा । पुत्रवत्वरिपाल्याच्श्र पुत्रास्ते धर्मतः स्मृताः ॥ (Mahabharat, 2018).

The relationship between vedic culture and ecology is the integral part of ancient Nepalese societies too. Diversified community in Nepal used many local knowledge and skills derived from experienced practices from generation to generation such as maintenance of home garden in their yard having different fruits and medicinal plants, watershed management practices having a belief that they should not cut plants surrounding the source of water, water harvesting and conservation making groundwater recharge pond and grazing land (gaucharan) protection specially for cow. Cultural belief on vedic civilization considers the Nature as 'the body of God'. Different natural resources are associated with different Gods and Goddesses and worshipped giving emphasis on their protection and conservation. Under use and exploitation of land is considered as unjust and immoral. Therefore, Vedic culture can be understood as a holistic model that inspires a reconnection of humans with nature and provides one of the best models for agricultural biodiversity conservation (Kaphle B. , 2022)

Nepal is rich in religious, cultural, ethnic and biological diversity. Even now, in Nepal these components are well integrated in the farming system in Nepal. The farming system of Nepalese agriculture varies according to the agro ecological zones. However, integrated farming system, having agriculture, animal husbandry and agroforestry are the major components, is prevalent even now. From the very beginning of vedic civilization, human societies developed various institutional mechanisms, customs and religious beliefs to conserve, protect and promote their natural resources including land. Integrated farming system with focus on agro-horti-silvicultural and similar types of efforts as described in the vedic texts can contribute for reutilization of abandoned and fallow agricultural land.

3.3 National Plan, Policies and Programs for Proper Utilization and Management of Land in Nepal

Nepal has made increasing efforts for proper utilization and management of land through different policies and programs. Constitution of Nepal focus on scientific land reforms with due respect to the interests of the farmers and enhance product and productivity by discouraging inactive land ownership. It also focus on land management and commercialization, industrialization, diversification and modernization of agriculture, by pursuing land-use policies to enhance agriculture product and productivity, while protecting and promoting the rights and interests of the farmers.

Likewise, government has formulated and implemented national land policy 2015 addressing land access issues and the recognition of informal tenure. It also seeks to improve the regulation, management, use, and governance of land resources.

Furthermore, government prepared and implemented the land use act 2019 which serves to drive economic development, control the fragmentation of agricultural land, and regulate the land market by effectively classifying the country's land resources for use and management. This act classifies the existing land into nine categories viz. agricultural (given special importance by this law), residential, commercial, industrial, mining-mineral, forest, river-lake-wetland, public use and cultural-archeological.

For overall agricultural sector development government has implemented Agriculture Development Strategy (ADS) since 2015. ADS reported that the 12-year conflict that concluded in 2006 had adverse effects on the agriculture sector. Hundreds of thousands of rural households left the land behind and moved to the cities-mostly to the Kathmandu Valley; others moved abroad and this trend turns the cultivated land into barren. Basically, fresh vegetables, fruit and tea has been focused as subsector horticulture in ADS (Kaphle, et.al., 2021).

In line with ADS, government has formulated and implemented Prime Minister Agriculture Modernization

Project (PMAMP) since 2016/17. It has provisioned large commercial agricultural production and industrialized center development called 'superzone' followed by zones, blocks and pockets at different levels. Many horticultural crops including apples, citrus, vegetables and spice crops have been included as focused commodities in superzone, zone, block and pocket program (Kaphle, et.al., 2021).

The fifteenth five-year plan (2019/20-2023/24) has a provision to increase profitability form agriculture and make it competitive by production, processing, and marketing of industrial crops, fruits, vegetables and flowers will be promoted focusing on specific regions and locations for the establishment and expansion of agro-industries. Meanwhile priority to horticulture and farming of other appropriate crops are planned to be promoted alongside river basins and highways as per the principle of proper utilization of agro-climatic zones in coordination with the local level (Kaphle, et.al., 2021).

3.4 Reutilization of abandoned and fallow agricultural land in the context of federal structure of government

The constitution of Nepal has provisioned for three tires governmental system- federal, provincial and local level with some autonomy to province and local governments. Looking at the annual programs on agricultural development of all three layers of governments, utilization and management of land through integrating farming focusing on commercial livestock production, horticultural crops. Though national policies do not include the direct program and activities for abandoned land utilization, overall principles are supported to scientific and sustainable land use in Nepal, which ultimately favors to expedite the abandoned land utilization processes. Some of the provincial and local level government have made policies and program for the reutilization of abandoned and fallow land providing technical and financial support to the farmer. However, limited studies have been done for its impact on abandoned and fallow land utilization (Paudel.et.al., 2022).

4. Conclusion

Overall study revealed that ancient wisdom on agriculture, expressed in vedic literatures right from the human civilization, is remarkable and praiseworthy for abandoned and fallow agricultural land utilization. Basically, natural resources including agricultural land utilization and management was done with religious, ethical and cultural belief. Study shows that the Current trend and the problem of agricultural land abandonment is increasing because of youth migration from villages to the city centers for the better opportunity. Nepal has formulated and implemented different policies and programs for proper utilization and management of land. The vedic wisdom on proper utilization of land through integrated farming focusing on agro-horti-silvicultural model provides the guideline and is equally relevant in the present context of agricultural land utilization properly. Finally, it can be concluded that further study is needed by scholars and researchers to utilize the valuable treasure of ancient vedic wisdom for agricultural land management and utilization.

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LANDCOVER CLASSIFICATION USING DECISION TREE ALGORITHM*

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ABSTRACT

This research aimed to use a supervised algorithm to classify land use and land cover (LULC) images using the Decision Tree Algorithm in R programming. The study was divided into two parts: the categorization of LULC and accuracy assessment. The study area after classification showed that it consisted of various land use categories, including agriculture (183.903 km2), urban areas (169.45 km2), forest (268.378 km2), water bodies (km2), and river banks (10.15 km2). The results of the study showed that forest was the most prevalent land use category, accounting for 41% of the total study area. The overall accuracy of the classification was 86.25 percent. This study provides valuable information that can be used by planners and decision makers to plan for sustainable development in the environment.

KEY WORDS: *AOI, Confusion Matrix, Decision Tree, Land Classification, Sentinel image, Supervised Classification*

1. INTRODUCTION

For corporate, business, and administrative objectives, information on land use and cover is required. Due to their spatial specificity, the data are especially crucial for environmental preservation and spatial planning. Classifying land uses is crucial because it gives data that can be utilized in modeling, which in turn may be used in numerous decision-making processes for the growth of a community, a society, and a country.

Modern remote sensing techniques was developed in early 1970s. Remote sensing by its definition, it is a technique of surveying in which data is collected about the object without being in touched to it. Several types of thematic data crucial to GIS analysis, such as data on land use and land cover features, are mostly derived via remote sensing. Aerial and Landsat satellite photos are commonly used to assess land cover distribution and update existing geospatial information. The role of remote sensing in Geospatial Information Technologies (GIS) has grown dramatically since the advent of remote sensing systems and image processing software.(Otukei & Blaschke, 2010).

The creation of a classification map of the identifiable or relevant features or classes of land cover types in a scene is a common use of remotely sensed data.(*Supervised Classification*, Purmal et al.,2010). As a result, the main product is a thematic map featuring themes such as land use, water, and vegetation kinds, etc. The process of allocating pixels or the basic units of an image to classes is known as image classification in the domain of remote sensing. By comparing pixels to one another and to those of known identity, it is likely to assemble groupings of identical pixels detected in remotely sensed data into classes that fit the informative categories of user interest. (*Supervised Classification.Pdf*, n.d.). There are two kinds of image classification techniques, they are supervised classification and unsupervised classification. Here, this research has used supervised classification techniques for the analysis purpose.

Different kinds of methods are available for classifying the satellite image and Machine learning is one of them. Machine-learning methods applied to remotely sensed imageries for LULC mapping have received a lot of interest. (Talukdar et al., 2020). Machine learning algorithms is divided into two sub types: supervised and unsupervised techniques. Support vector machine (SVM), random forest (RF), spectral angle mapper (SAM), fuzzy adaptive resonance theory-supervised predictive mapping (Fuzzy ARTMAP), Mahalanobis distance (MD), radial basis function (RBF), decision tree (DT), multilayer perception (MLP), naive Bayes (NB), maximum likelihood classifier (MLC), and fuzzy logic are some of the supervised classification techniques, while unsupervised classification techniques include Affinity Propagation (AP) cluster algorithm, fuzzy c-means algorithms, K-means algorithm, ISODATA (iterative self-organizing) etc. (Talukdar et al., 2020). Among the supervised techniques, decision trees algorithm has widely gained attention over a decade.

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The rising use of remote sensing data and technology has made geospatial processes faster and more powerful, but the added complexity also increases the risk of inaccuracy.(Rwanga & Ndambuki, 2017). Previously, image classification studies did not prioritize accuracy assessment because of the increased potential of inaccuracy that digital photography presents, accuracy evaluation has become a critical process.(Rwanga & Ndambuki, 2017) . In the processing of remote sensing data, accuracy evaluation or validation is an important stage. It determines the user's information value of the resultant data. Geo data can only be used productively if the quality of the data is known. The total accuracy of the classified image is determined by comparing how each of this classified to the definite land cover conditions received from the ground truth data. Producer accuracy is a measure of how well real-world land cover categories can be categorized based on mistakes of omission. The likelihood of a classified pixel matching the land cover type of its corresponding real-world location is represented by the user's accuracy, which assesses errors of commission. (Rwanga & Ndambuki, 2017). The kappa coefficient and error matrix have become standard measures of image classifying accuracy. Furthermore, error matrices have been used in a number of land categorization studies and were an important part of this study.

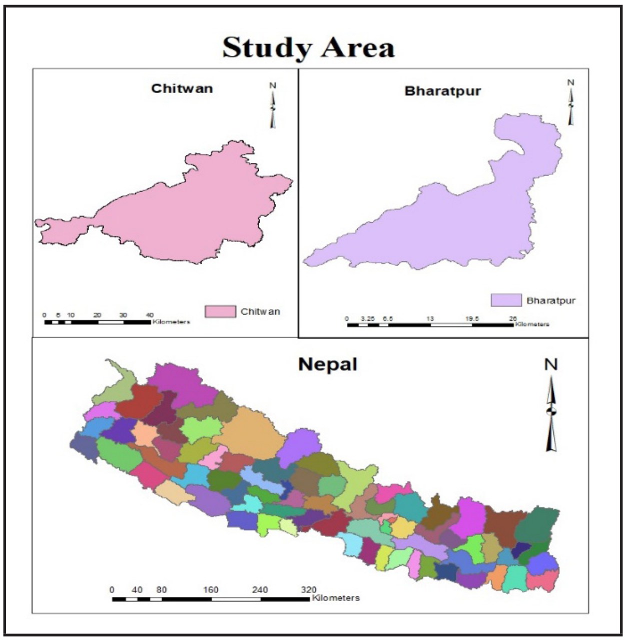

Figure 1. Study Area

1.1. Study area

Study area of this research project is Bharatpur, Chitwan. It lies in the central southern belt of Nepal. It lies above 208 from sea level with total area of 433 km^2. Local level, district level and national level database is used for the preparation of the map. Study area is shown in figure 1

2. Materials and Methods

This paper is divided into two parts: a classification of land use and land cover, and an accuracy evaluation of the results. Figure 2 illustrates how these two processes are carried out and the required results are attained. The flowchart here illustrates the research technique.

2.1. Land use /Land cover Classification

Land classification process was performed using the sentinel 2.0 image which was taken by the satellite on October 21, 2021. Purpose of this report is to perform only image classification, so image of single date were used to perform the analysis. Sentinel image includes total 12 image file in the downloaded folder.

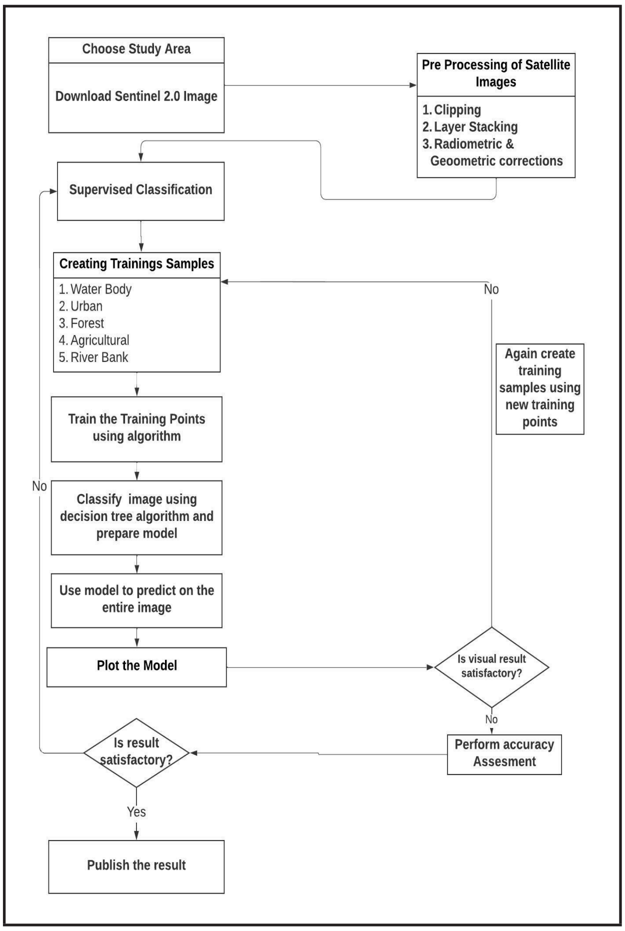

Figure 2 Schematic of work flow for LULC and accuracy assessment.

2.1.1. Image Preprocessing

The dates of the Landsat satellite photos were influenced by the image clarity, particularly for images with little or no cloud cover. The satellite image has not undergone any geometric rectification. Using ArcGIS, the Bharatpur shape file was used to trim obtained photos of the Chitwan region during the preprocessing phase. Here, each necessary band of the photos was clipped using the data management's clip tool. All necessary pre-processing tasks, including layer staking, viewing the image in true color composite and false color composite procedures, were completed in R Studio after each band of the photographs had been clipped. Figure 4 displays the preprocessing results.

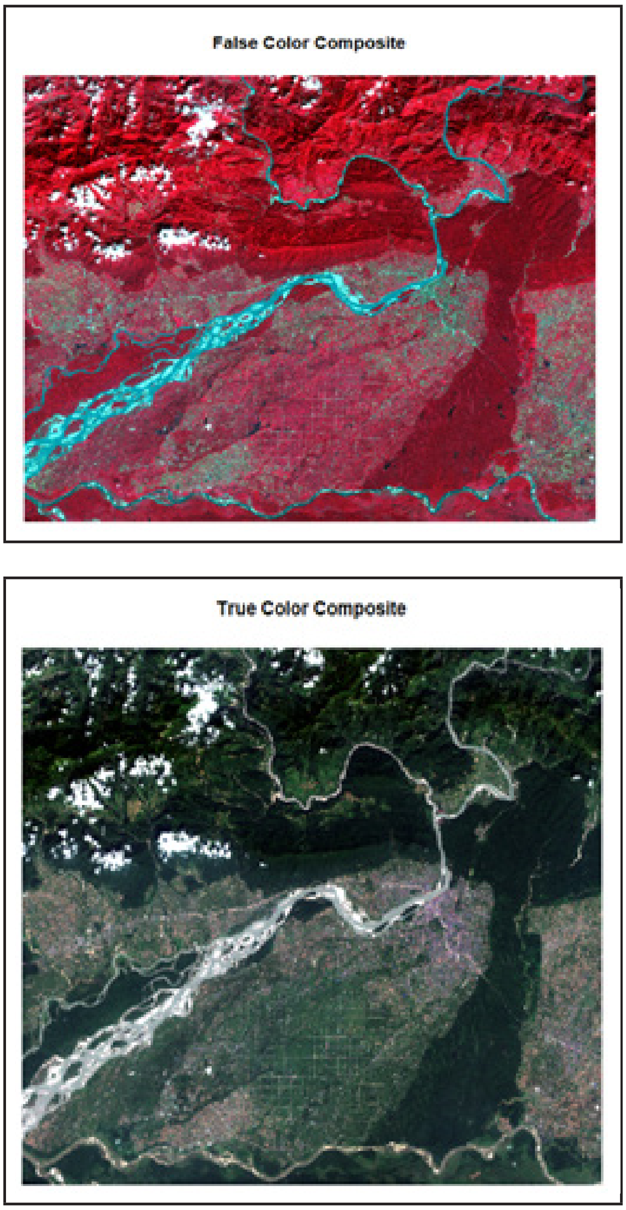

Figure 3 False Color composite and True Color Composite of the Bharatpur area

2.1.2. Supervised classification

2.1.2.1 Defining AOI/ Sample Points

Supervised Classification were performed and the spectral signatures of known categories are developed. Training samples of five different categories were chosen. Five categories were forest, crop land, urban, water, and river bank. During the creation of the sample point's different band combination is used. Since different feature reflects different band value it will be easier to select the training points easily. Band combination of 3, 2, and 1 to visualize the urban area, band combination of 4, 3, and 2 is used to visualize image in false color composite to select the vegetation area easily. Similarly for selecting the water band combination of 4, 3, and 1 is used. Again for visualizing the crop and selecting the training points, band combinations of 11, 8, and 2 is used for creating crop training points. Selection of training points can be seen in the figure 4.

2.1.2.2 Combining the individual sample points

After selecting the training points these training points are combined and made a training classes, these training classes are called Area of Interest (AOI).it is done by using R code. Later this would be used to create a model to perform the supervised classification. Training points were selected by using the R Studio. Here the R program gives us an interface to select the points and polygon of the required feature. These feature are saved and combined to make training samples. Training points are saved in the shape file format so that it can be used later to perform the classification. This procedure can be seen in the figure 4.

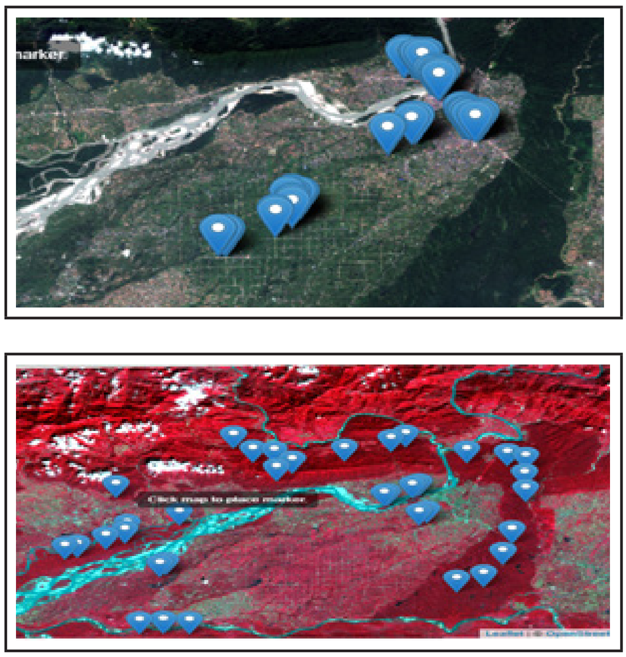

Figure 4 training points selection for urban class and vegetation

2.1.2.3 Classification is performed using Decision Tree algorithm.

Decision Tree is a versatile tool with numerous applications. Both classification and regression problems can be solved with decision trees. The name implies that it use a tree-like flowchart to display the predictions that come from a sequence of feature-based splits. It begins with a root node and finishes with a leaf decision. It falls under the family of supervised learning algorithms. It is not parametric type of algorithm. Non-parametric decision tree (DT) classifiers are those that do not require any a priori statistical assumptions about data distribution. A decision tree's structure is made up of a root node, some non-terminal nodes, and a set of terminal nodes. According to the stated classifier framework, the data is recursively segmented down the DT. A decision tree is a subset of a binary tree and one of the most popular algorithms for constructing a decision tree is ID3 algorithm(Kulkarni & Kulkarni, 2017). The ID3 algorithm works on the principle of building a tree from the root node up. Every property is checked at the root node, and the attribute that best classifies data is chosen. The ID3 algorithm decides which attribute is the best based on information gain.(Kulkarni & Kulkarni, 2017).

Decision tree algorithm is a supervised machine learning technique that can be used for land use classification. It involves creating a model in the form of a tree-like structure, where each internal node represents a decision based on the values of input features and each leaf node represents a class label. The algorithm starts with the entire dataset and recursively splits it into smaller subsets based on the feature that maximizes the separation between different classes. The final tree can be used for predicting the class label of new input samples by traversing the tree from the root to a leaf node. Decision tree algorithm is widely used in land use classification because of its ability to handle non-linear relationships and missing data. (Reference: Talukdar et al., 2020) Classification Tree that is implemented during classification is shown in figure 5

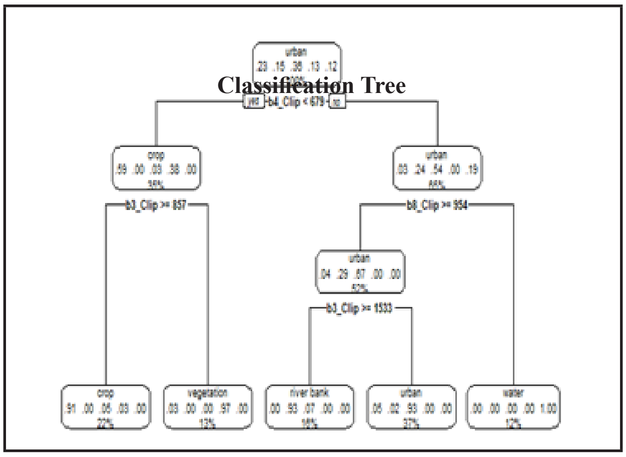

Figure 5 Classification tree of classification process

3. Result of Classification Process

Result of the classification process were classified map of the research area, total land cover by each and every class of the research area in square Kilometers. Figure 7 shows the detail land use and land cover map of the research area.

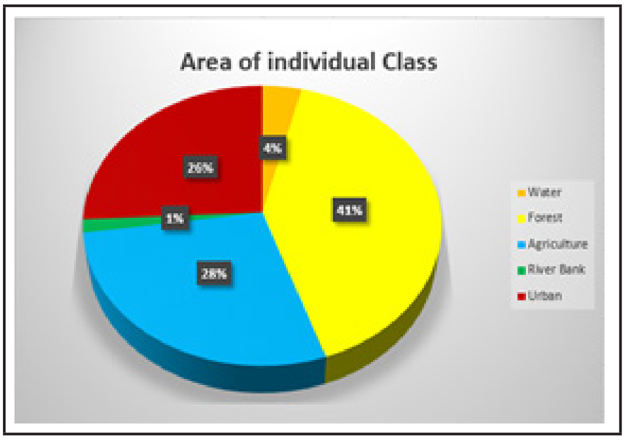

Figure 6 Pie Chart of individual Class Coverage

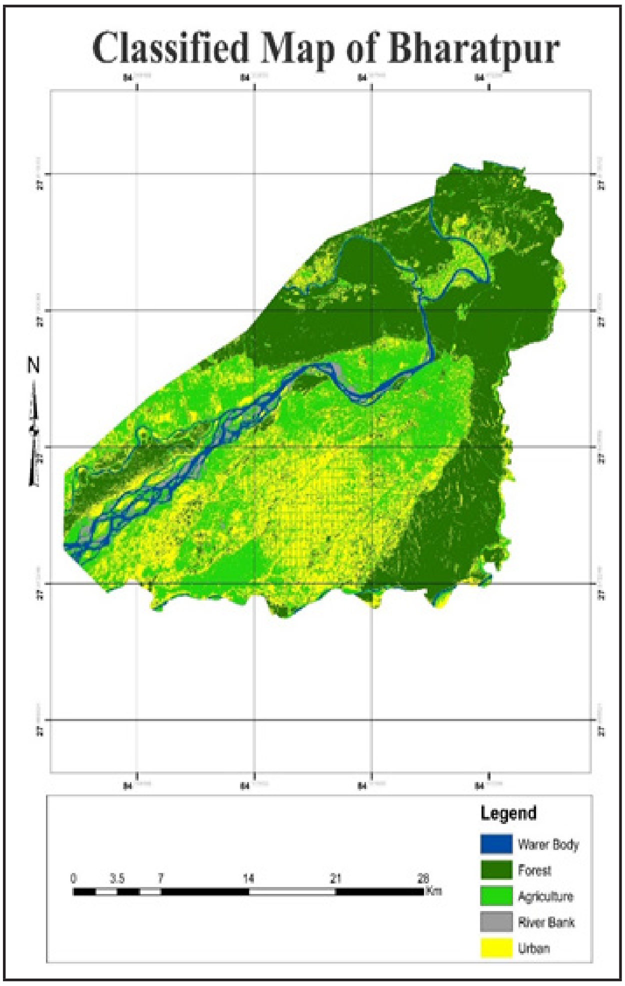

Figure 7 Classified Map of Study Area

Figure 7 shows, classified map with five classes. Spatial resolution of the classified map is 10 m. Each pixel covers 10 m by 10 m on the ground. Total number of each class can be accessed from the map in GIS. So total number of pixel multiplied by the area of each pixel gives the total area covered by each class and this is shown in the table1.

s.n.	Class Name	Number of Pixels	Area of each Pixels in each pixles	Total area of each Class in square meters	Area in square kilometers
1	Water	257220	100	25722000	25.722
2	Forest	2683771	100	268377100	268.3771
3	Agriculture	1839031	100	183903100	183.9031
4	River Bank	101505	100	10150500	10.1505
5	Urban	1694544	100	169454400	169.4544

Table 1 total area covered by each class

From table 1 it is seen that maximum area of Bharatpur municipality is covered by urban area, since urbanization is being increasing day by day, urban area is being grown. Similarly Bharatpur area of Chitwan is widely used for agricultural purpose. Classified map shows that crop land is also dominant in the Bharatpur. Total area covered by each classes in percentage can be seen in the figure 6.

4. Accuracy Assessment

Accuracy assessment is an important step in land classification using satellite images. It is used to evaluate the accuracy of the land classification results by comparing them to ground truth data. This is typically done by randomly selecting a set of sample pixels from the classified image and comparing them to the corresponding pixels in the ground truth data. The accuracy is then calculated as the percentage of correctly classified pixels. Model obtained after the classification process were used to perform the accuracy assessment. The accuracy assessment is a crucial final stage in the categorization process. The goal of accuracy evaluation is to determine how well pixels were sampled into the appropriate land cover groups. Furthermore, locations that could be readily detected on both the sentinel high resolution image and Google earth were prioritized for accuracy evaluation pixel selection.

Confusion matrix was used to validate the model. Total 80 points were randomly taken from the classified map, these points from the classified maps were given unique number according to their class. For river 1, forest 2, urban 3, River bank 4 and crop 5. By the help of these points confusion matrix was created with the ground truth points those were selected form google earth and accuracy assessment was performed. Table 3 shows the relationship between ground truth data and the corresponding classified data obtain through error matrix report.

s.n.	class name	class id	number of points
1	River	1	16
2	Forest	2	11
3	Urban	3	15
4	River Bank	4	22
5	Crop	5	16

Table 2 number of points for accuracy assessment

Confusion matrix is a very popular measure used while solving classification problems. It can be applied to binary classification as well as for multiclass classification problems. In this research accuracy assessment is performed using confusion matrix. A confusion matrix is a tool commonly used in accuracy assessment to evaluate the performance of a land classification model. It is a table that compares the predicted class labels from the model to the true class labels from the ground truth data. Each row of the matrix represents the instances in a predicted class, while each column represents the instances in an actual class (or vice versa). The entries in the matrix represent the number of observations known to be in a particular class and predicted to be in a particular class. The confusion matrix can be used to compute various metrics that provide information about the performance of the classification model, such as accuracy, precision, recall, and F1-score. These metrics can help to identify areas where the model is performing well or poorly and inform decisions about how to improve the model.

User Accuracy and Producer Accuracy were computed, and these values are used to compute Overall accuracy

Accuracy Assessment using confusion matrix

	River	Forest	Urban	River Bank	Crop	Total(User)
River	12	0	0	4	0	16
Forest	0	11	0	0	0	11
Urban	0	0	14	0	1	15
River Bank	1	1	2	18	0	22
Agriculture	0	2	0	0	14	16
Total(Producer)	13	14	16	22	15	80
Total Accuracy	86.25					

Table 3 accuracy assessment using confusion matrix.

$$\text{Overall Accuracy} = \frac{\text{Total number of correctly classified pixels (diagonal pixels)}}{\text{Total numbers of Reference Pixels}} \quad (1)$$

Table 3 shows a theoretical confusion matrix (error matrix) of a LULC classification. The columns of the confusion matrix show to which classes the pixels is in the validation set belong (ground truth) and the rows show to which classes the image pixels have been assigned to in the image. The diagonal show the pixels that are classified correctly. Pixels that are not assigned to the proper class do not occur in the diagonal and give an indication of the confusion between the different land-cover classes in the class assignment. From Table 3 total accuracy was found to be 86.25 percent.

5. Conclusion

An image classification technique can be used to create Land Use/Land Cover maps, which depend on remote sensing data. Production of LULC maps at any scale, enhancement and use of classification methods, including supervised and unsupervised methods using knowledge base processes, and incorporation of auxiliary data into classification methods, including digital elevation model (DEM), road, soil, land use, and census data, have all seen notable advancements in a short amount of time. As data science has advanced, a variety of platforms and algorithms can be utilized to execute the picture classification process. This study explores the usage of the Decision Tree algorithm for image classification in the R programming language. A decision tree is a tree-based classification used in data mining that separates the incoming data set into specified categories. The decision tree method is used to train the visual interpretation system and carry out supervised machine learning. These libraries were utilized to carry out the image analysis technique in this research. R programming offers a vast number of libraries to execute the image analysis procedure. Additionally, categorizing sentinel photos to obtain accurate and trustworthy LULC data is still a challenge that depends on a variety of factors, including the imageries selected, the complexity of the terrain, image processing methods, and the classification process itself. Geospatial processes have become faster and more potent as a result of the increased use of remote sensing data and technology, but the complexity that comes with it also raises the possibility of error. This study's objective was to classify and map the land use-land cover (LULC) in the study area using remote sensing and GIS techniques, as well as to assess classification accuracy. The R programming language was used to do supervised classification using the Decision Tree algorithm. Agriculture (183.903 km2), Urban Area (169.45 km2), Forest (268.378 km2), Water Bodies (km2), and Riverbank were the five categories used to categorize the image (10.15 km2). With 41% of the entire research area covered by forests, this type of land use was shown to be dominating. Before being utilized as input for any applications, a classed image must also be evaluated for correctness. The accuracy assessment utilizing confusion matrix was carried out using ground truth points from Google Earth and sample points selected from the model. Overall classification accuracy for the study was 86.25%. The categorized map is deemed suitable for further study as a result.

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IDENTIFICATION OF LAND MARKET IMPACT FACTORS IN THE CONTEXT OF THE INTRODUCTION OF THE LAND USE REGULATION IN NEPAL: STAKEHOLDERS' PERSPECTIVE*

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ABSTRACT

A land market is a complex system of processes where several actors, such as landowners and buyers, land developers, land administration authorities and financial institutions interact at different levels to achieve a market outcome. These actors or participants may have different perspectives on the impact of land policy intervention on the land market that cannot be ignored while assessing the impact. This study focused on exploring the land market impact factors in the pursuit of the holistic impact assessment due to the introduction of land use regulation in Nepal through the stakeholders' perspectives. Qualitative data related to the impact of land use regulation on the Nepalese land market was collected through interviews and then analysed in the QDA Miner software. The study identified fourteen land market impact factors across four dimensions, namely Transaction cost, Valuation, Mortgage availability, Taxation, and Compensation across the economic dimension; Lot size, Subdivision restrictions, and Coordination across the institutional dimension; Awareness, Expectation and Proximity across the social dimension; and Risk reduction, Quality of residential land, Suitability of zoning classification across the environmental dimension. Perspective-based impact factors were found to be in commonality with those pointed out by literature and therefore suggest their applicability in the holistic assessment of land market across multiple dimensions. However, further research is warranted to apply these factors to realise the degree and direction of the impact of land use regulation on the land market in Nepal. The identified impact factors can be considered applicable in assessing the land market in similar other jurisdictions.

KEY WORDS: *Land use regulation; land market; stakeholders, qualitative data analysis, impact factors.*

1. Introduction

A large body of literature was found to have addressed various factors in the context of studying the impact on land markets as a result of land policy interventions (Dowall, 1992; Ihlanfeldt, 2007; Williamson et al., 2010; Needham et al., 2011; Lees, 2018). Subedi (2021, P. 38) presents various land market impact factors across economic, social, environmental, and institutional dimensions based on desktop review study. A land market outcome is a function of socio-cultural settings, institutional arrangements, and the participants across the jurisdiction (Dale et al., 2006). Therefore, the impact of land use regulation on a land market cannot be easily generalised for the simple reason that each land market can have unique characteristics. It is dynamic, relative, and contextual. It varies across cases and jurisdictions.

In India, the introduction of restrictive land use regulation to control land fragmentation resulted in increased transaction costs (Awasthi, 2009). In the UK, the broad economic impact of planning policies increased housing costs and taxes, leading to an undersupply of developed land (Cheshire and Hilber, 2011; Cheshire, 2018). In Brazil, land use regulation reduced the supply of residential land, which increased housing rents (Lima and Silveira Neto, 2019). In Nepal, land use regulation restricted the fragmentation of agricultural land through an enforced agricultural classification throughout the country (Government of Nepal, 2017). The restrictions resulted in litigation by the stakeholders against the government's decision (Himalayan News Service, 2017; Rimal, 2018).

A land market outcome, perceived as positive for a particular group of stakeholders, can be negative for others. Therefore, the view of land market stakeholders cannot be ignored while assessing the impact of land use regulation on the land market. This study aims to identify the land market impact factors based on the stakeholders' perspectives in the Nepalese land market. The study acts as a gateway to subsequent research towards the quantification of the impact of the introduction of land use regulation on the Nepalese land market. The

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identified impact factors are expected to be suitable for their applicability in assessing the land market in similar other jurisdictions.

2. An Overview of Land Use-Land Market Situation in Nepal

The Land Market in Nepal, in general, fits in the three pillar land market Model of Dale and Baldwin (2000) which comprises land registry services, financial services, land valuation services as well as participants as major components to constitute a land market. In Nepal, there are more than 25 million land parcels recorded in the District Land Revenue Office throughout the country (Nepal and Marasini, 2018) that acts as the market goods. The Land Revenue Office also plays the role of a coordinating body to perform land valuation as mandated by the Land Revenue Act (Ghimire et al., 2015). The District Land Revenue and Survey Office provides the land records to their customers such as landowners, notaries, financial institutions, land developers and real estates. Financial institutions offer credit services to the landowners holding their land properties as collateral (His Majesty's Government of Nepal, 1978; Nepal Rastra Bank, 2011). These participants mutually interact with each other which leads to the transfer of land rights through the land transaction process (Tuladhar, 2004; Acharya, 2008). The legal foundation of the Nepalese land market is mainly the Land Revenue Act (His Majesty's Government of Nepal, 1978), the Land Act (His Majesty's Government of Nepal, 1964) and the Land Survey and Measurement Act (His Majesty's Government of Nepal, 1963).

The government of Nepal has committed significant funding to build the infrastructure for land use planning, including the development of land use plans, public awareness-raising, compensation, and data dissemination. Since the establishment of National Land Use Project in 2001, the Government of Nepal has spent around $20 million (USD) in preparing land zoning mapping and developing land use policy in the country to support sustainable development (Ministry of Land Reform and Management, 2015). The objective of this investment was to implement land use planning to make the best use of national resources for the socio-economic benefit of the people and ensure the environmental sustainability of the country (Government of Nepal, 2015).

The formal land classification system in Nepal commenced in 1964 when the government classified land into four classes based on the productivity of dominant food crops (primarily rice) in the country. The limited agriculture-based land classification proved inadequate in addressing land management issues such as land fragmentation and the haphazard use of land fuelled by as a result of rapid population growth and internal migration from the rural to the urban areas (KC et al., 2017; Upreti et al., 2017). Foreign employment has enabled Nepalese citizens to invest in land particularly for the residential purpose (Paudel et al., 2013; Nepal Rastra Bank, 2016). Although urban and peri-urban land markets were growing as indicated by the increasing rate of fragmentation, the uncontrolled land use system in the country increased concerns in agricultural production and food insecurity (Government of Nepal, 2012); urban congestion, growing pollution, and the lack of open space and green areas in the urban sector posing a threat to the environment (Government of Nepal, 2007, 2012). To address these problems, the Government of Nepal introduced the Land Use Policy 2015 (Government of Nepal, 2015). The policy defined a new land classification with 11 different zones including agricultural; residential; commercial; industrial; mining; forest; riverine land and wetland; public use; cultural and archaeological; and other areas designated by the government (Government of Nepal, 2015).

The policy specifies various land use implementation strategies such as standards for the right of way of roads and rivers, delineation of hazard areas, subdivision control, and land pooling. However, due to the delay in enacting the land use law, land fragmentation continued in Nepal (Upreti et al., 2017) which required the government to issue a ministerial decree to restrict the subdivision of agricultural land throughout the entire country (Government of Nepal, 2017). This created a widespread dissatisfaction among real estate agents and private land developers, resulting in court cases against the government's decision. However, the High Court upheld the government's decision and directed the continuation of the restriction until the enactment of the Land Use Act (Rimal, 2018). The introduction of the Land Use Act 2019 (Government of Nepal, 2019) has closely followed by land market stakeholders including academics and researchers (Paudel et al., 2013; Upreti et al., 2017) and there is need to better understand what the stakeholders perceive of the impact of the land use regulation on the Nepalese land market.

3. Research Methods

3.1. Study Area Selection

The Kathmandu Valley of Nepal was selected as the study area as it is a representative case for this study (Figure 1). The Kathmandu Valley comprises the Kathmandu, Bhaktapur and Lalitpur districts and covers 19 local administrative units. The population of the Kathmandu

Valley is approximately 3.0 million (CBS, 2021). There are nine land revenue and cadastral survey offices providing land transaction services within it. There are approximately 1.5 million landowners registered within the Kathmandu Valley (Ministry of Land Reform and Management, 2012). It contains 23% of the total number of financial institutions in the country (Nepal Rastra Bank, 2019) and around one-third of the country's economic activity occurs within the valley (Nepal Rastra Bank, 2012). Key government institutions such as ministries and departments, land professional organisations, and private land development agencies are located within the Kathmandu Valley. The Kathmandu Valley Development Authority (KVDA) is responsible for implementing land use-related activities, such as road and river zoning and urban planning within the valley area. Given the recent introduction of subdivision restrictions and lot size control, the valley also serves as a suitable study area for exploring land use restrictions where demand for residential land is anticipated to be very high. For these reasons, the Kathmandu Valley was selected as the representative sample for identifying the impact of land use regulation on Nepal's urban land market.

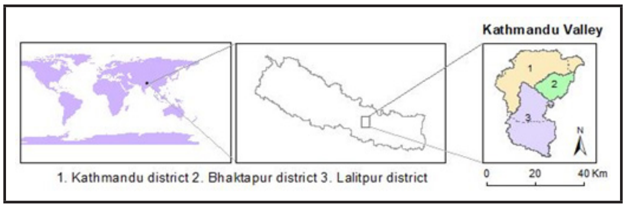

Figure 1: Study area

3.2. Data Collection

We adopted semi-structured interview methods to collect the qualitative data for this study. Ethical clearance was acquired from the University of Southern Queensland prior to the field mobilisation. The field data collection was carried out from June to August 2018. Data collection began with identifying the stakeholder organisations and research participants who would provide data for this research.

3.3. Stakeholders Identification

In this study, a stakeholder was defined as a person, a group of individuals or an organisation which can participate in the land market processes. According to the literature, landowners, cadastral and land registration organisations, real estate agencies, land developers, banks and financial institutions, and land professionals are key participants in a land market (Dale et al., 2006).

The inclusion of stakeholders from both expert and non-expert groups broadens the participation space in a research study (Stirling, 2008). Campbell et al. (2020) discuss the non-probability purposive stratified sampling where specific kinds or groups of participants need to be included in the sample. Stakeholders can be identified by opening up their pre-existing networks (Leventon et al., 2016). The identification of stakeholders was initiated through a pre-meeting with officials from the Survey Department of Nepal, the key organisation for land use mapping and national mapping agency in the country. The objective of the pre-meeting with survey department was only to identify stakeholders' organisations related to one of the identified groups in Kathmandu Valley . Stakeholders were classified into three groups according to their role in the land market:

(i) **The private and professional group**: real estate agencies, private land and housing developers, local land experts, and surveying and engineering consultancies. Important agencies in this group were the Credit Information Bureau, Real Estate Agents Association Nepal, Nepal Land and Housing Developers' Association, Nepal Notary Public Council.

(ii) **The institutional group**: government agencies, including the ministry and departments that look after land registration and surveying activities, and land use mapping and implementation. Important agencies in this group were the Ministry of Land Management, Cooperatives and Poverty Alleviation, Survey Department, and the Department of Land Management and Archive.

(iii) **The financial group**: included banks and financial institutions. Nepal Rastra Bank (the Federal Reserve Bank of Nepal) and Micro-Credit Enterprise (Cooperatives) were crucial organisations in this group.

The roles and positions of the participants were considered before including them in the data collection process. A minimum criterion was set to qualify participants for data collection. In the institutional group, the minimum criterion for the participants was that they must be at least a gazetted officer. A gazetted officer is the minimum qualification to be the officer-in-charge at the district level land revenue and survey offices in Nepal. A gazetted officer is responsible for locally implementing government-approved plans. For the financial group, a participant was required to be at least either a loans officer or a branch manager of the bank. The loans officer can provide information about the changes in the loan-flow in the bank following the introduction of land use regulation. The manager is responsible for the overall management of the financial institution. For the private land professional group, a participant must be a member of the executive committee or a manager of a land professional organisation.

A total of 60 interview participants were selected through purposive sampling across institutional, private and financial organisations, with 20 respondents per group following the methods. The semi-structured interview included questions focused on exploring participants' perspectives on the impact of land use regulation on the land market across economic, social, environmental and institutional dimensions, to reveal land market impact factors relevant in the Nepalese context. The interviewees provided a good cross-section and representation across land market stakeholders in Nepal. The interview respondents' profile has been attached in the Appendix 1.

The interview sought to explore the perspectives of stakeholders regarding the impact across the economic, social, environmental and institutional dimensions on the land market resulting from the introduction of land use regulation in Nepal. A total of 14 questions were asked to identify the impact factors and issues associated with land use regulation that have affected the land market.

The interview initially contained an open question asking stakeholders about the broader impact of land use regulation across economic they had experienced. Questions regarding the possible changes related to taxation, transaction cost, mortgage availability, and payment of compensation for the loss caused due to the land use regulation were then sequentially asked. Interviewees were then asked if they experienced any changes across social dimension such as conflict resolution, peaceful land transaction. We also sought responses whether the introduction of the land use regulation support to meet social expectation as well as have addressed resettlement of people living in hazardous areas. Questions were also asked aiming to explore the impact factors and associated impact issues across the environmental dimension, particularly how the land use regulation caused changes the environmental situation across the Kathmandu valley. We also asked questions aiming to investigate the existing implementation arrangements and how those arrangements might have impacted the land market through institutional perspectives. Finally, questions were also asked to summarise the participant's view of the overall impact of land use regulation on the land market.

3.4. Data Analysis

The transcribed interview data was coded based on the themes that emerged in relation to the impact on the land market across a particular dimension. A link analysis of these codes was performed in QDA Miner software to produce codes clusters. The clusters of the codes that had a closer relationship in terms of themes were manually put together and visualised assigning different colours. A frequency analysis of the codes was performed, and the size of each node in each cluster was set in proportion to the frequency of the coded responses. The results of the QDA Miner analysis are detailed below across the economic, social, environmental and institutional dimensions.

Qualitative data analysis involves processes of data reduction, classification, and interpretation (Lillis, 1999). Miles and Huberman (1994, p. 10) suggest an applicable systematic analytical protocol comprising three sequential activities: data reduction, data display, and conclusion-drawing and verification.

Data reduction is the process of selecting, analysing, simplifying, abstracting and transforming relevant data from a set of collected raw data (Miles and Huberman, 1994).

We used a deductive approach in the overall analysis of the interview data in this research. Recorded interviews were first transcribed into text format and saved as individual files, then reviewed and checked for any transcription errors. Data codes were established based on their thematic alignment to an identified dimension namely: economic, social, environmental or institutional. Data coding was then performed in the QDA Miner; each transcribed document was scrutinised for the data themes and then coded. Coding helped to consolidate the data and categorise it into different thematic classes. QDA Miner allowed the identification of recurring codes in the transcribed data set and performed link analysis on the coded data to generate its clusters. The 'Analyse tool' available in the QDA Miner allows a range of data analysis option such as coding frequency analysis, co-occurrence analysis etc, visualisation of frequency distribution and clusters.

The recurrences of codes in any given cluster were examined through frequency analysis. The software assists in defining an initial set of codes and locating recurring words and phrases associated with these codes. Computer-based analysis is limited to the statistical distribution of codes including the calculating of the measure of centrality or the standard deviation etc. but, cannot itself categorise, or derive the concept that can be revealed from within the data. Yin (2009, P. 128) emphasises the need of the further interpretation of the computer-derived output to derive the themes.

Identifying themes originating from a set of data is an iterative process that involves frequency analysis and transformation of clustered qualitative data into a theme in a broader context (Boyatzis, 1998).

Recurrences of codes and their clusters were further scrutinised to identify what they indicate in a broader context. This stage required data interpretation in three stages that ultimately resulted in defining a representative theme (key message) associated with each cluster.

4. Results

4.1 Identification of Impact Factors Across Each Dimension

4.1.1 Economic Dimension

The analysis performed in the QDA Miner software showed interrelated clusters of responses across the economic dimension (Appendix 2). These clusters were found to be related to changes in the land price or value, transaction cost, taxation, mortgage availability and compensation against the loss caused by the implementation of land use regulation, which have been centrally visualised each cluster.

Respondents indicated that there were changes in land prices or values after the introduction of land use restrictions, particularly as a result of land reclassification and subdivision control. Most of the responses (68%) indicated that prices of residential land had increased and 23% indicated a reduction in the price of agricultural land in the Kathmandu Valley due to the reduced supply of land caused by land use restrictions. The enforcement of the land use classification changed the ability to use the land for its previous purpose and therefore affected the land value. The reduction in supply increased demand; in turn, the value of the land increased due to speculation in the land market. The increase in the price of residential land in the Kathmandu Valley also resulted in higher demand in the rental housing market.

The subdivision restrictions did not allow landowners to sell their developed land, considering that the land was originally classified as agricultural land. The financial strength of landowners who were developing the land as part of a business was impacted in that they could not make loan repayments to their financial institutions and were consequently blacklisted. For banks, the number of non-performing loans or defaults increased, and so financial institutions identified that there was a higher risk in providing loans for real estate development. Therefore, the land market experienced a reduction in the mortgage availability due to these increased risks.

Affected landowners also could not receive compensation for the financial loss incurred by their inability to sell their land following the land reclassification. Landowners expected support such as subsidies for agricultural production, but this was not available. There was no compensation provided for private land acquired by the Kathmandu Valley Development Authority (KVDA) for road expansion. Only a few landowners received compensation for the collapse of their buildings due to road construction, and this payment took a considerable amount of time. The lack of compensation impacted the finances of landowners, who had expected some form of compensation for the impacts of the implementation of land use regulation.

Some landowners also incurred penalties for not using their land, which was an additional financial burden on them. The government experienced a reduction in the revenue collected from land transactions despite increases in the transfer tax and capital gains tax.

The implementation of land use regulation also resulted in changes to the cost of land transactions, with additional time spent on field verification to confirm road boundaries and land use categories. Following the introduction of land use regulation, landowners were reluctant to confirm their land use category and were required to pay for land information. Respondents indicated that the land use regulation caused them to spend more in the transaction process as they were often required to pay a higher fee than earlier. Banks and financial institutions also experienced longer transaction times for their applications to be processed in the Land Revenue Offices. Overall, most of the responses indicated changes in transaction costs due to land use regulation.

The coded text in each identified cluster was then interpreted to group them into impact issues indicative of the impact of land use regulation. These impact issues were then further analysed to identify the key message in the context of the overall objective of research. Table 1 summaries the third stage data reduction process from initial coded information to the key messages.

Table 1: Interpretation of codes and data reduction across economic dimension

Codes in clusters (first stage reduction of raw data)	Impact issues derived from codes (Second stage reduction)	Key message from the interview (Third stage reduction)
• Transaction cost changed • Time for transaction increased • Cost required for the verification of land use information • Cost of motivation required • Mortgage approval time increased • Cost of transaction did not change	• Transaction fees changed, • Time taken for transaction changed	Changes in the **transaction cost** occurred
• No compensation against the loss due to land use regulations • No compensation against the loss due to categorisation • No compensation against the loss by subdivision restrictions • No compensation against the land given for the road • Compensation partially provided for the house or wall demolished • Financial strength of landowners affected • Time taken for compensation distribution long • No Subsidies / No motivation • Subsidies provided • Compensation is not necessary	• Compensation paid for loss due to subdivision restriction was not sufficient • Compensation for loss due to road expansion was not sufficient • There was a delay in the payment of compensation • The subsidy was not sufficient.	There was inadequate **compensation** to landowners for loss due to land use regulation
• Land revenue decreased • Transfer tax increased • Annual land tax increased • Tax rate did not change • Capital gain tax increased • Penalties for 'no-use' enforced	• Change in the land tax • Penalties against misuse or no use of land.	Changes in **taxation** occurred
• Residential land price increased • Agricultural land price decreased • Demand of residential land increased • Supply of residential land decreased • Value affected by the usability of land • Changes in land price occurred • Hope value increased • Speculation increased • Rental market for housing increased • Financial strength of landowners affected	• Changes in the price of residential land occurred • Changes in the price of agricultural land occurred. • demand of land increased, and supply of land decreased implied that changes in price occurred • Rise in price speculation occurred	Changes in the land price or **valuation** occurred differently across new land classifications
• Loan recovery risk increased • Strength of financial institutions decreased • Willingness to provide the real estate loan decreased • Land collateral decreased • Instalment payment delayed • Willingness to pay the real estate loan decreased • Financial strength of landowners decreased • Landowners blacklisted • Mortgage availability reduced • No effect on mortgage availability	• Accessibility to loan using the land property as collateral • Number of landowners who received the loan from financial institutions decreased • Number of blacklisted landowners/ Capability of landowners to repay the loan decreased. • Changes in the financial strength of the financial institutions/Non-performing loan increased	**Mortgage availability** reduced by land use regulation

4.1.2 Social Dimension

The interview responses suggested that the implementation of land use regulation caused a range of social impacts on stakeholders. The link analysis indicated three significant clusters of responses across the social dimension: awareness of land use regulation, particularly subdivision restriction and land classification; failure to meet social expectations; distance to the workplace (Appendix 3).

Respondents indicated that there was limited communication with and participation by stakeholders in the policy formulation and implementation process. Landowners were unaware of the subdivision restriction and were confused about the new land classification system which was different to what was specified in the land use policy.

Because of this lack of awareness, landowners continued to engage in the usual land market practices such as making advanced payments for residential land despite the new subdivision restrictions. When the land transaction could not occur, arguments would ensue between clients and the staff of the Land Revenue and Survey Offices. The buyer would request the return of the deposit from the landowners and brokers. If the money was not returned, conflicts between the landowners, brokers and buyers then led to court cases.

Another social factor causing dissatisfaction to stakeholders was that the new restrictions did not allow land subdivision. To overcome this restriction, some landowners initiated a family split, which allowed the subdivision approval through court proceedings. This meant that court cases related to subdivisions associated with divorces increased and the steps taken by these landowners were indicative of the level of dysfunctional behaviour within families caused by the new regulations.

Similarly, the implementation of road widening resulted in the forced eviction of landowners, which increased their stress levels, impacted their financial situation and stripped them of dignity when their land was acquired by force, or they were blacklisted by their bank or financial institution.

A small number of respondents identified social issues with a resettlement scheme implemented by the government to shift landowners and their families away from areas prone to landslides or flooding. The identified resettlement areas were often a significant distance from residents' existing dwellings, which affected the distance and time taken to travel to their farmland or workplace. Some respondents also indicated that landowners felt at risk of losing their property if they were resettled at a distant location; they were therefore reluctant to be resettled despite the risk of landslides or floods. The overall impact was that the resettlement program caused social dissatisfaction of landowners based on these proximity issues. Table 2 summarises the three-stage data reduction process from initial coded information to the identification of key messages.

Table 2: Interpretation of codes and data reduction across social dimension

Codes in clusters (first stage reduction of raw data)	Impact issues derived from codes (Second stage reduction)	Key message from the interview (Third stage reduction)
• Stakeholders were confused about the restrictive provisions • Conflict between sellers and buyers increased • Poor public participation in the land use decision making • Protest against subdivision restrictions • Argument and dispute between the client and staff occurred • Caused social dissatisfaction/Satisfaction • No conflicts due to land use regulation • Awareness of subdivision restrictions and land categorisation lacking	• Conflict between sellers and buyers due to lack of awareness of land use regulation • Dispute between clients and staff over the failure of parcel subdivision	Low level of **awareness** of the land use regulation created conflict between the stakeholders
• Court orders required for subdivision approval • The dignity of landowners lowered • Acquiring subdivision approval is a social burdening • Court cases increased • Inheritance-based subdivision increased • Family disintegration encouraged • Distressful situation created • Informal settlement promoted • Mental stress to the landowners increased • Poverty promoted • Landowners were evicted from their dwellings • Social expectation not met	• Ease of the subdivision approval process decreased due to the requirement of court orders and inheritance-based fragmentation • Number of court orders increased for acquiring subdivision approval	**Social expectation** not met as revealed by increased court cases for subdivision approval
• Distance to the workplace increased • Travel time to the workplace increased • Livelihoods challenged • Resettlement not accepted due to cultural differences Landowners advised of resettlement dissatisfied • Property security challenged • Landowners reluctant to resettle • Changes in the land market participant occurred	• Satisfaction of landowners due to distance to the workplace/Dwellings. • Satisfaction of landowners due to travel time to the workplace. • Changes in number of landowners/ buyers in the existing local land market	Landowners were dissatisfied with the allocation of resettlement or lack of **proximity.**

4.1.3 Environmental Dimension

Three clusters of recurrent responses were identified across the environmental dimension related to risk reduction, quality of residential land in planned areas, and haphazard or unplanned land use (Appendix 4). The quality of residential land differed significantly between planned and unplanned areas, with planned subdivisions having improved amenity, including wider urban roads and a utility service network, maintained green space, additional open space, reduced pollution and lower fire risk. The increase in the environmental value also increased the market value due to a higher demand for these quality residential areas. However, the supply of such quality residential properties is not sufficient, despite their positive contribution to the environment.

Due to land regulation, land available for residential use decreased and residential land supplied by the land pooling projects was not sufficient to meet the demand.

This demand resulted in an increase in unplanned or haphazard use of agricultural land for housing purposes in the Kathmandu Valley. The motivation behind the subdivision restriction was to maintain open space; however, this was challenged by the number of housing construction approvals granted by municipalities to cope with housing shortages. Table 3 summarises the three-stage data reduction process from initial coded information to the identification of key messages.

Table 3: Interpretation of codes and data reduction across Environmental dimension

Codes in clusters (reduction of raw data)	Impact issues derived from codes	Key message from the interview (theme derived)
• Insufficient planned area • Road space increased in planned areas • Open space added in planned areas • Open space contributed by the subdivision restriction • Quality of residential land use enhanced in planned areas • Pollution controlled • Fire risk decreased • Environmental safety better in planned land areas • Environmental value of land in the planned area increased • Land value increased in planned areas	• Change in the supply of residential land with added enhanced road and utility infrastructure • Change in the supply of quality residential land with added open land pooling areas. • Change in the land value of quality residential plots compared to surrounding unplanned areas	Changes in the **quality of residential land** affected the land market by changing the value and supply of quality land.
• Land for non-agricultural purposes is not sufficient • Availability of residential land decreased • Housing construction in the agricultural areas increased • Haphazard use of land increased • Greenery lacking • Mixed land use-not allowed • Fire risk increased • Open space enhancement by inadequate zoning challenged • Air pollution increased due to delayed road construction	• Sufficiency of land allocated for non-agricultural purposes. • Changes in the haphazard housing construction in agricultural land in Kathmandu Valley	Inadequate classification or **Suitability of Zoning Classification** did not address the land requirement and promoted haphazard use
• Environmental safety and better land in planned areas after the flood control • Flood controlled • Hazard-risk considered • Risk-reduced land added to the land market • Land value affected by the risk considerations • Landslide hazard addressed • Earthquake hazard addressed	• Changes in the flood-risk area in the Kathmandu Valley • Changes in the supply of road hazard-safe plots in the Kathmandu Valley	**Risk reduction** changed supply and value in the land market

4.1.4 Institutional Dimension

Respondents raised concerns in their responses across the institutional dimension about the property rights associated with the land (Appendix 5). Most of the responses focused on three factors associated with the impact of land use regulation on the land market in Nepal: subdivision restriction, lot size control, and the absence of coordination mechanisms.

Regarding lot size control, it was found that availability of qualifying lots in the urban land market was limited. The lot size standard restricted the subdivision of land smaller than a specified area, thereby reducing supply. The purchase of larger land parcels was not affordable for most of buyers. The lot size control was seen as an impingement on land rights by both potential buyers and existing landowners, who were deprived of the opportunity of selling their properties. Lot size control triggered informal transactions in the land market which created further risks to property rights.

The reduction in the availability of land increased land cost and therefore reduced access to the land for the poor. Landowners who intended to buy a small piece of land adjoining their lot to increase their total land area or improve access also could not buy extra land.

According to the respondents, a robust coordination mechanism was lacking for the effective implementation of land use regulation. At the time this research was conducted, there was no organisation established for the effective implementation and monitoring of land use planning in Nepal. Some respondents mentioned that communication and sharing of land use information between the implementation agencies was lacking. This lack of coordination resulted in conflicting and overlapping land use plans devised by various organisations. The lack of coordination and communication also impacted on planning decisions and standards and had resulted in an increase of unplanned land development within and around the Kathmandu Valley. Table 4 summarises the impact issues explored across the institutional dimension.

Table 4: Interpretation of codes and data reduction across Institutional dimension

Codes in clusters (first stage reduction of raw data)	Impact issues derived from codes (Second stage reduction)	Key message from the interview (Third stage reduction)
• Private plots were acquired for roads for the public purpose • Organisation set up for implementation and monitoring does not exist • Coordination mechanism lacking • Communication and sharing of land use information lacking • Property rights affected due to poor coordination • Unplanned development occurred due to zoning uncertainty	• Change in the quantity (or number) of private lots affected by the road expansion • Number of court cases registered against the KVDA to secure property rights caused by poor coordination • Change in the Zoning Certainty	• Poor **coordination** mechanism affected property rights
• Transaction volume changed • Ease of the use of land affected due to subdivision restriction • Informal transaction promoted • Availability of agricultural land increased • Property rights affected due to subdivision restrictions • Rights to access to the property weakened	• Decrease in the number of land parcels subdivided • Changes in the accessibility to the adjoining parcel to use for road purposes. • Increase in the number of informal transactions	• **Subdivision restriction**s affected the availability of land and accessibility to land rights
• Lot size control enforced in the new urban development area • Availability of land reduced due to lot size control • Accessibility to land reduced due to lot size control • Informal transaction occurred due to lot size control • Property rights affected due to lot size control	• Changes in the number of availabilities of available qualifying the transaction • Changes in the number of land transactions involving parcels bigger than the enforced threshold size • Changes in the accessibility to land rights	• **Lot size** affected the availability of land and access to land rights

5. Conclusions

This study confirmed that the introduction of land use regulation in Nepal have had an impact on the Nepalese land market across economic, social, environmental and institutional dimension as perceived by the land market stakeholders. This agrees with the existing findings that a land market cannot entirely assessed only by viewing through the single theoretical lens. A holistic assessment entails its examination across multiple dimensions. The study identified fourteen land market impact factors associated with the introduction of land use regulation in Nepal, namely Transaction cost, Valuation, Mortgage availability, Taxation, and Compensation across the economic dimension; Lot size, Subdivision restrictions, and Coordination across the institutional dimension; Awareness, Expectation and Proximity across the social dimension; and Risk reduction, Quality of residential land, Suitability of zoning classification across the environmental dimension. Perspective-based impact factors were found to be in commonality with those pointed out by literature and therefore suggest their applicability in the holistic assessment of land market across multiple dimensions. Multiplicity of these impact factors further strengthened the theoretical concept that a land market cannot be completely assessed if it is viewed through the lens of economic theory and therefore needs multiple theoretical lens for a holistic land market assessment. However, the diversity of impact factors having different characteristic across multiple dimensions challenges to measure the impact in quantitative terms. Further research is warranted to design methods of impact measurement which incorporate the identified impact factors to identify the depth and direction of impact of land use policy intervention on the Nepalese land market.

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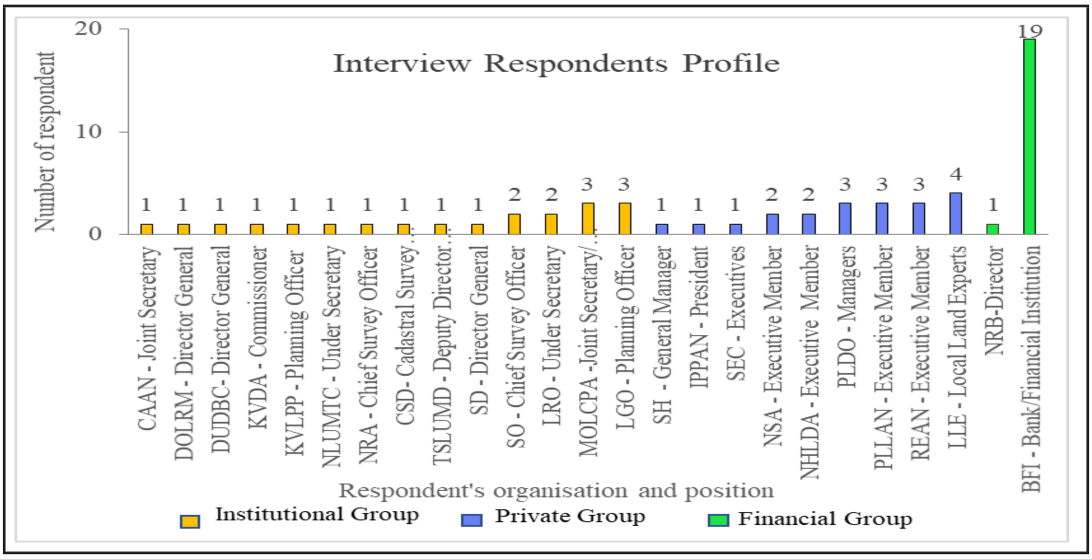
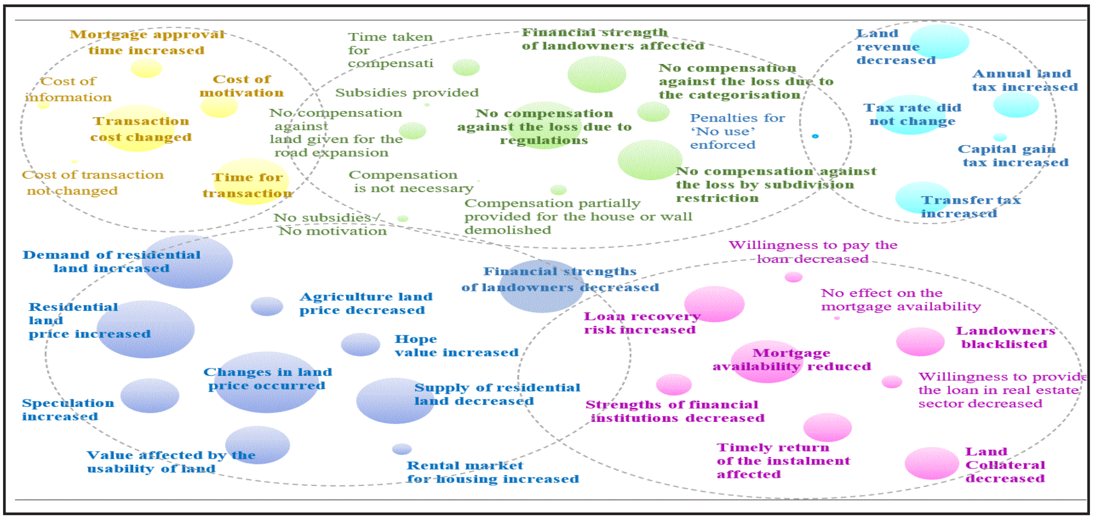
Appendix 1: Interview Respondents Profile



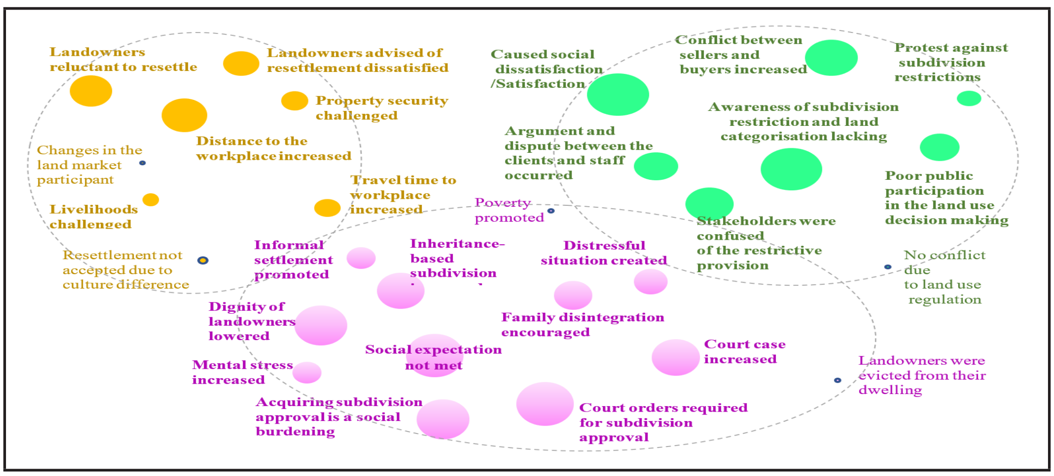
Interview respondents by group, organisation, and their role

Appendix 2: Segregated clusters of responses across the economic dimension



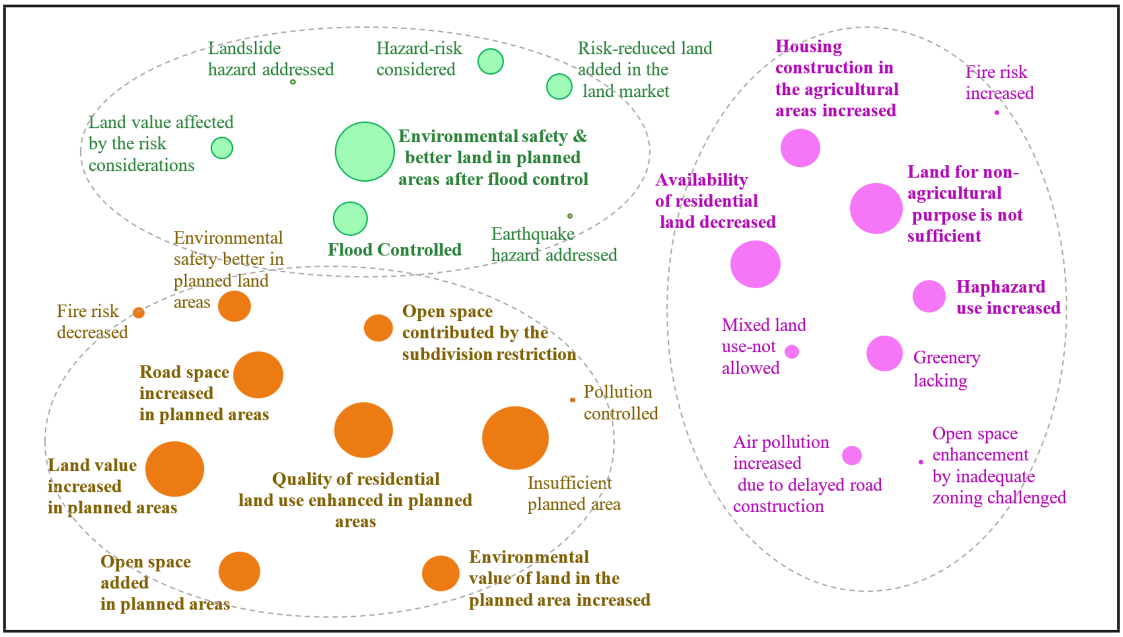
Segregated clusters of responses across the economic dimension

Appendix 3: Segregated clusters of responses across the social dimension



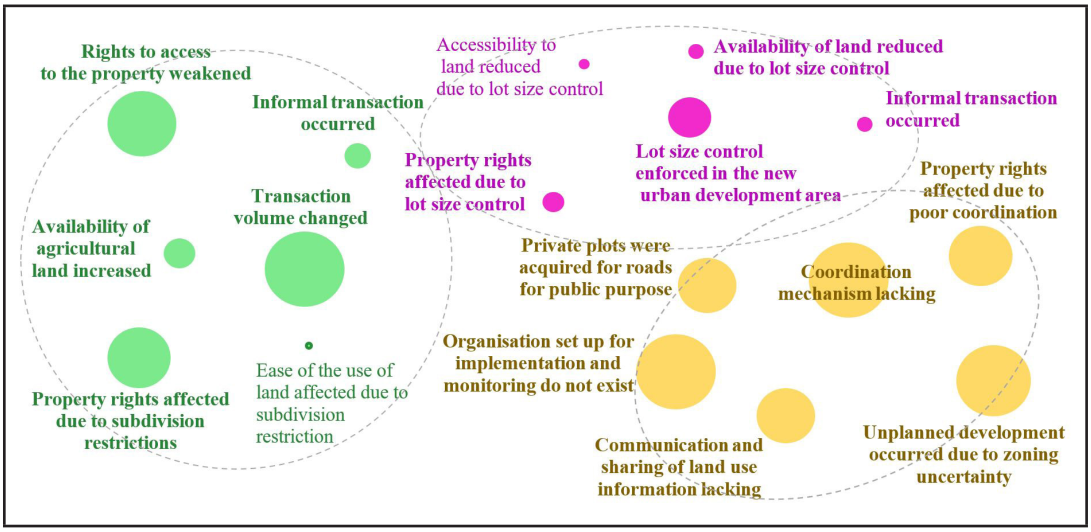
Segregated cluster of responses regarding the outcome across the social dimension

Appendix 4: Segregated clusters of responses across the environmental dimension



Segregated cluster of responses as to the outcome across the environmental dimension

Appendix 5: Segregated clusters of responses across the institutional dimension



Segregated cluster of responses regarding outcomes across the institutional dimension

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

Author Name[1], Author Name[2]

[1]Author Affiliation & Email Address

[2]Author Affiliation & Email Address

ABSTRACT

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

KEY WORDS: *Manuscripts, Journals, LMTC, Guidelines for Authors, StyleGuide*

1. MANUSCRIPT

1.1 General Instructions

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

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

1.2 Page Layout, Spacing and Margins

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

1.3 Length and Font

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

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

Table 1. Margin settings for A4 size paper

2. TITLE AND ABSTRACT BLOCK

2.1 Title

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

2.2 **Key Words**

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

2.3 Abstract

Leave two blank lines under the key words. Type "**ABSTRACT:**" flush left in bold Capitals followed by one blank line. Start now with a concise Abstract (100 - 250 words) which presents briefly the content and very importantly, the news and results of the paper in words understandable also to non-specialists.

3. MAIN BODY OF TEXT

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

3.1 Headings

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

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

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

Use decimal numbering for headings and subheadings

3.2 Footnotes

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

3.3 Illustrations and Tables

3.3.1 Placement: Figures must be placed in the appropriate location in the document, as close as practicable to the reference of the figure in the text. While figures and tables are usually aligned horizontally on the page, large figures and tables sometimes need to be turned on their sides. If you must turn a figure or table sideways, please be sure that the top is always on the left-hand side of the page.

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

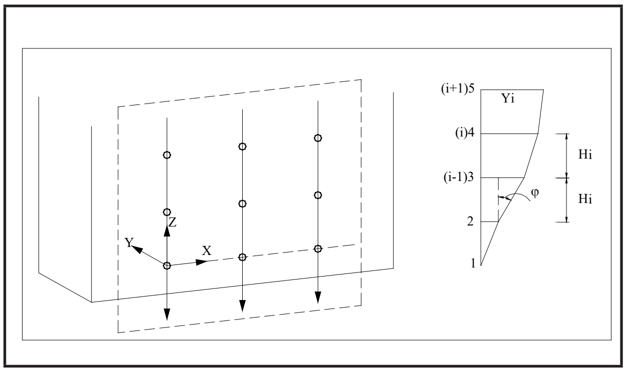


Figure 1. Figure placement and numbering

3.4. Equations, Symbols and Units

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

$$x = x_0 - c\frac{X - X_0}{Z - Z_0}\ ;\ y = y_0 - c\frac{Y - Y_0}{Z - Z_0} \qquad (1)$$

where c = focal length

x, y = image coordinates

X_0, Y_0, Z_0 = coordinates of projection center

X, Y, Z = object coordinates

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

3.5 References

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

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

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

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

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

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

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

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

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

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

Acknowledgements (optional)

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

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Appendix (optional)

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

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

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SUMMARY REPORT ON INTERNATIONAL WORKSHOP ON LAND USE PLANNING AND LAND ADMINISTRATION: INTEGRATION AND DECENTRALIZATION*

Ganesh Prasad Bhatta[1], Rheecha Sharma[1], Sharad Chandra Mainali[1]

[1] Land Management Training Center, Dhulikhel, Kavre

Introduction

The Land Management Training Center (LMTC) successfully organized the "International Workshop on Land Use Planning and Land Administration: Integration and Decentralization" from February 16-17, 2023, at its campus in Dhulikhel, Kavrepalanchowk, under the patronship of the Ministry of Land Management, Cooperatives, and Poverty Alleviation (MoLMCPA). Preceding the workshop, a significant side event titled "Masterclass on Land Management Integration and Decentralization" took place on February 15, 2023. This event marked a major milestone for the center, as it was included and approved in the fiscal year 2079/80 (2022/2023 AD) programs scheduled to be conducted.

The workshop was organized in collaboration with several government organizations, including the National Disaster Risk Reduction Management Authority (NDRRMA), Ministry of Agriculture and Livestock Development (MoALD), Survey Department (DoS), and Department of Land Management and Archive (DoLMA). Additionally, esteemed organizations such as Nepal Institution of Chartered Surveyors (NICS), Nepal Remote Sensing and Photogrammetric Society (NRSPS), World Bank (WB), Korean Green Growth Trust Fund (KGGTF), Kadaster International (KI), Faculty ITC of the University of Twente (ITC), School of Land Administration Studies (SLAS), Global Land Tool Network (GLTN), and Department of Geomatics Engineering, Kathmandu University (DoGE, KU), also contributed as strategic and academic partners. The Community Self Reliance Center (CSRC), a prominent civil society organization dedicated to empowering communities in matters of land rights, played a pivotal role as another essential partner in this event.

The principal sponsor of the event was Trimble Inc., while GeoSLAM Ltd. acted as the co-sponsor. Financial support was also provided by DoS, NICS, NRSPS, and CSRC, whereas WB-KGGTF and GLTN sponsored the travel expenses of the invited experts. KI-ITC-SLAS took the responsibility of sponsoring the resource persons for the mentioned side event.

The LMTC meticulously designed this event to encompass a wide range of topics, making it an ideal global networking platform that brought together distinguished professors, academicians, researchers, professionals, and students from around the world. The highlight of the program was the presentations on real-life practices of land use planning in various scenarios.

Land Use is recognized as an interdisciplinary topic of utmost importance in land management worldwide. To ensure comprehensive coverage, the organizers focused on key themes for presentations, including Spatial Planning Tools, Integrated Land Use Planning, Agricultural Land Use Planning, Forest Land Use Planning, Land Use Planning for Water Bodies, Infrastructure Development and Land Use, International Practices on Land Use Development, Education and Outreach on Land Use Development, and Disaster Risk Management and Land Use Planning.

The workshop was an invitation-only event, yet it attracted approximately 170 participants, featuring about 20 plenary presentations and 8 technical presentations under the major themes. The attendees hailed from diverse countries, including The Netherlands, Australia, Mongolia, India, Indonesia, Ghana, South Korea, and Nepal, adding to the event's international significance. Notably, a special session on land use planning in Nepal was graced by the presence of high-level delegates from various national and international institutions.

Objective

The main objective of this event is to establish a robust platform for sharing research findings, international best practices, and professional experiences in the field of land use planning among the diverse attendees. By doing so,

* The digital version of the proceedings of the event can be downloaded from the website of Land Management Training Center (www.lmtc.gov.np)

we aim to gather a wealth of international knowledge and experiences in land use planning, which will pave the way for its successful implementation within Nepal, aligning with the Government's current efforts to introduce land use planning countrywide.

Additionally, a secondary objective was to promote and foster collaborative relationships between national and international institutions, academics, and professionals. Through meaningful knowledge sharing and technology transfer, these partnerships seek to yield mutual benefits and further advancements in the domain of land use planning.

Inaugural Ceremony

The event began with the inaugural ceremony, presided over by the Executive Director, Mr. Ganesh Prasad Bhatta. The event was inaugurated by the Chief Guest, Hon' Rajendra Kumar Rai, Minister of the Ministry of Land Management, Cooperatives, and Poverty Alleviation. The ceremony commenced with the lighting of the lamp, accompanied by the auspicious *Swasti Baachan* performed by *batuks*. Delivering warm greetings and welcome remarks to all the dignitaries and distinguished international and national participants, Mr. Punya Prasad Oli, the President of NICS, set the tone for the event.

In an encouraging video message, Dr. Diane Dumashie, the President of FIG, applauded the organizers for arranging such an engaging event focused on enhancing the capacity to address global land use planning and administration issues concerning integration and decentralization. The workshop garnered further support and well-wishes through speeches by various distinguished individuals, including Ms. Lada Strelkova from the World Bank and Mr. Ashok Byanju, the Mayor of Dhulikhel Municipality.

The keynote message on the theme "The Land-use Planning and its Economic Implications" was delivered by Prof. Dr. Achyut Wagle, the Registrar of Kathmandu University. His insightful speech covered various aspects, including the current status of land management, historical perspectives, land resources, relevant laws and institutions, and the economic significance of effective land-use planning.

The opening remarks were delivered by Dr. Gobinda Prasad Sharma, Secretary of the Ministry of Agriculture and Livestock Development, and Dr. Damodar Regmi, Secretary of the Ministry of Land Management, Cooperatives, and Poverty Alleviation. The session also featured speeches from Prof. Dr. Bhola Thapa, the Vice-Chancellor of Kathmandu University, and the Chief Guest, Hon. Minister Mr. Rajendra Kumar Rai, who graced the event with their presence and encouragement.

Plenary Sessions

Following the inaugural ceremony, the event seamlessly transitioned into four engaging plenary sessions. Plenary Sessions I and II were held on Day I, while Sessions III and IV were scheduled for Day II. Each session on Day I featured four presentations, with an additional nine presentations showcased on Day II. These plenary sessions served as platforms to present and discuss international practices in the fields of land use planning and Land Administration. The table 1 and 2 below provide an overview of the presentation titles, along with the session chairs and rapporteurs. The plenary sessions received an enthusiastic response from the audience, and active participation was encouraged through interactive question-and-answer rounds held at the end of each session.

Nepal Session

In addition to the Plenary Sessions I and II held on Day I, a special Nepal session was also conducted. This session had a distinct focus on showcasing how the Government of Nepal is actively implementing land use planning across various thematic areas, including agriculture, urban development, forest management, water resources, and physical infrastructure development. The session featured five presentations delivered by esteemed Government officials with expertise in their respective fields.

The Nepal session garnered significant interest, especially from the international participants, who were keen to learn about the practical approaches and initiatives taken by Nepal in land use planning. The audience's response was highly positive, and they actively engaged in the session, making it a lively and interactive experience. A question-answer round at the end of the session further encouraged enthusiastic participation, providing a platform for fruitful discussions and knowledge exchange.

Table 1: Overview of the Plenary sessions on Day I and the Nepal Session

S.N.	Sessions	Title	Presenter
1	**Plenary Session I** **Session Chair:** Dr. Rohan Bennett **Rapporteur:** Er. Sharad Chandra Mainali	1. Understanding Disaster and Climate Risk: Nepal's Experience on Collective Action and Localization for Risk Assessment & Decision Making	**Mr. Anil Pokharel**, Chief Executive of National Disaster Risk Reduction and Management Authority, Government of Nepal.
		2. An Introduction to National Territorial Plans, Capital Region Policy and Urban Disaster Prevention in Korea	**Dr. Wonseop Lee**, emeritus research fellow at Korea Research Institute for Human Settlements (KRIHS)
		3. Gujarat's System of Land Use Management for Cities and Towns	An Architect and Urban Planner **Ms. Shirley Ballaney**
		4. The Current and Planned Spatial Planning System in Indonesia	**Mr. Mirwansyah Prawiranegara** Head of Sub Directorate of National Strategic Area Spatial Planning,
2	**Plenary Session II** **Session Chair**: Dr. Dimo Todorovski **Rapporteur:** Er. Binod Humagain	1. Land Use Planning in Australia and Nepal – Challenges and Opportunities	**Dr. Kevin McDougall**, Professor, University of Southern Queensland,
			Dr. Jagannath Aryal, Associate Professor, University of Melbourne, Australia
		2. Framework for Land Use Planning Directives, Nepal	**Dr. Mahendra Subba**, Regional and Urban Planner and Former Joint Secretary at the Ministry of Urban Development
		3. Food Green City: An Approach of Promoting Urban Agriculture Integrating with Urban Land use Planning of Nepal	**Dr. Sunil Babu Shrestha**, the former Vice-Chancellor of Nepal Academy of Science and Technology (NAST)
3	**Nepal Session** **Session Chair:** Dr. Purna Bahadur Nepali **Rapporteur:** Er. Sudarshan Gautam	1. Land Management & Land Use Planning in Nepal-Dealing with Land Issues for National Prosperity: An Urban Planning	**Ar. Yek Raj Adhikari**, Project director/ Joint Secretary, New Town Project Coordination, DUDBC under the Ministry of Urban Development
		2. Agriculture Land Use Planning in Nepal- Issues, Practices and Prospects	**Ms. Sabnam Shiwakoti**, Joint secretary, Ministry of Agriculture and Livestock Development, Government of Nepal.
		3. Forest Land Use in the context of development projects in Nepal: Issues and Challenges	**Mr. Babukaji Dallakoti,** Under Secretary, Ministry of Forest and Environment
		4. Land Resource Mapping and Assessment of Nepal for the Irrigation Purpose	**Dr. Yogendra Mishra**, Senior Divisional Engineer, Ministry of Energy Water Resource and Irrigation
		5. Perspective Issue of Land Acquisition for the Development of Highways and Railways in Nepal	**Mr. Guru Prasad Adhikari**, Section chief in Railway Management Section, Ministry of Physical Infrastructure and Transport

Table 2: Overview of the Plenary Sessions on Day II

S.N.	Sessions	Title	Presenter
1	**Plenary Session III**	1. Land use planning: The tenure-responsive concept and practice in country level interventions	Prof Dr. Eugene Chigbu
	Session Chair: Dr. Reshma Shrestha	2. Planning and Development Underdeveloped Areas, the case of Ulaanbaatar, Mongolia	Mr. Chinzorig Batbileg, founder and consultant at the Nomad Systems LLC
	Rapporteur: Er. Shivajee K.C	3. Evolution of Land Use Planning and Urban Development in Korea	Dr. Jungik Kim, Urban Specialist, Korea Land & Housing Corporation (LH)
2	**Plenary Session IV**	1. FIG Commission 7 Agenda 2023-26	Dr. Rohan Bennett, chair of FIG Commission 7 on Cadastre and Land Management 2023-2026
		2. Professional Education current and future prospects that could support integration and decentralization	Dr. Dimo Todorovski,Chair of FIG Commission 2 – Professional education (2023-2026).
	Session Chair: Mr. Madhu Sudan Adhikari	3. An Example Subdivision of a Cadastral Parcel in Brisbane, Queensland, Australia	Mr. SudarshanKarki
		4. Identification of Land Market Impact Factors in the Context of the Introduction of the Land Use Regulation in Nepal: Stakeholders' Perspective	Dr. Nab Raj Subedi
	Rapporteur: Nabaraj Subedi	5. Land Evaluation Approach for Formulation of Land Use Plan	Mr. Bikash Kumar Karn, Chief Survey Officer, Survey Department
		6. Land Use Planning and Well Being: Looking from the Place Making for Healthy Cities	Dr Reshma Shrestha, Associate Professor and HOD, Geomatics Engineering, Kathmandu University.

Special Session on Land Use Planning for Nepal

Day II commenced with the informative Plenary Session III, followed by a significant Special Session on Land Use Planning for Nepal, which featured three insightful presentations. The main focus of this session was to demonstrate the recent advancements and practical implementation of land use zoning and planning activities within the country.

In light of the enactment of the Land Use Regulations in 2022, local governments are now entrusted with the responsibility of carrying out land use zoning, with technical support from the Survey Department. This session, led by the Survey Department, included a presentation by representatives from Kankai Municipality, shedding light on their experiences in local land use planning.

The session generated considerable interest among the audience, with particular attention given to the concerns raised by both attendees and government officials regarding the identification of challenges in implementing effective land use zoning and planning at the local level. The session proved to be highly informative and lived up to the expectations of the participants.

For further details regarding the session, please refer to Table 3.

Table 3: Overview of the Special Session

S.N.	Sessions	Title	Presenter
1	**Special session on Land Use planning for Nepal** **Session Chair:** Mr. Janak Rak Joshi, **Rapporteur** Mr. Lekhnath Dahal,	1. Land Use Implementation: Technical Aspect	**Susheel Dangol,** Deputy Director General of the Survey Department
		2. Land Use Implementation in Nepal, Present Status and Way Forward	**Ajeet Kunwar**, Chief Survey Officer of the Survey Department
		3. Forest Land Use in the context of development projects in Nepal: Issues and Challenges	**Rajendra Kumar Pokhrel**, Mayor of Kankai Municipality

Technical and Sponsor Session

On Day II, two parallel sessions were conducted alongside the Special Session on Land Use Planning. The first session was the Technical Session, which featured four insightful presentations. Simultaneously, the second session was the Sponsors' Session, exclusively dedicated to the principal sponsor, Trimble Inc., and the co-sponsor, GeoSLAM. In this session, both sponsors had the opportunity to present their contributions, with a total of two presentations.

For detailed information on the presentations and their respective sessions, please refer to Table 4 below:

Table 4: Overview of the Technical and Sponsor Session

S.N.	Sessions	Title	Presenter
1	**Technical session** **Session Chair**: Dr. Subash Ghimire **Rapporteur**: Er.Bhagirath Bhatt	1. Landcover classification using decision tree algorithm	**Mr. Sanjeev Kumar Raut**, Survey Officer, Survey Department
		2. Land Banking Initiative in Nepal for Sustainable Land Management: Unfinished Agenda of Decentralizing Land-use Planning and Land Reform	**Bhupendra Jung Kesari Chand**
		3. Reutilization of Abandoned and Fallow Agricultural Land in Nepal: Lensing through the Vedic Wisdom Perspective	**Mr. Basudev Kafle**, joint secretary, Ministry of Agriculture and Livestock Development
		4. Land Use Planning Initiative in Nepal	**Mr. Punya Prasad Oli,** former joint secretary of Government of Nepal
2	**Sponsor Session** **Session Chair:** Ramesh Gyawali **Rapporteur:** Er. Khem Raj Devkota	1. Land Management with Trimble Geospatial Portfolio	**Mr. Pallav Mathur**, Product Application Manager at Trimble Navigation India Privated Limited
		2. ZEB Family Introduction	**Mr. Dev Jyoti Biswas**

Closing Ceremony

Upon the completion of four plenary sessions, special sessions, sponsors' session, and technical sessions, the workshop culminated with a grand closing ceremony on February 17, 2023. The ceremony was chaired by the Executive Director, Mr. Ganesh Prasad Bhatta, with the esteemed Dr. Damodar Regmi, Secretary of the Ministry of Land Management, Cooperatives, and Poverty Alleviation, serving as the Chief Guest. The event was skillfully hosted by Instructor, Ms. Sushmita Timalsina.

During the closing ceremony, Dr. Rohan Bennet, Chair of the Technical Committee, presented a comprehensive summary of the entire workshop. He applauded the presenters and organizers for their valuable contributions to the event.

Dr. Bennet highlighted the cross-cutting themes that were explored throughout the workshop, including urban-rural migration, property values, infrastructure development, poverty reduction, climate change, and disaster response, which encapsulated the essence of the workshop's focus.

Dr. Bennet shared key insights from each session, commending the thought-provoking discussions in Plenary Sessions I and II. He emphasized the importance of disaster risk management (DRM) and the significance of integrating land use planning tools and techniques to address disaster preparedness and recovery. The Nepal Session shed light on the challenges in integrating and decentralizing land use planning due to urbanization, population growth, and climate change. Plenary Session III impressed him with its focus on inclusivity, vulnerability, sustainable redevelopment, and tenure-responsive land use planning, with special attention to the case of Mongolia. The final session brought forth global and local perspectives on health issues and land use planning, presented by representatives from Australia, FIG, and academia.

The Chief Guest, Secretary Dr. Damodar Regmi delivered his closing remarks, expressing satisfaction with the workshop's successful gathering of professionals from around the world. He acknowledged the knowledge exchange that took place and the valuable insights shared to address the challenges in implementing land use policies and legal arrangements. Dr. Regmi assured the participants that the Ministry would consider the suggestions received from the workshop report and incorporate them into future endeavors, further enhancing their efforts in land use planning.

The Executive Director of the Land Management Training Center and Chairperson of the Organizing Committee also delivered closing remarks, expressing heartfelt gratitude to all distinguished guests, eminent dignitaries, presenters, participants, and the dedicated organizing team. He attributed the resounding success of the workshop to the collective efforts of everyone involved, creating a memorable and impactful event that will continue to contribute to the advancement of land use planning.

Acknowledgement

We would like to begin by expressing our heartfelt gratitude for the unwavering moral support and patronage extended to us in organizing this remarkable event by the esteemed leaders of the patron organization, the Ministry of Land Management, Cooperatives, and Poverty Alleviation. Specifically, we would like to acknowledge the invaluable support from Honorable Minister Rajendra Rai and Respected Secretary Dr. Damodar Regmi.

Additionally, we extend our deepest appreciation to our co-organizers - DoS, NICS, NRSPS, FIG Commissions 7, and 2 - for their exceptional collaboration and support throughout the event's planning and execution. We are also immensely grateful to our strategic partners, WG-KGGTF, for sponsoring the invited speakers and to GLTN for their generous sponsorship of one of our esteemed speakers.

A special word of gratitude goes to Trimble, Inc. for their consistent and unwavering support as the principal sponsor. We are also delighted to welcome GeoSLAM as a co-sponsor for the first time and are grateful for their valued contribution.

The encouragement and active involvement of various ministries and government organizations, including NDRRMA, MoALD, DoLMA, and academic partner DoGE, KU, were instrumental in making this event a resounding success. To their respective leaders, we extend our sincerest thanks.

We are profoundly grateful to CSRC, a dedicated CSO working on land rights in Nepal, for not only participating in the event but also making a financial contribution. Their support has been invaluable.

A very special acknowledgment is due to KI, ITC, and SLAS, with a heartfelt thank you to Dr. Rohan Bennett, Chair of FIG Commission 7, and Dr. Dimo Todorovski, Chair of FIG Commission 2, for organizing the enriching side event titled "Masterclass on Land Management Integration and Decentralization." Dr. Bennett's contributions as the Chair of the Technical Committee and his excellent summarization of the event deserve an additional round of applause.

We are immensely grateful to all our distinguished speakers, including the Keynote Speaker, Prof. Dr. Achyut Wagle, the Registrar of Kathmandu University, as well as the distinguished plenary speakers, technical presenters, Session Chairs, and Rapporteurs. Their insights and expertise made the event truly exceptional.

Finally, we extend our gratitude to everyone involved in making this event a resounding success. The support, engagement, and contributions from each and every individual and organization mentioned above have been invaluable, and we look forward to future collaborations.

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

LAND MANAGEMENT TRAINING CENTER

Dhulikhel, Kavrepalanchok

INTRODUCTION

Land Management Training Center (LMTC), under the Ministry of Land Management, Cooperatives and Poverty Alleviation, Government of Nepal was established in 1968. LMTC is the oldest and the only governmental institution continually and significantly producing human resources and enhancing capacity of the government personnel in the field of Surveying and Mapping, and Land Management since its establishments. The center has already produced more than 9000 land professionals at different levels through various types of training courses.

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

VISION

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

MISSION

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

OBJECTIVES

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

OUR FACULTIES/TRAINERS

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

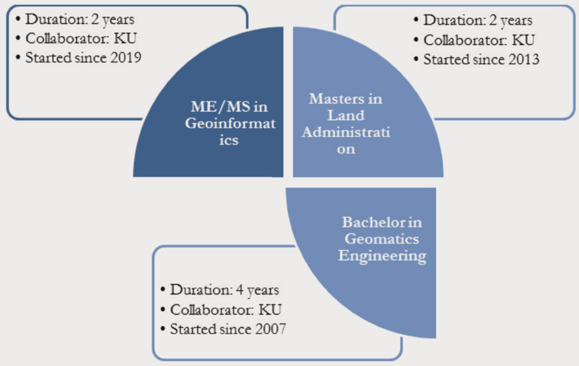
ANNUAL PUBLICATION

JOURNAL OF LAND MANAGEMENT AND GEOMATICS EDUCATION

OFFICIAL WEBSITE

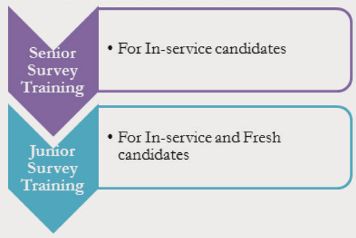
www.lmtc.gov.np

ACADEMIC COURSES (In Collaboration)



TRAINING COURSES

LONG TERM TRAININGS



SHORT TERM TRAININGS

FUTURE PLANS

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

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

LAND MANAGEMENT TRAINING CENTER

ACHIEVEMENT OF FY 2079/80

NOVEL SUCCESSES

Achievements of 2079/80

- International Workshop on Land Use Planning and Land Administration: Integration and Decentralization
- Residential Training of Trainers (TOT) for capacity building of LMTC staff
- Refresher Course for High Level Officials Working in the field of Land Management
- Conducted informal land tenure trainings for Member Secretaries of District Committees under National Land Commission
- Conducted several trainings for Local Level
- Launched Journal of Land Management and Geomatics Education

TRAININGS LAUNCHED THIS FISCAL YEAR

- GIS Training for Local Level – 75
- Training for District Judges – 20
- Instrument Handling & Orientation – 96
- Land Management for Local Level – 108
- Informal Land Tenure Training – 58

ADDITIONAL CAPACITY BUILDING SHORT TRAININGS

- Digital Cadastre (28)
- Orientation Training for New Officers (17)
- Remote Sensing (35)
- Land Administration & Management Gazetted Class III (40)
- Land Administration & Management Non-Gazetted (30)

LONG TERM TRAININGS

- Senior Survey Training Inservice (50)
- Junior Survey Training Fresh (24)
- Junior Survey Training Inservice (46)

INSERVICE TRAINING GRANTING 2 POINTS

- Professional course on Geomatics & Land Administration (Gazetted Class III) – 20
- Digital Cadastre & Office Management Training (Non-Gazetted Class I) – 20
- Digital Cadastre & Office management Training (Non-Gazetted Class II) – 20

SALIENT FEATURES

Extended MOU with Kathmandu University in 2023 and Launched ME/MS in Geoinformatics in-addition to previously running MS in Land Administration and Bachelors in Geomatics Engineering Courses

The figures in the parenthesis are the numbers of trainees

Photo Gallery

Chairing The Plenary Session I

Participant Presenting on Technical Session at International Workshop

Swastibachan At Opening Ceremony of International Workshop

Junior Survey Training Participants Performing Cultural Dance at Social Evening on International Workshop

Participants on International Workshop

Honourable Former Minister Rajendra Kumar Rai and Secretary Dr. Damodar Regmi Observing The Stalls at International Workshop

54th Anniversary of Land Management Training Centre

Journal Release Ceremony - Journal of Land Management & Geomatics Education Volume IV

Participant Performing at First Survey Sahitya Sabha

Blood Donation Program At LMTC on the Occassion of Civil Service Day

Trainees of Junior Survey Training (Inservice) at Nepal China Border(Korala Naka)
During Excursion with Instructors

Trainees of Junior Survey training (Fresh) at Rara Lake During Excursion

Junior Survey Training (Fresh) Batch 2079-80

Participants Of Advanced Remote Sensing Training

Participants of Instrument Handling and Orientation Training

Participants of Land Use Training for Local Levels at Koshi Province

Participants of GIS Training for Local Levels at Lumbini Province

Participants of Advanced GIS Training with Executive Director, Directors and Instructors of LMTC

Dignitaries & Other Participants From Ministry of Land Management, Cooperatives and Poverty Alleviation of Directive Commiittee Meeting

LMTC Staffs and Trainees With Honourable Minister Ranjita Shrestha, Secretary Dr. Damodar Regmi & Executive Director Mr. Ganesh Prashad Bhatta

Opening of Field Camp at Mangaltar, Kabhre

Field Inspection By Executive Director & Under Secretary & Officers from Ministry of Land Management, Cooperatives & Poverty Alleviation

LMTC Sports Week

Ladies Futsal on LMTC Sports Week

Plantation Program Organized at LMTC in Assistance with Lions Club International District 325F

Plantation Program Organized at LMTC in Assistance with Lions Club International District 325 F

LMTC Family
Internationl Workshop 2079