Mapping and Analysing Suicide Locations of Lalitpur, Nepal

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KEYWORDS

GIS, Hotspot and Coldspots, Spatial dependence, Suicide

ABSTRACT

This research utilizes geospatial and statistical analysis to examine spatial patterns in suicide occurrences within the Lalitpur district of Nepal. The dataset comprises suicide locations collected from the Lalitpur Police Range (LPR) over a period of six fiscal years spanning from 2074/75 to 2078/79 (2017 AD to 2023 AD). Textual data undergo preprocessing and geocoding processes to derive locations for spatial analysis. The methodology employs Local Moran's I to identify spatial patterns and Getis Ord Gi to identify hotspots and coldspots of suicide incidents. Due to location approximations, spatial analyses are conducted at aggregated levels, including administrative units (wards level) and 1km x 1km grids. The study reports the identified hotspots and coldspots based on these analyses.*

1. INTRODUCTION

1.1 Background

Suicide refers to the act of intentionally taking one's own life. It is a complex and multifaceted issue that often results from a combination of factors, including psychological, social, and environmental influences (Karthick, 2017). It is often associated with mental health issues, such as depression, anxiety, bipolar disorder, schizophrenia, and substance abuse. However, it is essential to remember that there is no single cause for suicide, and it usually results from a combination of factors. It's crucial to approach discussions about suicide with empathy and understanding, as it is a matter of great importance for public health and mental well-being (Johnson, 1965).

According to the World Health Organization (WHO) around 700,000 people die by suicide every year globally. This amounts to approximately one death every 40 seconds. Suicide is a leading cause of death worldwide, especially among young people aged 15-29. Low and middle-income countries account for the majority of suicides globally (WHO, 2023).

According to New Spotlight online News Magazines the suicide rate has increased by 72 percent in a decade in Nepal from 11 persons a day in the fiscal year 2068/69 BS to 19 persons in the fiscal year 2078/79 BS. As many as 53,298 people committed suicide in the last 10 years, which is described in Table 1 (Spotlight Nepal, 2022).

Mapping suicide locations is akin to tracking a disease outbreak. Just as we locate clusters to understand disease spread, identifying where suicides cluster helps pinpoint high-risk areas. This targeted approach enables more effective prevention efforts and ensures that resources are allocated where they're most needed. Additionally, studying suicide locations can provide valuable insights into societal and environmental factors contributing to suicidal behavior (Too et al., 2017).

Table 1: Number of suicides committed per fiscal year in Nepal.

S.N.	Fiscal Year	Number of Suicides
1	2068/69	3977
2	2069/70	3974
3	2070/71	4504
4	2071/72	4332
5	2072/73	4680
6	2073/74	5124
7	2074/75	5317
8	2075/76	5754
9	2076/77	6279
10	2077/78	7149
11	2078/79	6830

1.2 Objectives

The main objective of this research is to map the suicide locations in the Lalitpur districts of Nepal and analyze these locations to identify possible spatial patterns.

The specific objectives of the tasks are as follows:

- To identify the datasets related to suicides in the study area including the location of the suicide and visualize the spatial distribution.
- To compute the spatial autocorrelation measures to study the pattern in these locations
- To identify the hotspots and coldpsots of the suicide location.

2. STUDY AREA

Lalitpur is one of the 77 districts of Nepal and covers an area of 396.92 km^2. It is located in the Kathmandu Valley, Bagmati Province of Nepal, a landlocked country in South Asia. The total number of people in the district is 551,667 (as per the census of 2021). The district is surrounded by Kathmandu and Bhaktapur district in the north, Kavrepalanchok district in the east, and Makwanpur district in the south and west. The altitude of Lalitpur district ranges from 1000 m to 3000 m above sea level. The district includes 6 local units, which are Lalitpur Metropolitan City, Mahalaxmi Municipality, Godawari Municipality, Konjyosom Rural Municipality, Bagmati Rural Municipality, and Mahankal Rural Municipality as shown figure (Figure 1).

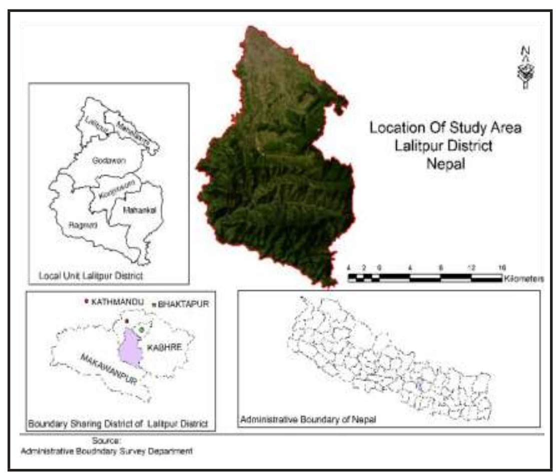

Figure 1: Study Area map.

The district has a diverse setup in terms of population distribution, as it has very densely populated regions within the Kathmandu valley as well as hilly and remote locations with sparsely populated regions. Along with this, there are only three police circles in this study area and all the incidents from these circles are aggregated by one police range making it easy to collect datasets.

3. METHODOLOGY

The methodology adopted for this research is described in this chapter. Figure 2 shows the overall methods adopted. The study involves the application of Geographic Information System (GIS) coupled with the spatial analysis techniques. The preliminary stage involved collecting data from the Lalitpur police range, which was in handwritten format. The collected data is then digitized, and the spatial locations are determined from the place names using tools like OpenStreetMap (OSM), Google Earth, and topographical base maps. These records had all the crime related events so collected data is subsequently filtered to isolate the suicide-related information. Then, spatial analysis is done on the suicide location by computing the Univariate local Moran's I and Getis ord method to compute the hotspots and coldspots. In the subsequent sections, the details are presented.

3.1 Data collection

The initial step involves collecting data from police stations, specifically in a handwritten format.

It should be noted that the DPR (District Police Range) Lalitpur records the suicides as a crime event within the study area. The crime data period covers fiscal years 2074/075 to 2079/080 (which is 2017 to 2023 AD) and specifically focuses on suicide incidents for each year. The process of gathering data for this study was to learn how many various sorts of reported crimes there were in the Lalitpur Police Range for each fiscal year. The dataset included information like the fiscal year, the precise type of crime, and the place names of the locations where these crimes took place. Official crime reports and records were used to extract the information. Once the information had been gathered, it was tabulated and structured to produce a comprehensive dataset that included both the temporal and geographic characteristics of crime occurrences. The ensuing research sought to map and examine the spatial distribution of different crime types throughout Lalitpur, and this information was crucial to that endeavor.

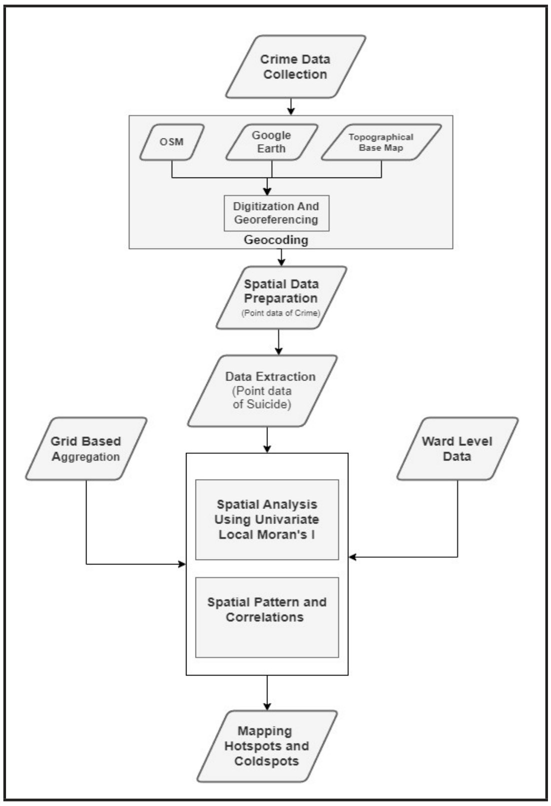

Figure 2: Overview of the adopted methodology

3.2 Geocoding

To enhance spatial analysis, Geocoding was performed manually using a combination of OpenStreetMap (OSM), Google Earth, and QGIS tools. This geocoding process involved associating precise geographic coordinates, such as latitude and longitude, with each recorded place names mentioned in the handwritten document. This meticulous geocoding effort facilitates accurate mapping and spatial analysis, enabling a comprehensive understanding of the distribution and patterns of suicide incidents across Lalitpur over the specified fiscal years.

These crime data for fiscal years 2074/075 to 2079/080 in the study area are digitized using QGIS. Figure 3 shows the spatial distribution of all the suicide incidents in the study area.

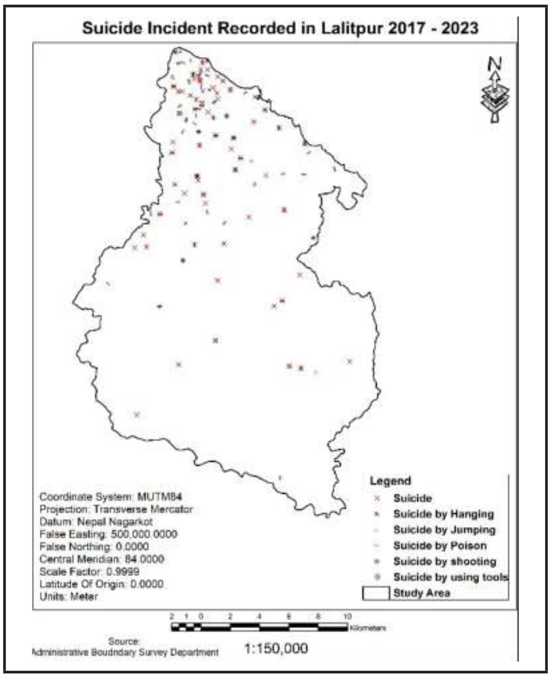

Figure 3: Suicide Incidents occurred in the study area between 2074/075 to 2079/080 BS.

3.3 Hotspot analysis

3.3.1 Hotspot and coldspots analysis

Hotspot and cold spot analysis are spatial mapping techniques used to identify clusters of high and low values, respectively, in a spatial dataset. In the context of suicide analysis, hotspot analysis pinpoints regions with significantly higher suicide rates, highlighting areas of concentrated risk. This information is crucial for targeted interventions and public awareness campaigns. Conversely, cold spot analysis identifies areas with unexpectedly low suicide rates, providing insights into effective prevention strategies and socio-cultural factors that mitigate risk. Together, these techniques offer valuable tools for understanding and addressing suicide at a community level.

3.3.2 Spatial autocorrelation

Spatial autocorrelation refers to the similarity or dissimilarity in values of a variable among nearby geographic locations. This concept is closely related to hotspot and coldspots analysis in the context of suicide research. Spatial autocorrelation quantifies the degree of clustering among these hotspots and coldspots, indicating whether neighboring areas exhibit similar suicide rates.

Local spatial autocorrelation statistics, like G statistics, focus on the relationship among the same property or magnitude across different areas. These statistics measure the local concentration or correlation among objects, providing insights into the spatial patterning of suicide risk.

Moran's scatterplot (Moran,1950) notes on continuous stochastic phenomena. Biometrika, 37(1/2), 17-23) Figure 4 classifies the nature of spatial autocorrelation into four categories, with positive spatial autocorrelation having similar values at neighboring locations, whereas negative spatial autocorrelation tends to have dissimilar values at neighboring locations. If the points in the scatter plot are clustered in the top right quadrant, it refers to some regions that has high attribute values compared to high neighboring values and so on.

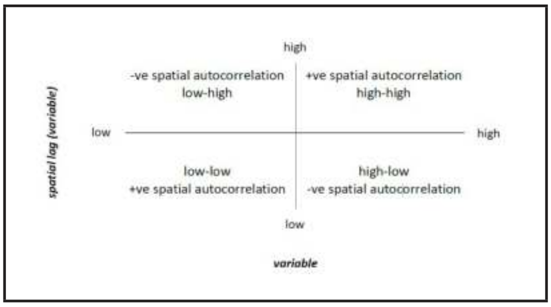

Figure 4: Moran's Scatterplot.

3.3.3 Getis-Ord

Getis-Ord Gi* (Getis,1992) is a local indicator of spatial association (LISA). LISA methods identify spatial clusters of similar values, either high or low. Getis-Ord Gi* uses a statistic called the Gi* statistic to identify clusters. The Gi* statistic is calculated for each grid cell in the study area. A positive Gi* statistic indicates a cluster of high values, while a negative Gi* statistic indicates a cluster of low values.

To compute the hotspot/coldspots the following equation of General G statistic is used:

$$G_i = \frac{\sum_{j=1}^{n} w_{ij} \cdot x_j - \bar{x} \cdot \sum_{j=1}^{n} w_{ij}}{s \cdot \sqrt{\frac{\sum_{j=1}^{n} w_{ij}^2}{n} - \left(\frac{\sum_{j=1}^{n} w_{ij}}{n}\right)^2}}] \quad \text{(i)}$$

Where,

G_i = Getis-Ord general G statistic for location i,

n = stands for the total number of locations considered,

xj = number of suicides at location i

wij= spatial weight between locations i ∧ j

x = mean of all suicides across locations,

s = standard deviation of suicides across locations.

Z-score formula:

$$Z_i = \frac{G_i - \overline{G}}{s_G} \quad \text{(ii)}$$

Where,

Zi = Z – score for location i,

$\overline{G}$ = mean G statistic acreoss all locations,

s_G = standard deviation of G Statistics across all locations.

P-value formula:

$P(Z_i) = 1 - \phi(Z_i)$ (iii)

Where,

$P(Z_i)$ = P – value for location,

ϕ (Zi)= cumulative distribution function of the standard normal distribution evaluated at Zi.

3.3.4 Getis-Ord in aggregated data

Due to the lack of point coordinates for suicide locations, two aggregation methods were used for analysis: regular-shaped square grids (1kmx1km) and the lowest administrative units in Nepal. The lowest administrative units chosen were the wards of Village Development Committees (VDCs) instead of the current local levels, as the country is in a transition phase and there is still widespread understanding of VDC wards. This choice was made because VDC wards are smaller compared to the wards of the current local levels, and it was assumed that they would better represent the provided place names. A total of 436 grids covered the whole Lalitpur district as shown in Figure 5 and there are a total of 42 Village Development Committees (VDCs) encompassing 391 wards according to the old administrative boundary as shown in Figure 5.

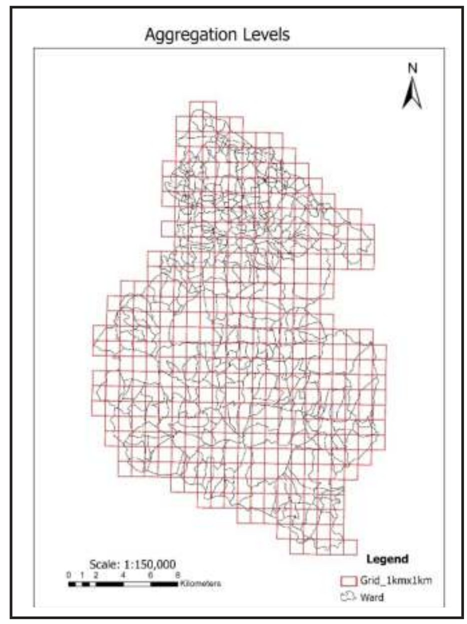

Figure 5: Grids of 1kmx1km with ward level of the study area.

4. RESULT

4.1 Exploratory data analysis

In the fiscal years 2074-075 through 2079-080, the Lalitpur police range office registered a total of 843 crime cases across 130 different locations. Among these cases, there were 562 instances of suicide, which accounts for approximately 66.66% of all the registered cases. Figure 6 illustrates the number of suicide incidents reported in each fiscal year alongside the corresponding count of unique locations. In the fiscal year 2074-2075, a total of 89 suicide incidents were documented, occurring in 14 distinct locations. Similarly, during the fiscal year 2075-2076, there were 92 recorded suicides, taking place in 19 separate locations. In the subsequent year, 2076-2077, 79 suicides were reported across 23 different locations. Moving to the fiscal year 2077-

2078, the number of suicides escalated to 108, distributed among 44 distinct locations. In the subsequent years, the pattern continues: 100 suicides in 59 locations for 2078-2079, and 94 suicides in 66 locations for 2079-2080.

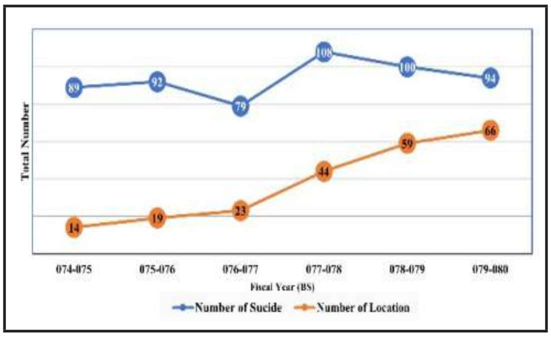

Figure 6: Suicide yearly chart.

To seek the movement, variation of variance is plotted for the time series data. The mean is 2.884422 and the maximum deviation of the mean is 9.0, which seems significant. A histogram of the data indicates that data seem slightly right skewed as well as multimodal as shown in Figure 7. This suggests the possibility of clustering in the suicide incidents.

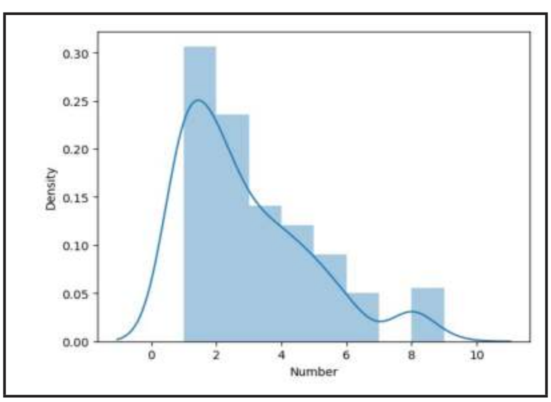

Figure 7: Histogram of Number of Suicide.

There were 562 suicide incidents recorded in the DPR in Lalitpur in 6 fiscal years. Suicide incidents are mapped with graduated symbols in which different sizes of features represent particular values of variables Figure 8.

It is evident from the spatial distribution of the suicide location that there are more suicide events in the Northern part of the district which is expected because the Northern part is a highly populated urban area whereas the southern part is a hilly region with a lower population density. Also since the southern region is more rural suicide cases may be under-reported as well.

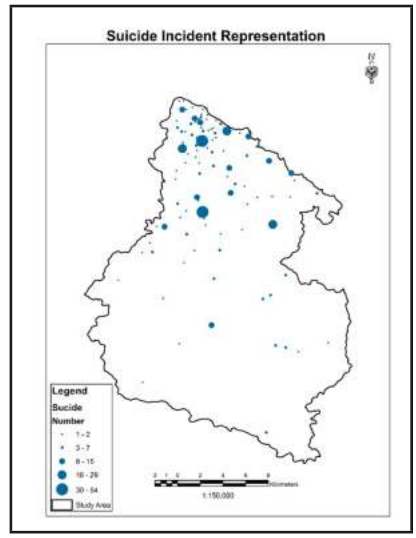

Figure 8: Area Representing Higher Rate of Suicide.

4.2 Spatial autocorrelation

In Figure 9 the Univariate Moran's I value of 0.313 in Lalitpur District's suicide data indicates a significant positive spatial autocorrelation.

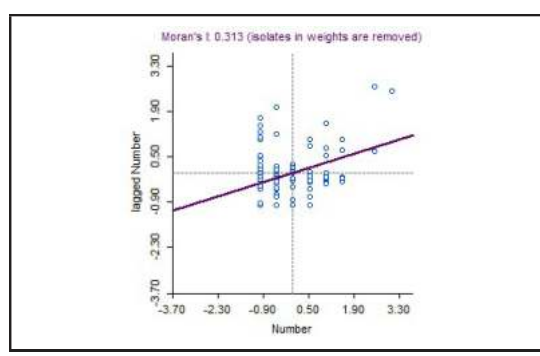

Figure 9: Univariate Local Moran's I.

This means that areas with similar suicide counts tend to be geographically clustered. The concentration of values in the upper right corner reflects the trend of high values grouping with high values and low values grouping with low values in neighboring locations. This spatial pattern has important implications for understanding the dynamics of suicide within the district, highlighting the role of geographic proximity in influencing suicide rates.

In Figure 10, the Local Indicators of Spatial Association (LISA) cluster map at the ward level is presented and the respective significance values are shown. Among these wards, 140 don't have any statistically significant (p-values greater than 0.05) spatial clustering. This implies that there is no clear pattern of neighboring regions or areas displaying similar suicide rates, suggesting a relatively random distribution across these wards.

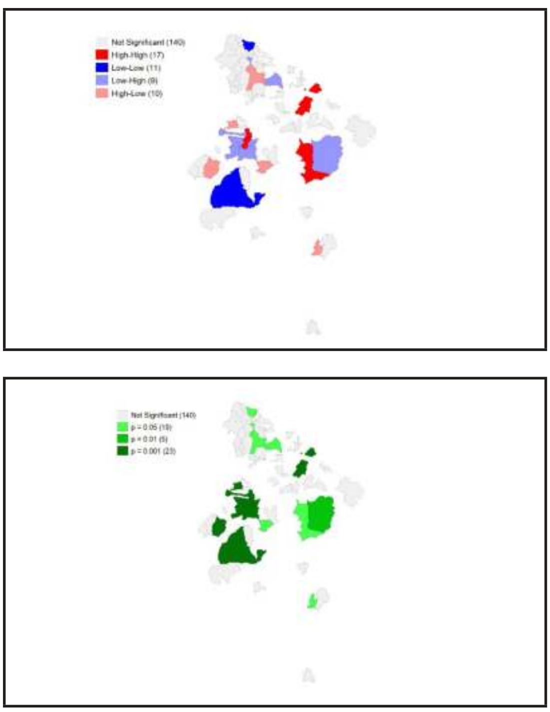

Figure 10: LISA Clusters of ward levels (top) and the respective significance level (bottom)

However, in 14 wards (significant at the 0.05 level), there is evidence of non-random clustering or dispersion of suicides. This suggests that certain areas have a higher concentration of suicide cases compared to what would be expected by chance alone. Moreover if we check at the significance level at 0.01 p value there are 5 wards with significant pattern. In these specific areas, the clustering or dispersion of suicides is particularly significant and unlikely to be attributed solely to random chance.

Overall, these findings shed light on the spatial dynamics of suicide occurrences, and highlights that there are few wards (at least 5) that have statistically significant clusters.

4.3 Hotspot and coldspots

We employed the Getis-Ord Gi* method to elucidate the distribution of hotspots and coldspots at the ward level. Our analysis revealed that within this framework, there are 7 wards categorized as coldspots. These include Bhattedanda ward 8, Harisidhi ward 9, Kaleshwar ward 2, Lalitpur sub metro ward 10, Lele ward 8, Nallu ward 8, and Pyutar ward 1. These wards exhibit relatively lower values in terms of the suicide.

On the other hand, 4 wards emerged as hotspots, signifying areas with notably higher values. These hotspots encompass Chapagaun ward 2, Godawari ward 6, Lubhu ward 4, and Lubhu ward 5. These wards showcase concentrations of the phenomenon in question that stand out from their surroundings. For a visual representation of these results, please refer to Figure 11.

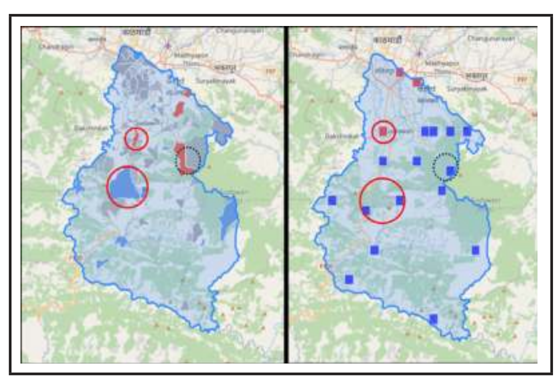

*Figure 11: Hotspots And Coldspotss at Old Ward Level (left) and at 1km*1km grids (right). Here, regions highlighted by circles are discussed in section 5.1 (Basemap: Openstreetmap)*

In the grid-based aggregation using a 1km x 1km grid to identify hotspots and coldspots within the study area, we made significant observations. Our analysis revealed 3 grids categorized as hotspots, encompassing 6 distinct locations: Asarang, Balkumari, Chyasal, Thecho, Tananitol, and Tikathali.

In contrast, our study identified 15 grids as coldspotss, each aligned with specific locations: Badikhel, Bhardeu, Bhattedanda, Bistachhap, Ghusel, Gimdi, Godamchaur, Iti Tole, Kaleshwor, Lakuribhanjyang, Nallu, Patlechhap, Pulchwok, Pyutar, and Tinpane Tower.

5. DISCUSSION AND CONCLUSION

5.1 Discussion

The study on suicide locations in Lalitpur faces challenges due to the aggregated nature of dataset. The data collected from the police stations is handwritten and includes the local name of suicide location thus it lacks precise coordinates, making it difficult to pinpoint exact suicide locations. Relying only on place names instead of actual coordinate limits the research's depth. Similarly, without detailed data, factors like demographics, socioeconomics, and culture that influence suicide rates remain unexplored. Therefore, while the study is a good start, its findings should be interpreted cautiously due to data limitations.

We have identified hotspots and coldspots using two different levels of aggregation and have observed similarities as well as differences in the identified hotspots. Figure 11 illustrates this, with solid red circles indicating similarities and dotted black circles representing dissimilarities. For instance, in both aggregation methods, the regions around Chapagaun and Thecho are identified as hotspots. However, there are discrepancies such as the ward near the Godawari forest being classified as a hotspot while the surrounding grids are considered coldspots. This demonstrates the significant impact of aggregation levels on such analyses. Therefore, we recommend carefully selecting the aggregation levels when performing hotspot and coldspots analyses.

Similarly, the temporal dimension was not considered in this study; all suicides were aggregated at the end of the study period, i.e.the 2078-79 fiscal year. Therefore, a future study could investigate the temporal dependencies associated with each of these suicide cases. Conducting spatio-temporal hotspot analysis would be a valuable approach to explore these dynamics.

5.2 Conclusion

In this study, we conducted an analysis of suicide locations in the Lalitpur district of Nepal, utilizing Geographic Information System (GIS) techniques and spatial analysis methods. The aim was to map suicide incidents, identify spatial patterns, and pinpoint hotspots and coldspotss within the study area.

The findings reveal several key insights into the distribution and clustering of suicide incidents. Over a span of six fiscal years (2074/075 to 2079/080 BS), a total of 562 suicide cases were reported, accounting for approximately two-thirds of all registered crime incidents in the Lalitpur police range. Exploratory data analysis demonstrated a concentration of suicide events in the northern, more densely populated areas of the district, compared to the sparser southern regions.

Spatial autocorrelation analysis using Univariate Moran's I indicated a significant positive spatial autocorrelation in suicide rates, revealing geographic clusters of similar suicide counts. Local Indicators of Spatial Association (LISA) cluster maps further highlighted statistically significant clusters of high and low suicide rates at the ward level, with specific areas exhibiting non-random spatial clustering.

Hotspot and coldspots analysis using the Getis-Ord Gi* method identified distinct wards and 1km x 1km grids as hotspots and coldspotss, underscoring areas with notably higher or lower suicide rates relative to their surroundings. The study revealed differences in hotspot identification based on aggregation levels, emphasizing the importance of careful consideration in spatial analysis.

Despite these insights, the study encountered challenges due to the aggregated and handwritten nature of the dataset, limiting the precision of location data and hindering deeper exploration of underlying socio-demographic factors influencing suicide rates. Future research should aim to incorporate finer-scale data and explore temporal dependencies to enhance understanding of suicide dynamics in the study area. In conclusion, this study contributes valuable spatial perspectives to the understanding of suicide patterns in Lalitpur district, Nepal. The findings underscore the importance of targeted intervention strategies and public health initiatives aimed at addressing suicide risk factors in specific geographical areas, thereby supporting efforts to promote mental well-being and prevent future suicides within the community.

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