Modern Approaches of Land Parcel Frequent Demarcation of Highly Flooded Prone Zone of Koshi and Kamala River Basin.

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Key words: Demarcation, Frequently flooded areas, Sustainable land practices, Food security, Community resilience, Land use planning

SUMMARY

Land demarcation is a fundamental process for defining and marking land boundaries, ensuring ownership rights, and facilitating effective land management. Frequent Land demarcation approaches is particularly essential for long-term land use planning in the flood-prone zone of Koshi River Basins. The purpose of this study was to look at the difficulties of frequent land demarcation in these areas and to identify potential solutions. The study utilized satellite images, cadastral maps, and field data to identify flood-affected parcels and evaluate the effect of floods on property borders. The study discovered that standard land demarcationn approaches were ineffective in capturing the changes produced by repeated flooding. To overcome these issues, the study proposed a novel method based on coordinate-based mapping and ground control points. The analysis revealed that a significant number of parcels had been affected by frequent flooding. In Ward no. 5ka, 155 out of 528 parcels were affected, covering a total area of 0.19427 square kilometers. In Ward no. 7, 158 out of 460 parcels were affected, covering a total area of 4.16 square kilometers. This study highlights the significance of modernizing land demarcation techniques in flood-prone areas to provide accurate and up-to-date land information. By using coordinate-based mapping and ground control points, it is feasible to enhance land management and mitigate the adverse impacts of floods on communities and livelihoods in the Koshi River Basins.

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1. INTRODUCTION

Land demarcation is the process of defining and marking the boundaries of a piece of land. It is a fundamental activity in land administration and management. There are two main systems of land demarcation: Metes and bounds (MB) and rectangular survey (RS). MB is a decentralized system where land boundaries are defined by natural features like rivers, ridges, and trees (Arruñada, 2018). Parcel shapes and sizes depend on the local topography. While RS is a centralized system that divides land into a uniform grid of square plots. Boundaries are defined by a centrally controlled grid system, often using the Public Land Survey System in the United States (Libecap & Lueck, 2009). In Africa, land demarcation has traditionally used general boundaries based on natural features. However, the Fit-for-Purpose (FFP) approach has gained attention in recent years (Israel, Maurice, & Erumbi, 2022). The impacts of FFP on land administration include increased flexibility, inclusivity, and affordability of land demarcation, improved security of tenure and land rights, reduced land registration timelines and increased use of para-surveyors to demarcate land.

Land demarcation in Nepal involves the establishment of boundaries for both agricultural and state lands, which is crucial for land administration, ownership rights, and resource management. The country has a complex land tenure system influenced by historical, social, and economic factors. Approximately 73% of land in Nepal is state-owned, with only about 29% classified as agricultural land. The distribution of land is uneven, often correlating with socioeconomic status, where historically marginalized groups, including Dalits and indigenous communities, face significant landlessness and poverty. Efforts at land reform since the 1950s, including tenancy reforms and land ceilings, have had limited success due to loopholes and inadequate implementation (Wily, Chapagain, & Sharma, 2008). The Survey Department of Nepal plays a pivotal role in land demarcation, mapping, and boundary management. It is responsible for creating topographical maps and conducting cadastral surveys, which are essential for planning and development activities across the country. The department has also initiated modern surveying techniques, such as LiDAR, to improve the accuracy of land demarcation and support disaster management efforts. Nepal shares borders with India and China, and the demarcation of these international boundaries has historical significance (Shrestha, Gyawali, & Poudel, 2023). The boundary with India was established through the Treaty of Sugauli in 1816 and has undergone various surveys and adjustments since then. The demarcation process involved erecting boundary pillars and creating maps that define the limits of Nepal's territory. However, some areas remain un-demarcated, particularly in the mountainous regions, due to the challenging terrain (Kulshreshtha, 2021).

The impacts of flooding in the Koshi River Basin, particularly on cultivation and residential

land, have been profound and multifaceted. The catastrophic floods, notably the 2008 event, have significantly altered the landscape and livelihoods in the region. The 2008 Koshi flood affected approximately 700 hectares of fertile agricultural land, rendering it uncultivable due to sediment deposition. Many areas became barren, with about 25% of the affected cultivated land remaining unproductive even years after the flood. The economic repercussions were severe, with the estimated loss of crops amounting to approximately USD 18.7 million, which had a notable impact on the national GDP (Kafle, Khanal, & Dahal, 2017). The floods led to the destruction of residential properties and critical infrastructure, displacing thousands of people. Entire villages were submerged, and many households lost their homes, leading to long-term displacement issues. The ongoing risk of riverbank erosion and the potential for additional flooding events continue to threaten both residential and agricultural lands in the basin (Maharjan, 2023).

The relationship between land demarcation and flooding in river basins is significant, particularly in the context of flood risk management and land use planning. Effective land demarcation can play a crucial role in mitigating flood impacts and enhancing community resilience (Sonu & Bhagyanathan, 2022). Efforts in land demarcation within the Koshi River Basin, particularly in the Terai region of Nepal, focus on addressing the challenges posed by flooding, sedimentation, and land degradation. These efforts are crucial due to the basin's vulnerability to natural hazards and its significance for agriculture and livelihoods in the region. The Koshi River Basin's management involves collaboration between Nepal and India, particularly concerning flood control and irrigation projects. The Sapta Koshi High Dam project aims to mitigate downstream flooding and improve irrigation in the Terai region, highlighting the importance of coordinated land management strategies across borders (Maharjan, 2023). The Koshi Basin Program has played a significant role in land demarcation efforts within the Koshi River Basin, particularly in addressing the challenges posed by climate change, flooding, and land degradation. The Koshi Basin Programme emphasizes the development of adaptation strategies that include floodplain zoning, which is crucial for effective land demarcation. By identifying areas at risk of flooding and erosion, the program supports communities in making informed decisions about land use, such as building embankments and shifting agricultural practices to more resilient crops. The findings from the program are intended to inform policymakers about the current gaps in land management and planning. By synthesizing research results, the program advocates for better strategies that facilitate effective land demarcation and management, ultimately aiming to enhance community resilience against climate-related challenges (ICIMOD, 2012). However, the existing demarcation of the flooded zone has not been suitable for the current scenario as the traditional techniques require months of period for the demarcation.

Therefore, the major aim of our study is the systematic demarcation of agricultural and residential parcels, which have been flooded frequently within a certain span of time. It also involves the creation of spatial database information of such land parcels based on the coordinate system, providing coordinate boundaries to each parcel which can be used for future reference as well as reduce the cost of existing demarcation techniques, methods, and conflict among the neighboring owner of the parcel.

2. MATERIAL AND METHODS

2.1 Study Area

The study area of our project is Hanumanagar-Kankalini municipality which is located in the Saptari district of Madhesh province in Nepal. It lies around 26° 30' 12" N latitude and 86° 51' 34" E longitude covering an area of 118.19 square kilometres. Geographically, Sunsari district and India are to the east of this municipality. In the west lies Tilathi Koiladi and Mahadeva rural municipalities. Southern border is totally touched by India while Kanchanrup and Tirhuth municipalities complete the northern border. Hanumanagar-Kankalini has a total of 14 wards, which are scattered across 118 square kilometers of geographical area. According to the 2011 Census conducted by Central Bureau of Statistics (CBS), Hanumanagar Kankalini Municipality had a total population of 45,734.

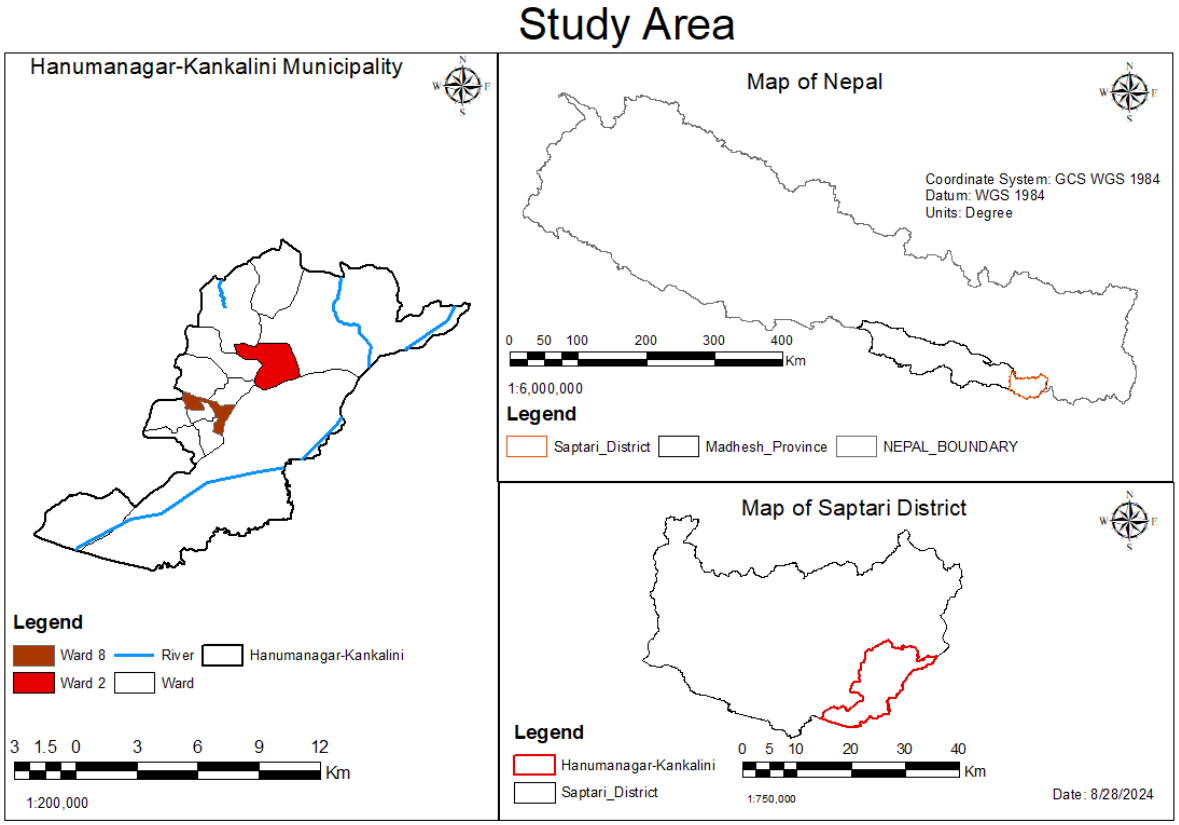

Figure 1: Study Area

The area is a highly flooded prone zone of Koshi River which is continuously by the flood of Koshi River. Due to high flood vulnerability and several past casualties in this area, there have been several issues regarding parcel identifications. Due to these reasons, we chose it as our study area.

2.2 Methodology

The following is the workflow we followed during our study:

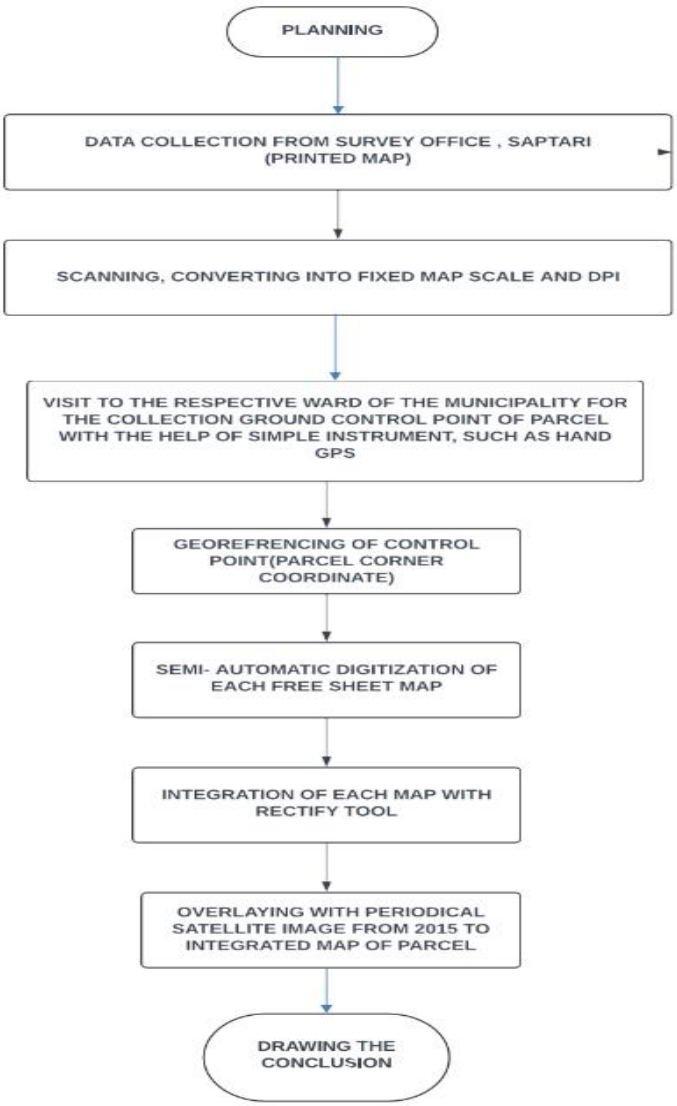

Figure 2: Methodological flowchart

2.2.1 Data source

Satellite images were downloaded from the satellites of google earth, the cadastral map (Free-Sheet) obtain from the respective survey office Saptari, and for geo-referencing, ground-control point of the few parcel (Corner-Coordinates) were observed and taken by the Field Visit, where the data were obtained by simple handheld GPS instrument. The recognition of parcel was done by the respective landowner, who were present in the Cadastral Survey of 2027-2028 B.S.

Figure 3: Parcel verification

2.2.2 Data processing and information generation

Paper maps that were gathered from the survey office were digitalized to create parcel information. Satellite data and cadastral information pictures were superimposed to identify area affected by flooding. The statute for the research of parcel border restoration and creation of a novel restoration modality of the parcel's border was completed. The layer of cadastral parcels and image after flooding were superimposed to determine the quantity of property and the flood-damaged neighborhood. The restoration strategy is predicated on the combination of identical owner's properties in a flood zone and preservation of a section of public land. The periodical Satellite images were overlayed to show the changes in the pattern of the land restored/re-established and flooded by the river within span of years.

3. RESULT AND DISCUSSION

The total number of parcel been damaged by the frequent flood of the Koshi river in ward no. 2 of the Map sheet of 7 and in ward no. 8, of the Map sheet of 5ka. The total no. of parcel, total no. of parcel being affected by the flood and the total area comes under the region of frequent flooded region are given as in the table below.

Table 1: Flood affected parcels

S.N.	Map Sheet No.	Total No. of Parcel	Parcel affected by Frequent Flood	Total area being affected by Flood (sq. km)
1	1_Joginiya VDC Ward no. 5ka	528	155	0.19427
2	2_Joginiya VDC Ward no. 7	460	158	4.16

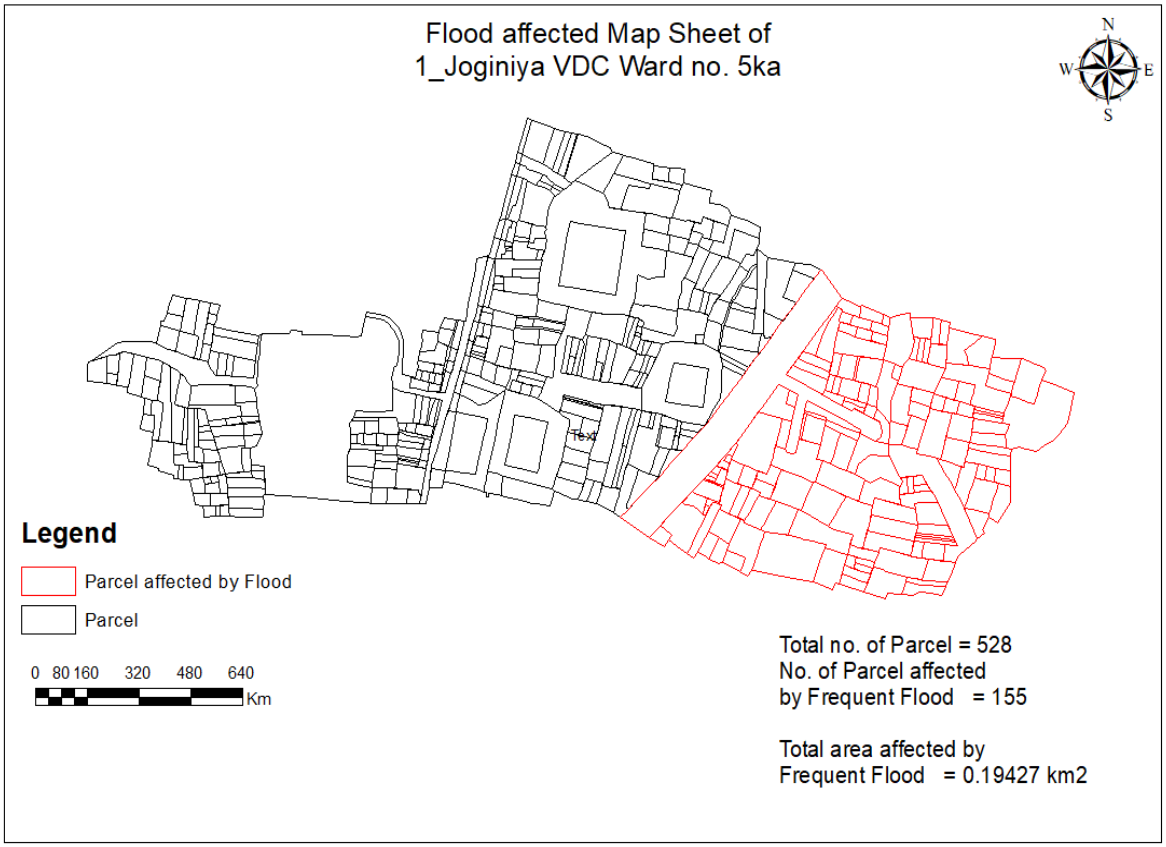

Figure 4: Flood affected map sheet of Joginiya ward 5

The above flood affected map sheet shows the area and no. of parcel being affected by the frequent flood of the present ward no. 2, Hanumanagar-Kankalini Municipality (previous 1_Joginiya VDC Ward no. 5ka map sheet). Out of 528, 30% (i.e. 155) of the parcel comes under the frequent flooded zone of Koshi-River basin consisting of 0.19427 sq. km of area. The red polygon shows the parcel in the flooded zone.

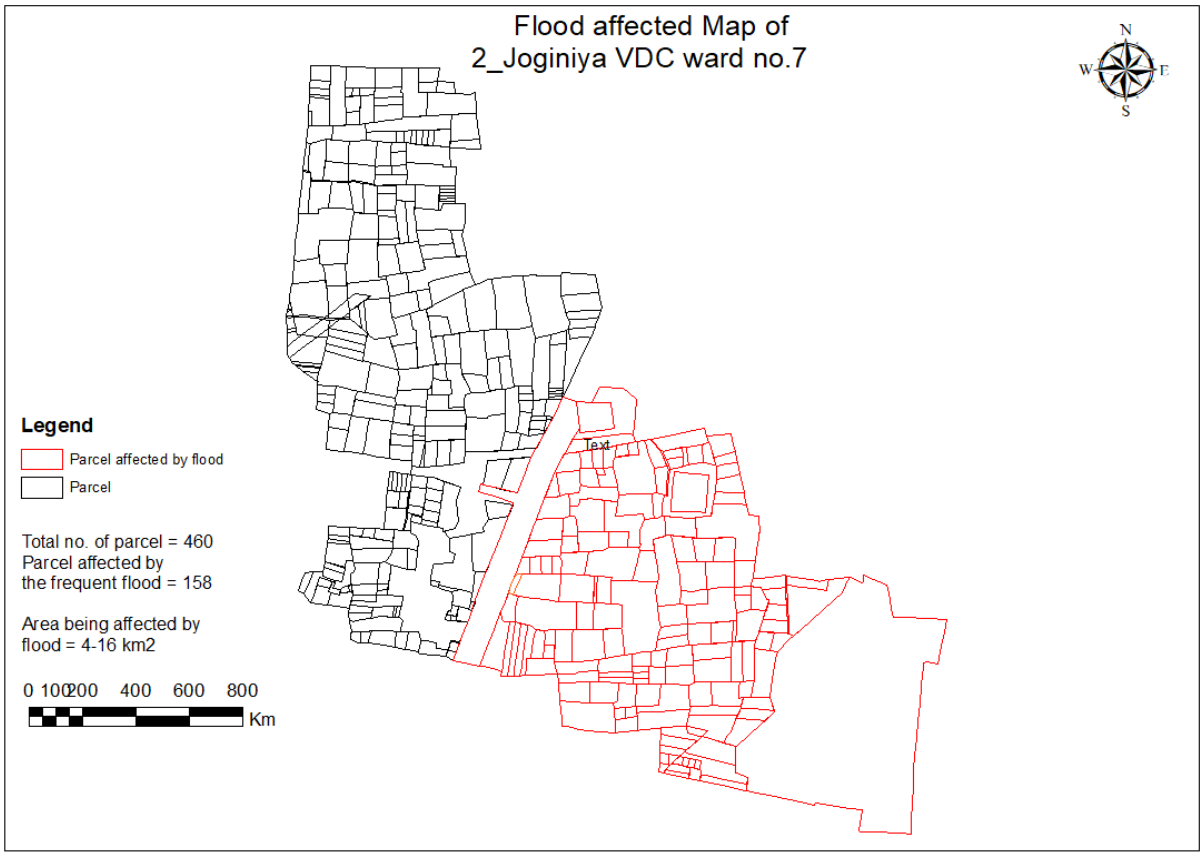

Figure 5: Flood affected map sheet of Joginiya ward 7

Similarly, the above flood affected map sheet shows the area and no. of parcel being affected by the frequent flood of the present ward no. 8, Hanumanagar-Kankalini Municipality(previous 2_Joginiya VDC Ward no. 7 map sheet). Out of 460, 30%(i.e. 158) of the parcel comes under the frequent flooded zone of Koshi-River basin consisting of 4.16 sq. km of area. The red polygon shows the parcel in the flooded zone.

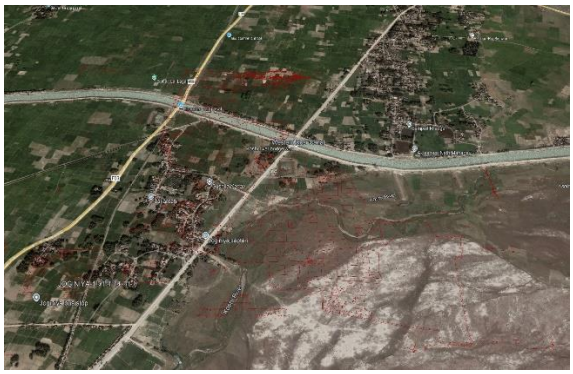

Figure 6: Ward 5 satellite image of 2011-03

Figure 7: Ward 5 satellite image of 2016-12

Figure 8: Ward 5 satellite image of 2017-08

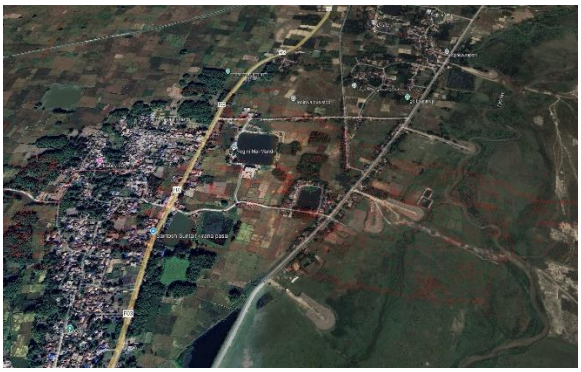

Figure 9: Ward 5 satellite image of 2024-08

The flood prone zone of the parcel being affected by Koshi lies in the east of Koshi Dam(Badh), the Satellite images from 2011-03 to 2024-08, were displayed, the major changes detected were analyzed and the event of major changes in the shapes of parcel were displayed as shown in the figures 6,7,8, and 9. The study shows that the parcel was restored by the personal effort without any survey measurements, which leads to unequal distribution and disputes among the landowners. In 2011, the area was swept out by the flood, the parcel was demarcated and restored in the late years of 2016. Later in 2017, few parcel were swept out by the flood. In present context 2024, maximum no. of parcel being re-stored/ demarcated without the existing demarcation process. The study shows that, these parcel are in the high-vulnerable risk zone of Koshi Flood.

Figure 10: Ward 7 satellite image of 2011-03

Figure 11: Ward 7 satellite image of 2016-12

Figure 12: Ward 7 satellite image of 2017-08

Figure 13: Ward 7 satellite image of 2024-08

The area affected by frequent flood lies in the south of Koshi West-Canal and east of Koshi Dam(Badh), the parcel shape-file is being represented by the red polygon overlayed over the periodical Satellite imagery. The Satellite images from 2011-03 to 2024-08, were displayed, the major changes detected were analyzed and the event of major changes in the shapes of parcel were displayed. The study shows that the parcel was restored by the personal effort without any survey measurements, which leads to unequal distribution and disputes among the landowners. In 2011, the area was swept out by the flood, the parcel was demarcated and restored in the late years of 2016. Later in 2017, few parcel were swept out by the flood. In present context 2024, maximum no. of parcel being re-stored/ demarcated without the existing demarcation process. The study shows that, these parcel are in the high-vulnerable risk zone of Koshi Flood.

4. CONCLUSION AND RECOMMENDATION

Frequent land demarcation is a crucial process for defining and marking land areas, particularly after floods, to facilitate sustainable land use management, such as riverbed and livestock farming. In this study, the existing Free-Sheet maps were transitioned to Trig-Sheet (coordinate-based) maps, utilizing ground control points of parcel corner coordinates for each sheet. By

analyzing periodical satellite images of the flooded parcel map sheets within the Koshi-River basin, the number of parcels was identified. This research provides unique parcel coordinates, aiding in future identification and demarcation(by staking out of the parcel corner coordinates of each parcel) using precise GNSS instruments with established control points by the local-level land use departments. The study emphasizes the potential of sustainable livelihoods management through sustainable land use practices in the Koshi-River basin, particularly for marginalized populations. It contributes to further research on land demarcation and offers valuable insights into the utilization of barren land distribution, promoting seasonal riverbed farming (December-July) in the highly flood-prone zones of the Koshi-River basin.

This study faced several limitations. The Free-Sheet Cadastral map, prepared in 2027-2028 B.S., has not been updated, making it challenging to represent current boundary scenarios. Geo-referencing using satellite imagery was difficult due to the map's format. Updating the cadastral map is a complex legal process, requiring visits to the respective survey office. Geo-referencing also necessitated interaction with landowners involved in the original survey, as frequent flooding has made boundaries indistinct. Due to limited financial resources and access to high-precision instruments like DGPS, RTK-GNSS, and drones, the study was confined to a few portions of Hanumanagar-Kankalini Municipality, as wards 1, 7, 9, and 13 are frequently affected by Koshi-River floods. To address these limitations, several recommendations are proposed. The Free-Sheet Cadastral map should be updated to a Trig-Sheet Cadastral map using high-precision instruments and field surveys. Collaboration among relevant stakeholders, including the Hanumanagar-Kankalini Municipality, Survey Office Saptari Rajbiraj, Survey Department, Koshi River Program, and NGOs/INGOs, is crucial for effective land resource management in the flood-prone region. Establishing control points in the affected wards would facilitate easier land demarcation by the local land use department. Empowering the local land use department with high-precision instruments and skilled manpower would enhance their capacity to perform land demarcation tasks. Given that 43.4% of the population in Hanumanagar-Kankalini is deprived and marginalized, with many being landless, the local government can promote riverbed farming as a sustainable livelihood option for the marginalized population, particularly replacing those people who comes from India for seasonal farming(December-July) in some areas of Koshi River basin. This can contribute to sustainable farming and improve local incomes.

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BIOGRAPHICAL NOTES

Dr. Subash Ghimire is currently the Associate Professor of the Department of Geomatics Engineering at Kathmandu University. Dr. Ghimire has multiple publications in several geospatial sectors. Meanwhile, Er. Bishal Khatri is a recent graduate of Geomatics Engineering program from Kathmandu University and Mr. Nabin Kumar Sah is the final year undergraduate student of Geomatics Engineering program at the same university.

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