Health, poverty, and education in Nepal districts

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Abstract

Access to education, healthcare, and safe living conditions often varies widely in a country. In Nepal, these indicators show significant variations at the district level, some districts face much bigger challenges than others. This study aims to identify and analyze patterns of health, poverty, and education differences across Nepal's districts using various geospatial techniques. Here we show that the far-western and mid-western districts consistently experience higher levels of poverty, higher % of child malnutrition, limited access to safe water, lower per-capita income, and lower education rates compared to other regions. Our analysis demonstrates a clear spatial clustering of socioeconomic challenges, underscoring the need for geographically targeted interventions. These results provide practical guidance for development practitioners to prioritize resources effectively in specific regions. In general, this study improves the understanding of district differences in Nepal and illustrates the value of geospatial methods in socioeconomic analyzes.

1 Introduction

Health, poverty, and education are among the most telling signs of how well a country is doing. Healthy people are better able to work and care for their families, while good schools give people the skills they need to find jobs. At the same time, low poverty means more people can meet basic needs like food, housing, and medicine. We know that those challenges are most extreme in the world's poorest places, yet even wealthy nations can struggle to keep all three areas on track.

Mlachila et al. [1] point out that looking only at economic growth gives an incomplete picture of economic development, so social factors such as health and education must also be counted. They argue that every development strategy should aim not just for higher economy, but for better living standards and less poverty. Likewise, Paudel and Acharya [2] shows how a strong financial sector can raise incomes, cut poverty and speed up overall growth, conversely, a weak financial system costs high, reduces investments and shrinks employment.

Yet in many of the world's poorest countries, health care, schooling, and poverty remain constant challenges. Those gaps hold back economic progress and damage people's quality of life. Despite decades of work to strengthen Nepal's health system, expand education, and reduce poverty [3, 4, 5], serious problems still persist, so there is a clear need for further analysis.

In this context, we explore the world of health, poverty, and education in Nepal districts. To keep things clear, we have turned this big topic into a few smaller research questions, such as:

- Is higher adult illiteracy linked to higher poverty?
- Does lack of safe water correlate with high malnutrition in children?
- Do the poorest districts tend to sit next to each other on the map?

- Which districts share similar socioeconomic profiles?
- How does school availability vary across districts?

By answering those questions and digging into district-level data, we can pinpoint where help is needed.

In Section 2 we provide context about the project in sens of historical, cultural, and technical aspects. In Section 3, we show the process we followed to collect and pre-process the data. In Section 4, we address the main methods we used to answer our research questions. In Section 5, we showcase the results of our methods across different socioeconomic indicators of Nepal that we picked for deeper analysis. Finally, in Section 6, we delve into the discussion and disclose the primary limitations which are followed by Section 7, which talks about the future work, and in the end, the conclusion in Section 8.

2 Background

Nepal, officially the Federal Democratic Republic of Nepal, is a landlocked nation in South Asia [6]. While many Asian countries are known for their rich cultures, some still face serious economic challenges. In fact, eight Asian countries are on the UN's list of Least Developed Countries, and Nepal remains there as of 2025 [7]. Over the years, researchers have carried out numerous studies on health, poverty, and education in Nepal, which has helped guide development efforts across the country.

A research from Thapa [8] in 2013 showed that as literacy rate increases, income poverty decreases. Based on their analysis, they conclude that educational attainment is a positive function of the level of income in Nepal.

Back in 2010/11, the Nepal Living Standards Survey found that 25% of households lived below the national poverty line, while the Human Poverty Index showed 44% of people lacked basic education, health care, or resources [9]. The 2023 Nepal Poverty and Equity Brief report by World Bank [10] says that by 2019, infant mortality had fallen from 10 to 6 deaths per 1,000 live births, school enrollment and literacy both rose, and Nepal's Multidimensional Poverty Index dropped from 30.1% to 17.4%. The latest 2025 Poverty and Equity Brief report by World Bank [11] reports a further fall in overall poverty to 20.3%, near-elimination of extreme poverty, and big gains in electricity access and road networks.

Even with plenty of existing research and clear national progress, district-to-district differences still matter. Rather than trying to fill gaps in the literature, this study builds on by digging deeper into district-level data by using the geospatial concepts and methods we have worked with in this course.

In this project, we examine the simple links between adult illiteracy and index poverty rates, and between lack of safe water access and child malnutrition, to measure how strongly these factors move together in each district. We test whether poor areas really cluster on the map using Moran's I and then drill down with a local version called LISA, which shows exactly which districts sit in high-poverty "hot-spots" and low-poverty "cold-sports". Then we use a grouping method (k-means clustering) to sort districts into clusters that share similar levels of poverty, adult literacy, child malnutrition, lack of safe water access, per capita income, and deprivation in economic provisioning. Finally, we bring it all to life with an interactive map showing the number of schools per 1,000 people in every district. This district-by-district approach reveals which areas have seen the biggest advances, which are still struggling, and where aid groups can focus their efforts most effectively.

3 Data

3.1 Data acquisition

Our analysis uses the "Health, poverty and education indicators for Nepal districts" dataset published by the GeoDa Data and Lab [12]. The data are provided as a standard ESRI Shapefile bundle (`.shp`, `.dbf`, `.shx`, `.prj`) containing 75 district polygons in WGS84 (EPSG:4326) and 61 variables. Key variables information can be found in Table 1.

Variable	Description
district	District name.
depecprov	Deprivation in economic provisioning.
povindex	Human Poverty Index.
pcinc	Per Capita Income.
malkids	% of children under age five who are malnourished
nosafh20	% without safe water.
population	Total population.
schoolcnt	Number of schools (2012–13).
schlppop	Number of Schools per population (in thousands) (2012-2013).
ad_illit	Adult illiteracy rate (2011).

Table 1: Key variables

The data is from years 1991-2013 with some variables being collected in specific years. Full list of the variables and their description can be found in Appendix 8, Table 5.

3.2 Data processing

All geospatial processing was performed in Python using GeoPandas. A quick integrity check confirmed that all socioeconomic variables are complete (75, non-null) except for four missing entries in `name_1` variable which was not used in our analysis. We also re-projected to (EPSG:32645) for metric-based analysis and to (EPSG:3857) for mapping analysis. No other data processing step was needed as the dataset was ready to go.

4 Methods

To answer our research questions we make use of multiple geospatial concepts and methods.

4.1 Choropleth maps - Bivariate

An univariate choropleth map colors each district based on data values, so you can instantly see where a measure is high or low (see Appendix 8, Figure 8, 9, 10, 11 for univariate maps). A bivariate choropleth map takes that one step further by combining two variables into nine possible color blends, low/low, low/medium, ... up to high/high, letting you judge how the two factors move together across space.

In our first map, we pair adult illiteracy with the poverty index. The second map pairs the lack of safe water variable with child malnutrition. For each map, we split both indicators into three bands (low, medium, high) and mix them into a 3×3 color grid. Districts with both high "variable 1" and high "variable 2" show up in the darkest color (purple), while those with low

values on both axes appear in the lightest color (light grey). We include a small 3×3 legend in the lower left corner and label the horizontal axis for the first variable and the vertical axis for the second, so readers immediately know which color combination means what.

To back up these visuals, we also calculated Pearson's correlation coefficient (r) and its p-value for each pair. That way, you not only see the map but also know whether the relationship is strong and statistically significant.

4.2 Global Moran's I and LISA

To find out whether poor areas are clustered on the map (`povindex`), we start by defining each district's neighbors with a Queen contiguity spatial weights matrix, which links any two districts that touch at a boundary or a corner. We then row-standardize those weights so that each district's neighbors sum to one. Using this matrix, we calculate Global Moran's I and Moran's p-value on the poverty index.

But a single number can't show us exactly where those clusters live. To do that, we turn to Local Moran's I, often called LISA. We used 999 permutations with a fixed seed (42) for reproducibility when calculating LISA. By running LISA at the 5 percent, 1 percent, and 0.5 percent significance levels, we flag each district as part of a poverty hot-spot, where high-poverty is surrounded by high-poverty, a cold-spot, where low-poverty is surrounded by low-poverty, or spatial outliers, where a high-poverty district sits among low-poverty neighbors or vice versa. Districts that don't meet the significance threshold remain unclassified. We then map all three LISA results side by side so readers can see how the pattern holds up under stricter tests and exactly which districts form genuine clusters. This combination of global and local analysis gives us the broad confirmation of poverty clusters in Nepal.

4.3 Spatial Clustering (k-means)

To find districts with similar socioeconomic profiles, we ran a k-means clustering on six key indicators: poverty index, child malnutrition rate, lack of safe water, adult illiteracy, per capita income, and economic deprivation (with a fixed seed (42) for reproducibility). First, we used a standard scaler to center each variable at zero with unit variance, so no single measure would dominate the clustering. Next, we tested cluster counts from 2 to 7, calculating both the Silhouette Score and the Calinski–Harabasz index for each choice of k, in order to find the best one.

We fit the k-means model and assigned every district to one of the k clusters. For the map, we reprojected our data into Web Mercator (EPSG:3857), colored each district by its cluster, and labeled each shape with its cluster number at the district's centroid. A simple legend shows which color each cluster represents. This map then lets readers see, at a glance, which districts share broadly similar mixes of poverty, literacy, water access, malnutrition, and income.

4.4 Interactive Map

Folium's interactive maps are a powerful communication tool. They can effectively convey complex geographical patterns and relationships to a broad audience [13]. Following this, we built our interactive map with Folium, centering it on Nepal at a comfortable zoom level so that you immediately see the whole country. Users can switch between three background layers, standard OpenStreetMap (our default), a simpler "Positron" view, or a satellite view, to suit their preference. On top of that, we draw each district's border in black to keep regional outlines clear.

In this map, we show school availability. We calculate "schools per 1,000 people" for every district and place a small colored square at each district's centroid. The color comes from a

red-to-green scale, districts with fewer schools are closer to red, and those with more are closer to green, so you can spot at a glance where coverage is weakest or strongest. Hovering over any square pops up a tooltip with the district name, total schools, "schools per 1,000 people" value, and overall population.

We also add a legend for the color scale, a tiny "mini-map" for context, and a layer control so you can toggle the school squares or district borders on and off.

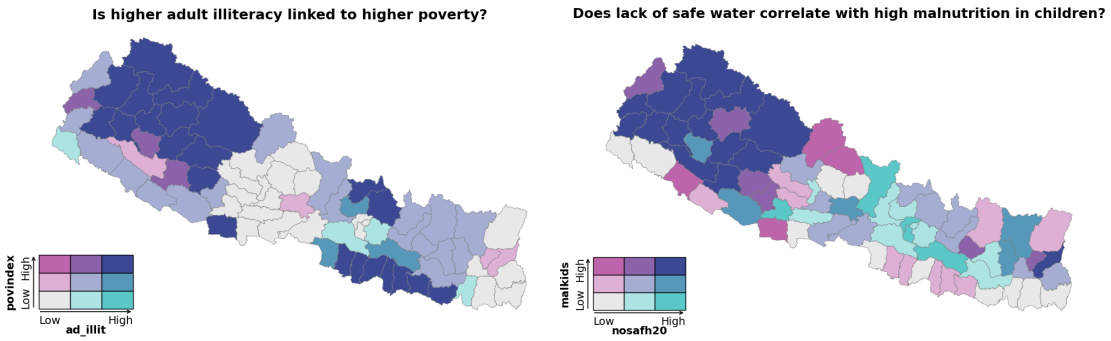
5 Results

The following subsections titles provide conclusions based on the results of each method. The interpretation of the cardinal directions of Nepal in following results is done based on Figure 5.

5.1 Strong Correlation between Adult Illiteracy and Poverty, Moderate Correlation between Lack of Safe Water and Child Malnutrition

Figure 1a shows the relationship between adult illiteracy and the poverty index. Districts shaded in the darkest purple have both high illiteracy and high poverty, while those in light gray have low values on both measures. We see a concentration of high–high districts mostly in the far-western and mid-western regions, with the central districts also being evident, and low–low districts around the capital city Kathmandu, and most of them around the west of Nepal, and the eastern part as well, where Jhapa and Morang are. Evident are also some mid-mid districts in the central-east part of Nepal. To back up the visual, Pearson's correlation between adult illiteracy and poverty is $r = 0.92$ ($p < 0.001$), confirming a strong, statistically significant link.

Figure 1b pairs the lack of safe water with child malnutrition. The deepest purples mark districts suffering both poor water access and high child malnutrition, most evident in the far-western and mid-western areas, whereas we can see that starting from the west all the way to the east, we mainly see districts colored with pale tones. Here, the correlation is moderate $r = 0.36$ ($p = 0.0017$), indicating a statistically significant but weaker relationship.



(a) Bivariate map of adult illiteracy and poverty index. (b) Bivariate map of lack of safe water access and child malnutrition.

Figure 1: Bivariate choropleth maps showing how two key development indicators co-vary across Nepal's districts.

5.2 Far-West and Mid-West Hotspots and Western Coldspots Highlight Poverty Clustering

Global Moran's I on the poverty index is 0.64 (p = 0.0010), indicating a tendency for similar poverty levels districts to sit next to one another rather than being randomly distributed (see the Moran scatterplot in Figure 6).

Figure 2 shows Local Moran's I (LISA) results at 5%, 1%, and 0.5% significance. In every map (significance level), the far-western (only Bajura at 0.5% significance) and mid-western districts light up as a clear hot spot (red), confirming that the highest-poverty areas cluster in Nepal's far-western and mid-western regions. Cold spots (blue), where low-poverty districts group, appear around Kathmandu and the western districts at 5% and 1%, and remain at 1% before fading almost all at 0.5%. All other districts are shown in light gray as not significant, and our results don't show any spatial outliers at none of the significance levels.

Together, the global and local tests make it clear that poverty in Nepal is spatially clustered, with the strongest concentrations in the far-west and mid-west, and point exactly to the districts where development resources should be focused.

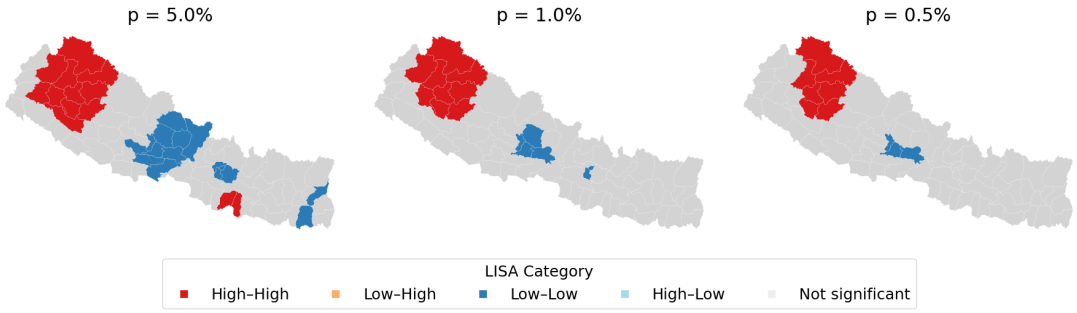


Figure 2: LISA for the poverty index (`povindex`) at 5%, 1% and 0.5% significance levels.

5.3 Nepal's Districts Fall into Two Clear Socioeconomic Groups

We chose two clusters ($k = 2$) based on the highest silhouette score (0.339) and Calinski–Harabasz index (48.718) in Table 2. Figure 3 shows how Nepal's 75 districts split into these two groups.

- **Cluster 0 (more deprived):** Districts in this group have a higher poverty index (≈39.8%)[1], greater child malnutrition (≈49.6%), higher % without safe water (≈26.8%), higher adult illiteracy (≈49.5%), lower per-capita income (≈NPR539)[2], and higher economic deprivation (≈38.2%). Geographically, these tend to lie in the far-western and mid-western mountain regions and some in the central part.
- **Cluster 1 (less deprived):** These districts show lower poverty (≈28.0%), lower child malnutrition (≈36.2%), lower % without safe water (≈13.0%), lower adult illiteracy (≈35.7%), higher per-capita income (≈NPR794), and lower economic deprivation (≈24.6%). They are mostly found in the western and some in the central part of Nepal, with a few in the lower part of the east as well.

This clear divide highlights which districts share similar socioeconomic challenges.

[1] All values shown in this subsection are means calculated per cluster.
[2] NPR = Nepalese rupee.

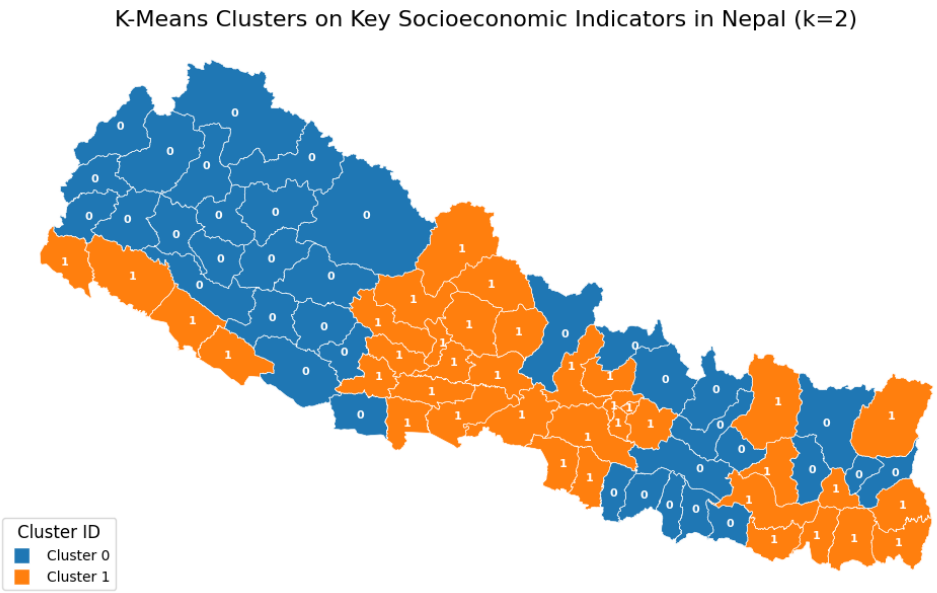


Figure 3: K-means clustering of Nepal's 75 districts using six socioeconomic indicators (poverty index, child malnutrition, lack of safe water, adult illiteracy, per-capita income and economic deprivation) with $k = 2$.

k	Silhouette Score	Calinski–Harabasz Index
2	**0.339**	**48.718**
3	0.295	42.667
4	0.292	36.813
5	0.311	38.936
6	0.302	35.586
7	0.269	34.948

Table 2: Clustering quality metrics for different values of k.

5.4 Fewer Schools per 1,000 residents in Densely Populated Districts

Figure 4 maps schools per 1,000 residents across Nepal's 75 districts, from red (fewest schools per 1,000 residents) to green (most schools per 1,000 residents). The lowest ratio appears in the part of Nepal where the elevation is the lowest (see Figure 7 for altitude information). For example, Dhanusa has just 0.53 schools per 1,000 residents, reflecting its high population and relatively limited school infrastructure. Across much of the eastern part (Morang, Sunsari, Jhapa), ratios also stay below 1.0, signaling a low number of schools.

As the altitude of the districts rises, ratios of schools rise into the 2–4 range. At the top end, the high mountain districts stand out: Mustang, which reaches about 6.04 schools per 1,000 people (Population: 11,585), and Manang scores above 5 (Population: 5,827). These areas combine very small populations with a handful of village schools, even where access can still be challenging due to high altitude.

Overall, the map shows a clear gradient from low ratios in the densely populated plains, through moderate coverage in the hills, up to very high numbers of schools per 1,000 residents

in the lower populated mountain districts. This gradient underscores where new school and building efforts are most needed to match the area population pressures.

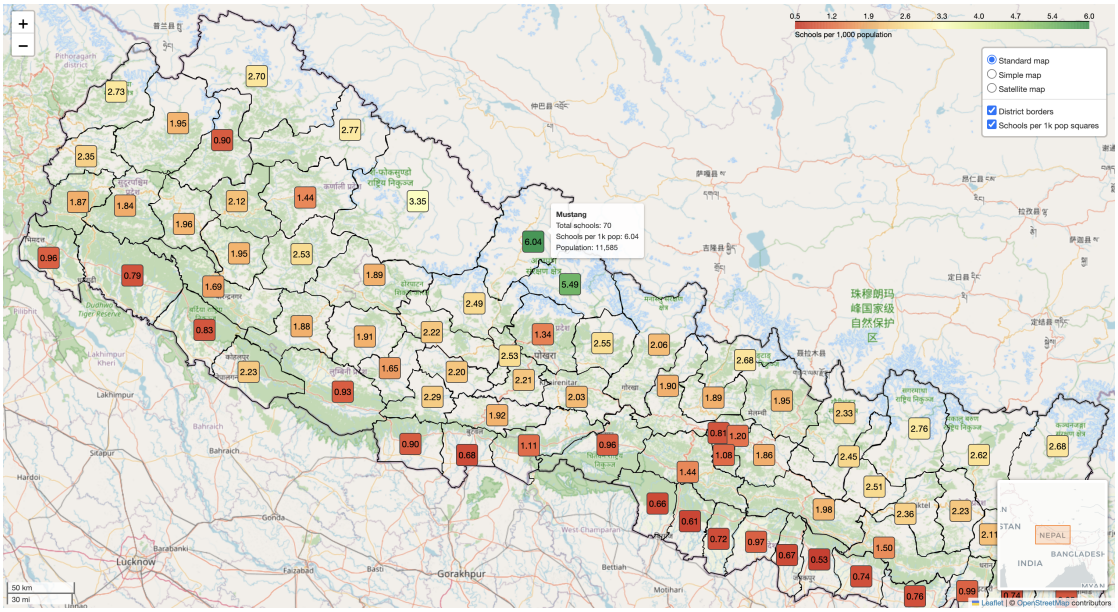


Figure 4: Interactive map of Nepal's districts showing the number of schools per 1,000 residents.

6 Discussion

In this project, our goal was to analyze health, poverty, and education conditions across the districts of Nepal. Additionally, we aimed to apply and demonstrate various geospatial methods learned throughout this course to extract meaningful insights from our available data.

Our results reflect patterns consistent with previous studies, highlighting that districts in far-western and mid-western Nepal often experience higher poverty, higher illiteracy rates, limited safe water access, greater child malnutrition, lower per-capita income, and higher economic deprivation. Districts included in the far-western Nepal are: Bajura, Bajhang, Darchula, Achham, Kailali, Doti, Kanchanpur, Baitadi and Dadeldhura (see Figure 5 for the full map and mid-western districts). A study by Maharjan and Joshi [14] found that in the rural far-western mid-hills of Nepal, factors such as illiteracy (education) and occupation are the main indicators contributing to the region's persistent poverty.

The methods we applied, including spatial clustering, bivariate choropleth mapping, spatial autocorrelation (Global Moran's I and LISA), and interactive mapping, were precise and robust enough to identify these clear geographical patterns. One strength of our approach is its generalizability and transferability. These methods can be applied to similar district-level datasets elsewhere, providing valuable insights into comparable socioeconomic issues.

Throughout this analysis, certain technical challenges emerged. Determining suitable significance levels for spatial autocorrelation tests and choosing the optimal number of clusters for k-means were particularly demanding tasks. We learned the importance of carefully standardizing data before clustering and clearly defining spatial relationships when applying spatial methods.

Our interactive map effectively highlighted the distribution of schools across districts, indicating that the number of schools is higher per population in districts with fewer people.

However, our approach has some shortcomings, and it is essential to acknowledge those limitations associated with our analysis, which we elaborate upon in the next subsection.

6.1 Limitations

Data age and district boundaries The data we use were collected between 1991 and 2013 and reflect Nepal's old setup of 75 districts. In September 2015 two new districts were added, bringing the total to 77, so our maps and numbers do not match today's boundaries [15]. The results from this study were focused to demonstrate the geospatial concepts and methods we learned in class and should be interpreted with caution. Even though the data are dated and the district lines have changed, Nepal still remains on the UN's list of least developed countries and continues to face serious health, education and poverty challenges as mentioned before [7].

7 Future work

Incorporating elevation data A next step would be to potential find a dataset with each district's average altitude. Adding that number to our data could show if higher altitude districts really do face poorer water access or higher child malnutrition. Elevation would then become another layer in our maps and clusters. Since Nepal is the country of 1310 peaks above 6000m [16], another layer on our maps which is elevation would help us see where mountain terrain actually makes a difference.

8 Conclusion

This study provided an insightful analysis of health, education, and poverty conditions across Nepal using various geospatial methods and concepts. Our findings highlight that the far-western and mid-western districts of Nepal require the most urgent attention regarding improvements in these key socioeconomic areas.

Moreover, we identified an interesting trend indicating that districts with higher populations tend to have lower school ratios per 1,000 residents, suggesting that densely populated areas may need more targeted educational infrastructure investment. Each of the applied methods, such as spatial clustering, bivariate choropleth mapping, spatial autocorrelation, and interactive mapping played an essential role in deriving these meaningful insights.

In summary, this project offers a useful analytical framework for understanding critical factors influencing a country's development. While acknowledging the documented limitations of older data and administrative boundary changes, we suggest that these findings might remain relevant to Nepal's current socioeconomic conditions. Nonetheless, further research using updated datasets is required to confirm whether our results hold true in contemporary contexts. This work lays a solid foundation for future improvements and encourages deeper investigation into health, education, and poverty dynamics in Nepal.

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Appendix A: Metadata tables

	Software metadata description	**Software**
S1	Current software version	Python 3.13.0
S2	Permanent link to your code in your Github repository	`https://github.com/veronhoxha/health-poverty-and-education-indicators-for-nepal-districts`
S3	Legal Software License	MIT License
S4	Computing platform / Operating System	macOS Sequoia 15.0
S5	Installation requirements & dependencies for software not used in class	Install all necessary packages by running: `pip install -r requirements.txt`. Read the `README.md` file for more information.
S6	If available Link to software documentation for special software	N/A

Table 3: Software Metadata Description.

	Data metadata description	**Metadata**
D1	Data License	All information can be found here: `https://geodacenter.github.io/data-and-lab/nepal/`
D2	Dataset name / main properties	"Health, poverty and education indicators for Nepal districts" . The dataset contains development-related data for Nepal with 75 observations (districts) and 61 variables (attributes). The Data is from years 1991-2013. Source: `https://geodacenter.github.io/data-and-lab/nepal/`

Table 4: Data metadata Description.

Appendix B: AI tools used

- **ChatGPT**: used to help fix a long taking code bugs.
- **Grammarly**: to check and correct grammar errors if any (mainly punctuation).

Appendix C: Tables and Figures

Variable name	Description
id	Unique id
name_1	Nepalese region
name_2	Nepalese zone
district	Nepalese district
DepEcProv	Deprivation in economic provisioning
PovIndex	Human Poverty Index
PCInc	Per Capita Income
PCIncPPP	Per Capita Income PPP
PCIncMP	Per capita income, Rs. at market price
MalKids	Percentage of children under age five who are malnourished
Lif40	Percentage of people not expected to survive age 40
NoSafH20	Percentage without safe water
Population	Population
BoyG1_5	Number of boys enrolled in Grade 1–5 (2012–2013)
GirlG1_5	Number of girls enrolled in Grade 1–5 (2012–2013)
KIDS1_5	Number of children enrolled in Grade 1–5 (2012–2013)
SchoolCnt	Number of schools (2012–2013)
SCHLPKID	Number of schools per child (in thousands) (2012–2013)
SCHLPPOP	Number of schools per population (in thousands) (2012–2013)
AD_ILLIT	Adult illiteracy rate (2011)
AD_ILGT50	Dummy variable (1 if adult illiteracy rate >50%, 2011)
VotNum	Number of voters (lunar years 2047–2063, approx. 1991–2006)
lon	Longitude
lat	Latitude
xxCAMT*	Project sector committed amount (xx = sector)
xxDAMT*	Project sector distributed amount (xx = sector)

Table 5: Variables and their descriptions.

Figure 5: Nepal's 75 districts grouped by region into Far West, Mid West, West, Central and East[3].

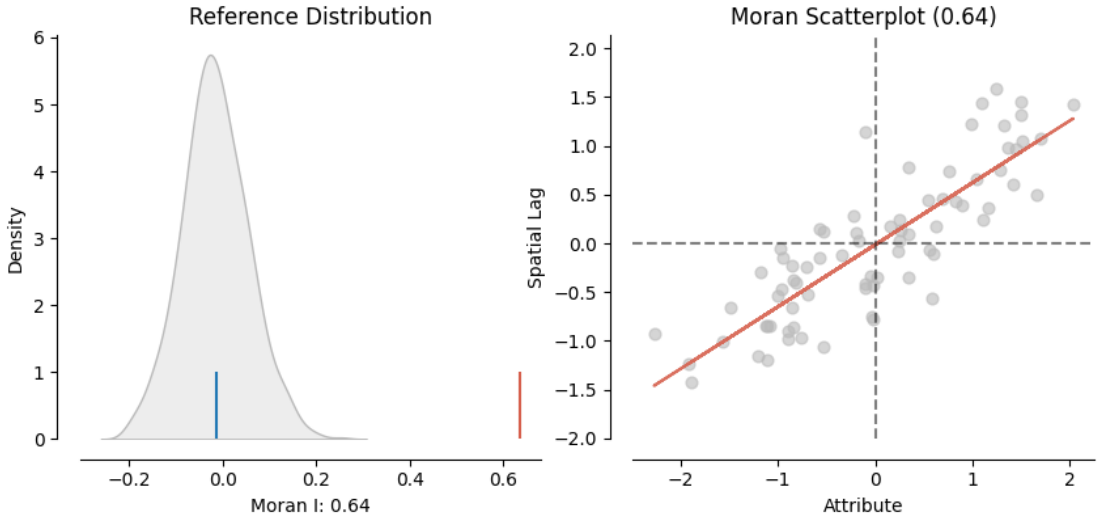

Figure 6: The Moran scatterplot for district level.

[3]This image was sourced from Wikimedia Commons (`https://commons.wikimedia.org/wiki/File:Nepal_Custom_Points_and_offices.png`) due to its better resolution. It shows the same regional grouping of Nepal's 75 districts as illustrated in Pyakurel et al. [17], which has a lower resolution.

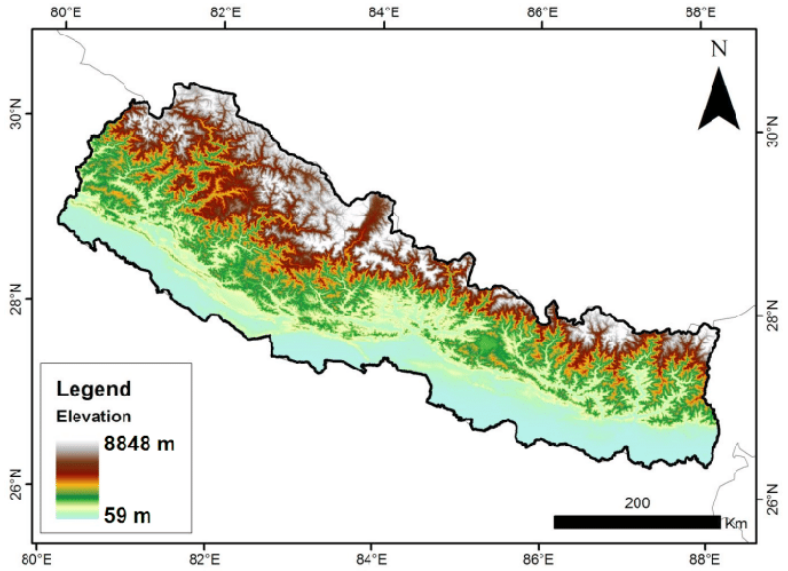

Figure 7: Elevation map of Nepal (Source: Sharma et al. [18]).

8.1 Choropleth maps - Univariate

This appendix subsection presents univariate choropleth maps for selected variables. These maps allow you to see, for each variable, which districts have higher or lower values.

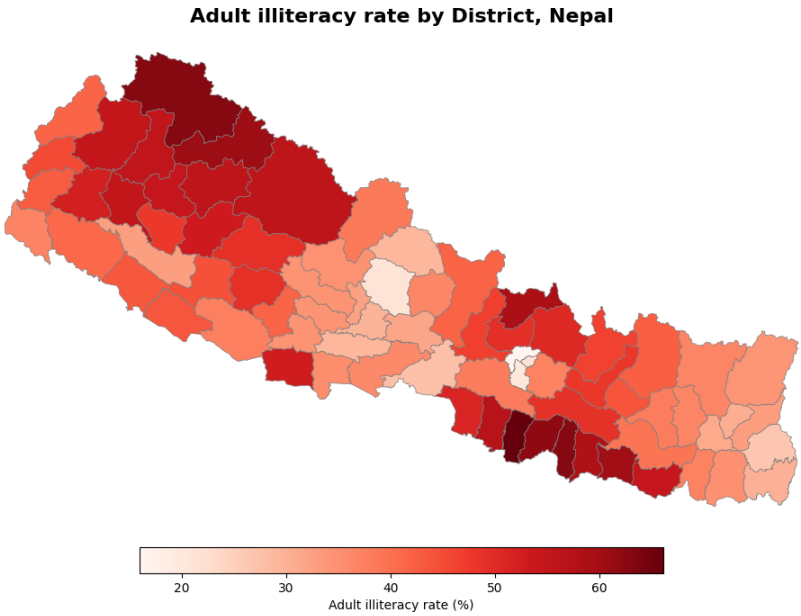

Figure 8: Univariate choropleth map of Adult illiteracy rate by District, Nepal.

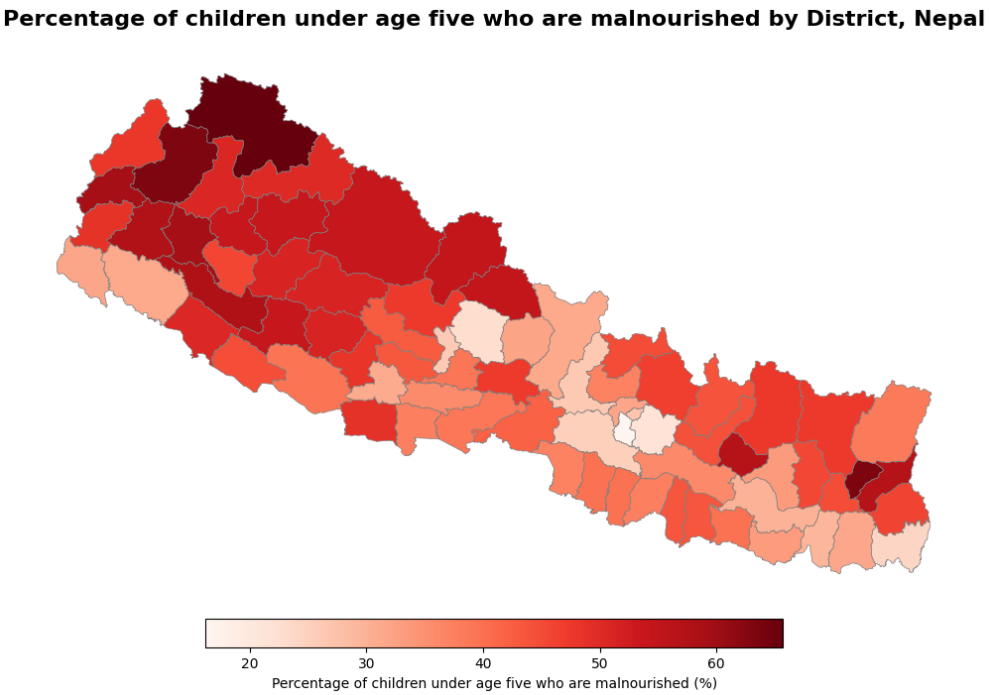

Figure 9: Univariate choropleth map of child malnutrition by District, Nepal.

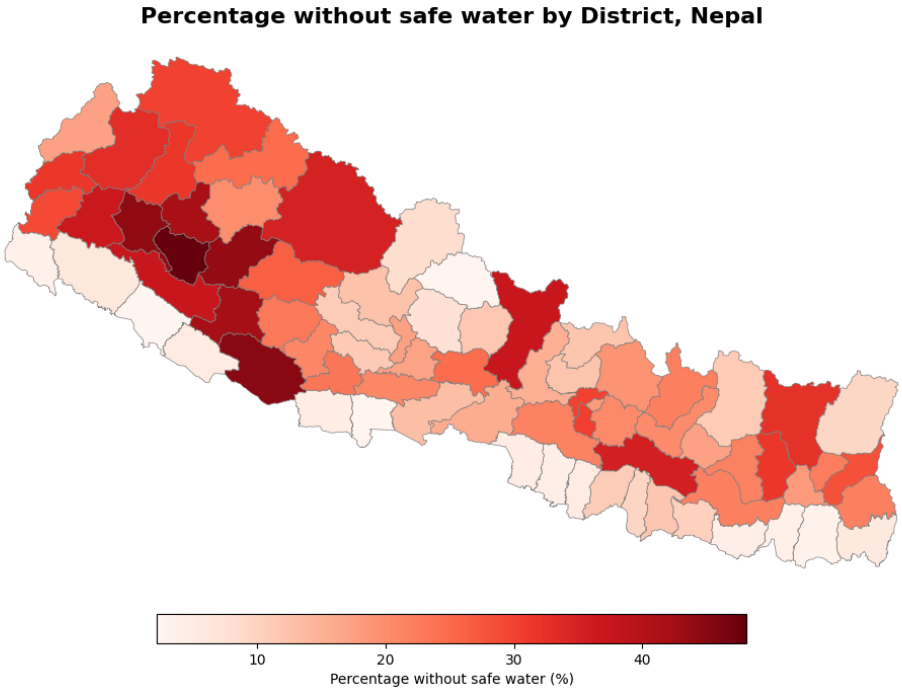

Figure 10: Univariate choropleth map of lack of safe water access by District, Nepal

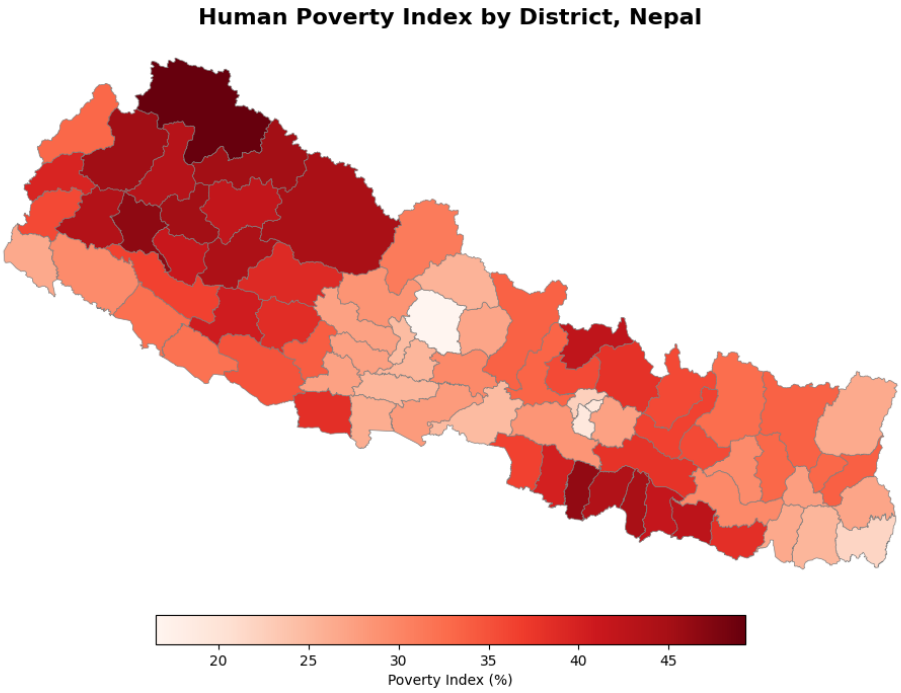

Figure 11: Univariate choropleth map of human poverty index by District, Nepal.