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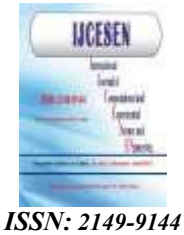

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Research Article

Dynamics of Educational Disparities in Nepal: Index-Based District Analysis across Three Census Years (2001-2021)

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Principal Component Analysis,
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Abstract:

This research develops an Education Development Index aimed at assessing and comparing educational advancement across various districts in Nepal from 2001 to 2021, highlighting trends and progress throughout this period. The EDI consists of fifteen indicators organized into four sub-domains: access, participation, quality, and achievement. It employs Principal Component Analysis and Factor Analysis to standardize and weight the indicators, with validation provided by KMO and Bartlett's tests. Districts are classified into four distinct levels of development: highly developed, developed, backward, and highly backward.The findings reveal a steady enhancement in the educational landscape across the nation, marked by rising literacy rates and an increase in the number of years individuals spend in school. Nonetheless, this advancement is marked by significant disparities. Urban centers such as Kathmandu and Lalitpur consistently demonstrate elevated EDI scores, whereas remote hill districts including Jumla, Manang, Humla, Bajhang, and Darchula have experienced significant advancements, with some transitioning from underdeveloped to highly developed status. On the other hand, certain Terai districts such as Bara, Mahottari, Kapilvastu, Banke, Kailali, and Rautahat have shown a lack of educational advancement or even a decline, underscoring the ongoing structural challenges that hinder progress. A notable observation is the evolution of educational priorities: shifting from the fundamental issues of access and participation in 2001 to a focus on institutional quality, efficiency, and learning outcomes by 2021. This change indicates a movement towards comprehensive improvement rather than simply broadening access to education. The EDI establishes a comprehensive framework for monitoring disparities, supplying essential evidence that can inform targeted policies and promote more equitable educational development across regions.

1. Introduction

To achieve sustainability in educational development, educational disparity needs to be quantified and mapped. Nepal, which has invested heavily in the education sector over the previous 20 years, considers this a top priority. The present study constructs an Education Development Index based on national census data for 2001, 2011, and 2021. This is the first such national-level effort that attempts to fully capture the spatial pattern and degree of educational disparity within all districts of Nepal. The EDI enables comparisons between individual districts objectively over different time periods. Results from this study indicate that there are very large educational disparities between districts as revealed by the indices showing how these disparities have evolved over a twenty-year period covering three census decades. Thus, this paper helps to understand disparities' persistence and change measured on an index-based scale(Motkuri, 2005; Raihan & Ahmed, 2016).

Education has become an important factor in gaining access to other social infrastructures like

healthcare and clean water. It presents issues because of the overlapping differences between geographic areas and social classes. The nation's vision is to create a modern, developed country supported by an efficiently managed workforce that is both educated and skilled. As a result, recent studies began addressing this challenge by examining district-level estimates concerning education and related infrastructure derived from census data(Nepali et al., 2019).These provide supporting evidence in the form of secondary-level explanation of spatial inequality-cum-development-oriented estimates (Angdembe et al., 2019). In Nepal, disparities show a pattern of non-linear temporal variation, with an overall declining trend indicating successive restructuring in the 2011 census. However, even by 2021, significant variation confirms periods of decline interrupted by high growth in urban cities.

The study of educational inequality has attracted a lot of scholarly attention, particularly in South Asia, where regional differences persist in spite of general progress. The focus on creating composite indices that capture the intricate, multifaceted nature of educational progress is a significant component of the academic discourse. Some studies in India, like Halder et al. (2021) and Maji & Sarkar (2017), have used Z-score normalisation techniques to measure differences at the district level. The studies, like Rasool et al. (2016), used rank-based methods. Additionally, studies had constructed composite indices using Principal Component Analysis (Naik & Sharada, 2013), the Wroclaw Taxonomic Method (Ohlan, 2013), and PCA/CCA-based frameworks in Haryana-focused analyses (Hooda et al., 2017a). These approaches support transparent weighting and capture variation in development trajectories across the regions. Drawing on UNDP Human Development Index framework, Singh and Behl (2019) computed scores that represent both deprivation and advancement, aligning the assessment of educational disparities with widely accepted benchmarks.

In the past, education was judged almost entirely by literacy rates. However, in recent years, a far wider range of indicators are employed, including the physical condition of school buildings, the effectiveness of resources used, and the quality of learning. The infrastructure of education (such as school density and pupil-teacher ratios), the learning environment (such as access to clean water and adequate sanitation) and system efficiency (such as dropout and repetition rates) are also utilized by recent research. Although core metrics like literacy, gender gaps, and enrolment remain crucial, these dimensions are critical to understanding educational progress (Maji & Sarkar, 2017; Naik & Sharada, 2013). In Nepal, the Multi-Dimensional Disparity Index by (Bhattarai et al., 2023) found education disparities within a wider set of disparities, highlighting that, how educational outcomes interact with health, economic conditions, and geography.

Taken together, the literature makes two points clear. Educational inequality is multifaceted and dynamic, requiring a diverse indicator which can actually capture education development and disparities. Moreover, to grasp the drivers of educational outcomes is the more situational disparities within their social and economic contexts. Besides this background, the present study applies an index-based approach and has two decades of Nepalese census data to trace the district-level trends in educational disparities, drawing on the recent methodological and conceptual advancement.

The study's objective is to construct an Education Development Index for Nepal's districts using the 2001, 2011, and 2021 census, thereby shedding light on patterns and progress in educational development over time. It also intends to group the districts into four levels of development to capture disparities among districts.

2. Material and Methods

Three representative primary datasets—spanning 2001, 2011 and 2021—anchor this analysis. District-level educational statistics, such, as school attendance and literacy rates are supplied by the Nepal Population and Housing Census (NPHC)(Statistics (CBS), 2003, 2014, 2023). Documented in the Statistics (CBS) releases of 2003, 2014 and 2023. Complementary administrative figures, on enrolment rates, teacher-to-student ratios and school counts are drawn from the Ministry of Education's (MoE) Flash Reports. The MoE data, from 2002, 2012 and 2022(Education (MoE), 2002, 2012, 2022) provide a baseline. Moreover the University Grants Commission's (UGC) EMIS reports furnish higher-education statistics—enrolment numbers, faculty capacity and the distribution of institutions—based on the Commission's releases in 2002, 2012 and 2022 (Commission (UGC), 2002, 2012, 2022). When combined, these datasets provide a strong and cohesive framework for analysing educational disparities over a range of time periods and across districts.

Selection and Classification of Indicators

Education development is multi-dimensional in nature. To capture this, the indicators were grouped into four intermediate dimensions.

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To construct the education development index for districts of Nepal, 15 mutually exclusive indicators of education are used, which belong to four different dimensions of educational development. The indicators used in this process are shown in Figure 1.

To reflect the development and spatial distribution of educational infrastructure relative to population and land area, a set of infrastructure densities was computed. These include the school density, campuses density, and university density. The dataset collected was recorded as the number of institutions per unit population (e.g., per 10,000 population). The absolute number of institutions (N) for each category was first derived using population (P) for each of the census using formula in equation 1.

$$Population\ density = \frac{N}{P} \quad \text{Equation (1)}$$

Where the population unit size was 10,000 for schools, 100,000 for campuses, and 1,000,000 for universities. Once the absolute number of institutions was estimated, the densities were computed by dividing N by the district's geographical area (A) as shown in Equation 2.

$$Area\ density = \frac{N}{A} \quad \text{Equation (2)}$$

These indicators offer a common measure of the availability of educational infrastructure in relation to both population and geographical size, allowing for valid comparisons between districts with varying population densities and land areas.

In order to allow for comparison among indicators, standardization was carried out using z-scores. Prior to the standardization process, negative-orientation indicators were multiplied by minus one so that higher values would always correspond to better development.

Prior to the implementation of dimension-reduction methods, we performed different tests to determine the appropriateness of our data for factor analysis. This encompassed the Normality test (Shapiro-Wilk, Lilliefors, and Anderson-Darling), Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity. The KMO value is indicative of how well the variables correlate with one another and thus justify using Principal Component Analysis (PCA) or Factor Analysis (FA). Meanwhile, Bartlett's test will indicate if a correlation matrix significantly deviates from being an identity matrix; this provides evidence that there are sufficient relationships between variables. Finally, VIF was used to check multicollinearity among indicators so that highly correlated variables do not skew results during factor extraction.

For identifying the weight of the indicators, the techniques suggested by the (OECD et al., 2008) were used, utilizing two major statistical techniques: PCA and FA. PCA was used to obtain the principal components and for the dimensionality reduction of the dataset. Factor analysis was carried out to extract the factor loadings. The square of the factor loadings was used for calculating the weights. The sum of squares for each factor loading was computed and normalized. The weights for indicators at the hierarchical intermediate level were taken from those factors whose eigenvalue is more than one. After finding out the factors that influence this set of selected indicators, then this weight of indicator was derived by that factor. Higher explanatory power, as evidenced by larger factor loadings, was translated into higher weights so that each indicator's contribution to the intermediate indicator truly reflects its importance in explaining variations within the dataset. The use of PCA and FA for deriving indicator weights has precedent in regional disparity research, where composite indices have been developed using similar statistical approaches (Hooda, Hooda, & Manocha, 2017; Hooda, Hooda, Manocha, et al., 2017). Using the obtained weights, the Education Development Index (EDI) was computed by following formula in Equation 3:

$$EDI_i = \sum_{j=1}^{n} w_j \,.\, Z_{ij} \quad \text{Equation (3)}$$

where:

i: district (or unit of analysis)

j: 1,2, …, n: number of indicators

w_j: weight of indicator

Z_{ij}: normalized value of indicator j for district i

After getting the EDI, disparity in the district-level EDI was computed using the mean and standard deviation of the EDI. Based on these, the districts were categorized into four categories(Naik & Sharada, 2013) as per the following:

Highly Developed: $EDI \geq \overline{EDI} + S.D.$

Developed: $\overline{EDI} \leq EDI < \overline{EDI} + S.D.$

Backward: $\overline{EDI} - S.D. \leq EDI < \overline{EDI}$

Highly Backward: $EDI < \overline{EDI} - S.D.$

Where,

EDI = Education Development Index of a district

$\overline{EDI}$= Mean (average) Education Development Index across all districts

S.D. = Standard Deviation of EDI values

3. Results and Discussions

The Shapiro-Wilk, Lilliefors, and Anderson-Darling tests of normality have shown that most educational indicators for the years 2001, 2011, and 2021 do not follow a normal distribution significantly, with p-values mostly less than 0.05. In 2001, normality was found in some indicators like the Student–Teacher Ratio (ED1-3) and Literacy Rate (ED7) but not in others such as dropout rates (ED5, ED6), school density (ED14, ED15), and access to higher education which clearly violated the assumption of normality. This non-normality has increased over time with more severity in 2011 and 2021 for metrics like number of campuses or schools per area and student–teacher ratios that have consistently given p-values very close to zero across several tests. These findings imply highly skewed distributions of education-related data across various districts possibly indicating structural disparities and uneven development in different regions of Nepal. The differences seen among three different tests for normality further highlight outliers and non-linear relationships within the data which are not properly fulfilled by parametric assumptions. Therefore, these results strongly recommend using non-parametric statistical methods or strict data normalization procedures before creating composite indices like the Education Development Index.

The Kaiser-Meyer-Olkin and Bartlett's Test results in Table 1 indicate that the dataset is appropriate for factor analysis in all three census years. The overall KMO values are 0.75 for 2001, 0.70 for 2011, and 0.683 for 2021 which fall under the 'good' range. This means that selected indicators have good sampling adequacy and shared variance that is appropriate to extract underlying factors. There is a small decrease in the KMO value, which has been noted for 2021; however, it still exceeds the acceptable limit of 0.60 indicating inter-correlations between variables are adequate. Bartlett's Test of Sphericity is very significant (χ^2 = 977.283 to 1101.093, $p < 0.001$) for all years thus rejecting the null hypothesis about an identity matrix and confirming that these correlation matrices are not random matrices at all. These results together allow validation of the internal consistency as well as factorability of indicators used in dimension education to construct Education Development Index.

Internal consistency of indicators of dimension education was assessed through Cronbach's Alpha (Table 2). Results indicate high reliability for all periods with alpha values of 0.816 for both 2001 and 2011 classified as excellent, and a value of 0.72 for the year 2021 indicating good internal consistency. This means that the chosen indicators are able to consistently measure the underlying construct of educational development. However, substantial disparities in item-total correlations suggest varying contributions of individual indicators over time. In 2001 and 2011, Mean Year of Schooling (ED4) and Campus per Lakh Population (ED8) exhibited the most robust correlations with the overall scale, signifying their consistent representation of educational attainment and access. Sometimes there is a weak negative in-item correlation in the Primary Dropout Rate (ED5) (0.004 in 2001) and GER 1-10 (ED13) (−0.124 in 2021) suggested that two measures may not be consistent or the context is changed in a way that affects their connection to the wider educational dimension.

Figure 2 shows that the first four to five principal components account for roughly 70–80% of the total variance in the education indicators. Similarly, in figure 3, the eigen value pattern also supports this cut-off. In 2001, eigenvalues fall below 1 after the fourth component, while in both 2011 and 2021 they drop below 1 after the fifth. Based on these patterns, the analysis retains four components for 2001 and five components each for 2011 and 2021.

Trends in educational advancement are both consistent and variable, according to an analysis of education indicators for 2001, 2011, and 2021. In all three years, Key Indicators of Mean Year of Schooling (ED4), Campus per Lakh Population (ED8), Number of Campuses per 100 sq. km (ED9), Literate Population with SLC and Above (ED10), and Total Number of Schools per 100 sq. km fell (ED15) into Subdomain 1, thus indicating a stable dimension relating to infrastructure, educational attainment, and access to education. Subdomain 2 consistently includes indicators such as the number of schools per 10,000 people (ED14) and student-teacher ratios (ED1-3), reflecting the efficacy of educational institutions and the quality of learning environments. Concurrently, Subdomain 3 consistently features NER 1-10 (ED12) and Dropout Rates (ED5-6), providing insight into system retention and educational participation. Yet higher education indicators such as Number of Universities per Ten Lakh Population (ED11) plus GER 1-10 (ED13) moved over time into different subdomain than others indicating that tertiary education is becoming more varied from basic plus secondary levels of schooling. These shifts over time illustrate the development of Nepal's educational system where an increase in access together with institutional diversity has resulted in more specialized sub dimensions within

the general framework for educational development.

The computed weights of education indicators (Table 4) show the relative importance of each indicators in contributing to the composite education development index for the years 2001, 2011, and 2021. In 2001, higher education and enrolment-related indicators had the largest weights: GER 1-10 (ED13) (0.099) and Number of Universities per 10 Lakh Population (ED11) (0.100). This highlights access and tertiary education as important factors in distinguishing district-level development. By 2011, GER 1-10 (ED13) (0.119) and Dropout Rate – Lower Secondary (ED6) (0.101) became more influential, which is an indication that there was growing attention toward retention and participation in secondary education during this period. In 2021, institutional and efficiency-related indicators gained more weight particularly Student – Teacher Ratios (ED1-3) (0.074 – 0.084) as well as school density measures; this indicates a shift towards quality education and infrastructure being key differentiators within the system. However, foundational metrics like NER 1-10 (ED12) and Literacy Rate (ED7) made less of an impact in subsequent years, most likely as a result of their widespread improvement and decreased district-to-district variation. Within the SEDI education dimension, Nepal's shift from increasing access to enhancing institutional quality and higher education differentiation is reflected in the overall temporal evolution of indicator weights.

Complex patterns of socioeconomic development over time and space are displayed in the EDI table for Nepal's districts from 2001, 2011, and 2021. Districts with high levels of development, such as Kathmandu, Lalitpur, Bhaktapur, Kaski, and Parbat, reflect the availability of infrastructure and services associated with ongoing urbanisation. Over time, a number of hill districts, including Darchula, Syangja, and Jumla, have begun to show improvements; in some cases, they have even moved from being backward to being developed or highly developed, which would suggest that localised interventions were successful. As a result of structural inequalities that persist, many Terai districts (such as Bara and Rautahat) continue to be extremely backward or have low fluctuating rankings. A case of data sensitivity or intermittent development gains may be the cause of some districts' seemingly non-linear trajectories, such as Banke and Manang, which alternate between being backward and highly developed over decades. As a result, the regional divide is widening: urban areas and a few hill districts are rapidly developing, while isolated Terai and far-western districts are falling behind. This is due to an unequal distribution of resources as well as ineffective infrastructure and governance. This implies that not all districts experience the same rate of improvement over time; despite national development initiatives, some districts stagnate or regress.

Between 2001 and 2021, Nepalese districts had different paths of development. Districts with low or moderate development statuses gave way to districts with significantly higher Educational Development Index values, including Jumla, Humla, Bajhang, Darchula, and Manang. For example, Jumla moved from being classified as low backward to highly developed; this may mean that there were successful interventions or large amounts of resources allocated in remote hill areas. The same goes for Humla and Bajhang which upgraded from backward to developed status - this means that there has been an improvement in infrastructure, education, and health sectors through some form of targeting.

On the other hand, Banke, Dang, Jhapa, Rupandehi, and Kailali had a decrease in their EDI or a decline in their rank. Banke experienced significant fluctuations; it went from being backward in 2001 to being developed in 2011 before rapidly regressing to being extremely backward by 2021. These findings reveal uneven and potentially unsustainable development trajectories. They demonstrate that progress is rarely uniform: while Nepal as a whole show’s improvement, certain districts in the Terai and Middle Hills continue to lag. This disparity highlights two distinct development patterns: some isolated hill communities have achieved rapid advancements, yet many Terai and western regions still confront significant structural and governance obstacles.

These findings demonstrate that educational progress is primarily confined to a limited number of districts, with urban centres consistently perpetuating their entrenched advantages. Consequently, regional educational disparities persist, with undeveloped areas continuing to experience pronounced developmental lags. Addressing these inequities effectively demands a shift beyond a mere place-based understanding to acknowledge the profound social-structural inequalities at play. To address this persistent issue, interventions must be context-specific. Specially, a region such as Nepal’s Madhes and its far-western hilly territories highlights the critical importance of localized approaches in bridging the educational attainment gap.

Table 1: *Tests for Suitability of Principal Component and Factor Analysis*

Year	KMO (Overall Measure)	Bartlett's Test χ^2	df	p-value
2001	0.750	977.283	105	<0.01
2011	0.700	1013.966	105	<0.01
2021	0.683	1101.093	105	<0.01

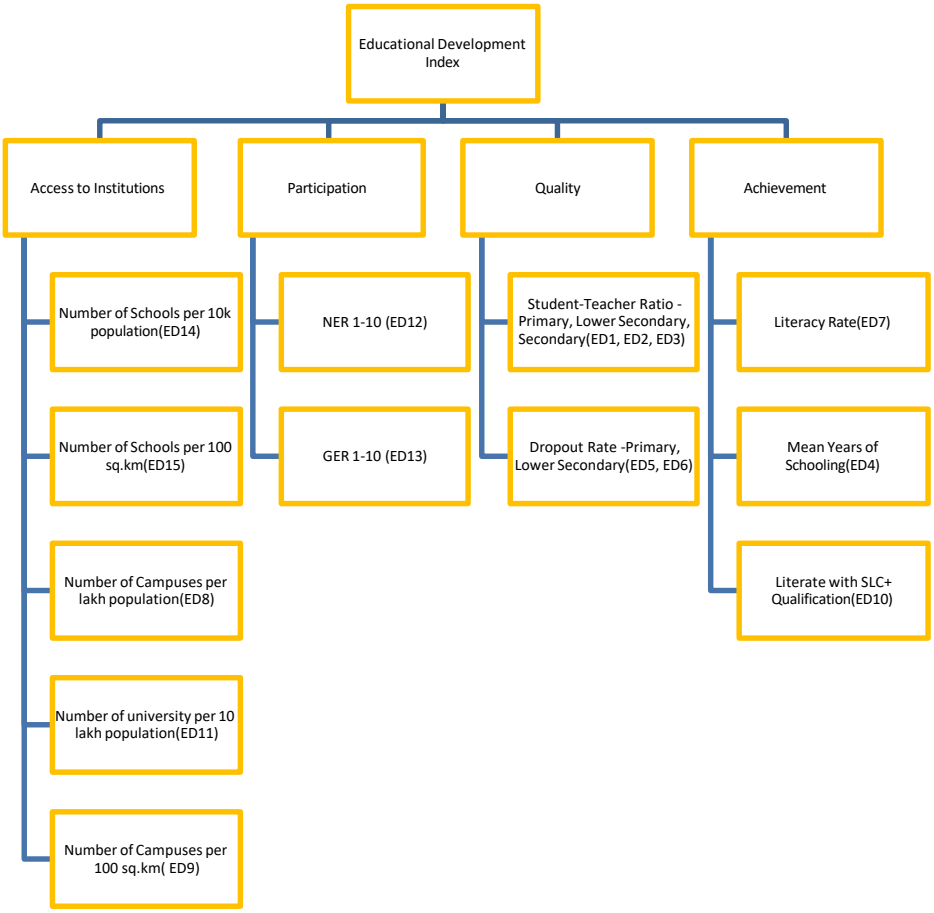

Figure 1: *Conceptual Framework of the Indicator with their notation*

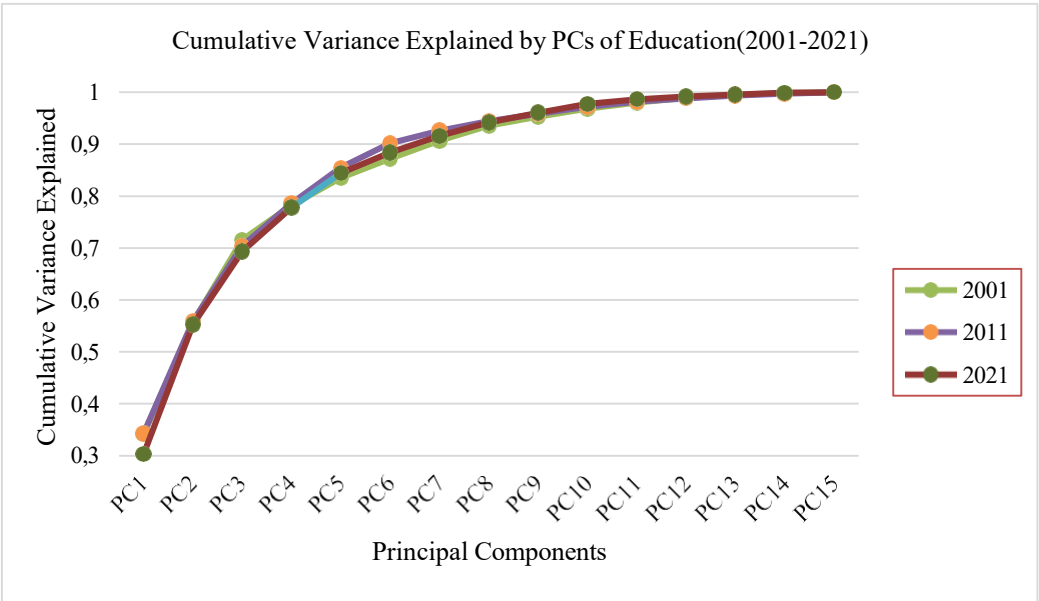

Figure 2: *Cumulative Variance explained by education indicators (2001-2021)*

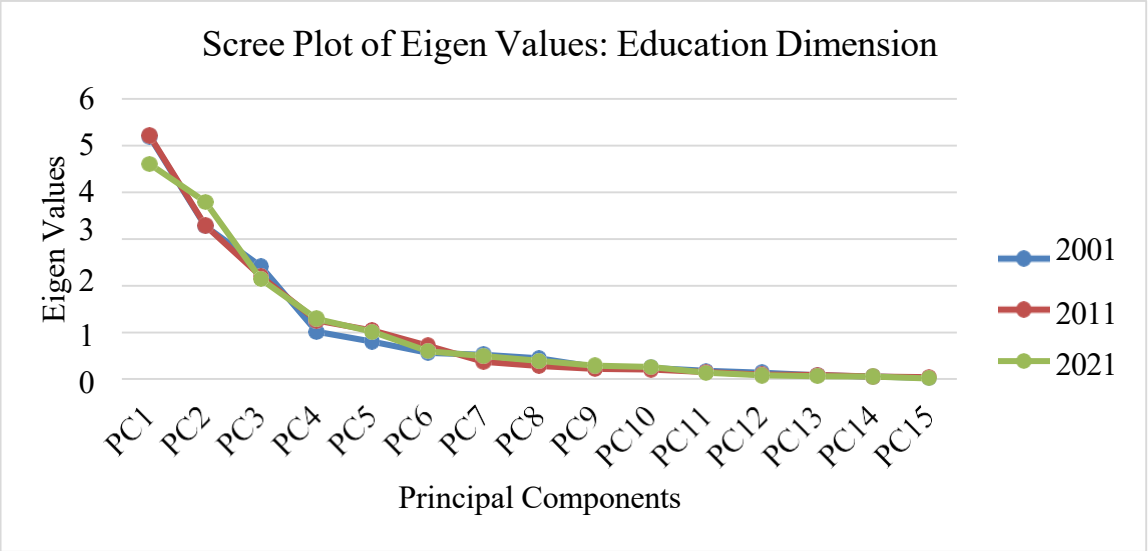

Figure 3: *PCA Results-Scree Plot of education dimension*

Table 2: *Reliability test: Cronbach's Alpha of Educational Indicators (2001–2021)*

Year	Cronbach's Alpha	Highest Item-Total Correlation	Lowest Item-Total Correlation
2001	0.816	ED4 (0.789)	ED5 (0.004)
2011	0.816	ED8 (0.814)	ED14 (0.017)
2021	0.72	ED8 (0.673)	ED13 (-0.124)

Table 3: *Sub-Domain Assignments on Factors*

Indicators	2001	2011	2021
ED1	2	2	2
ED2	2	2	2
ED3	2	2	2
ED4	1	1	1
ED5	3	3	3
ED6	2	3	3
ED7	3	2	1
ED8	1	1	1
ED9	1	1	1
ED10	1	1	1
ED11	4	5	5
ED12	3	3	3
ED13	3	4	4
ED14	2	2	2
ED15	1	1	1

Table 4: *Weights of Education Indicators (2001, 2011, 2021)*

Indicators	2001	2011	2021
ED1	0.069	0.080	0.074
ED2	0.077	0.075	0.084
ED3	0.060	0.061	0.080
ED4	0.054	0.028	0.057

ED5	0.039	0.066	0.069
ED6	0.023	0.101	0.064
ED7	0.048	0.037	0.028
ED8	0.073	0.042	0.052
ED9	0.083	0.072	0.071
ED10	0.049	0.059	0.045
ED11	0.100	0.087	0.101
ED12	0.091	0.053	0.036
ED13	0.099	0.119	0.099
ED14	0.051	0.051	0.071
ED15	0.084	0.070	0.070

Table-5: *District-wise Education Development Index (EDI) Scores and Ranks of Nepal,2001–2021*

Normalized EDI (Development), Rank			
District	**2001**	**2011**	**2021**
Achham	0.055(B), 66	0.278(B), 46	0.262(B), 58
Arghakhanchi	0.245(D), 23	0.323(D), 32	0.491(D), 26
Baglung	0.240(D), 25	0.368(D), 22	0.513(D), 21
Baitadi	0.181(B), 40	0.358(D), 25	0.507(D), 22
Bajhang	0.113(B), 54	0.299(B), 40	0.572(D), 13
Bajura	0.207(D), 32	0.278(B), 47	0.380(B), 40
Banke	0.081(B), 61	0.322(D), 33	0.183(HB), 64
Bara	0.004(HB), 73	0.050(HB), 72	0.000(HB), 77
Bardiya	0.005(HB), 72	0.224(B), 59	0.169(HB), 65
Bhaktapur	0.637(HD), 2	0.745(HD), 2	0.810(HD), 4
Bhojpur	0.187(B), 37	0.296(B), 42	0.365(B), 43
Chitwan	0.324(D), 11	0.491(HD),6	0.427(D), 33
Dadeldhura	0.051(B), 67	0.318(D), 34	0.464(D), 27
Dailekh	0.121(B), 52	0.240(B), 54	0.350(B), 45
Dang	0.269(D), 16	0.344(D), 27	0.240(B), 61
Darchula	0.253(D), 20	0.371(D), 21	0.659(HD), 9
Dhading	0.102(B), 56	0.299(B), 39	0.369(B), 42
Dhankuta	0.277(D), 14	0.372(D), 20	0.535(D), 16
Dhanusa	0.059(B), 65	0.069(HB), 71	0.149(HB), 69
Dolakha	0.173(B), 43	0.324(D), 30	0.430(D), 32
Dolpa	0.237(D), 26	0.251(B), 52	0.569(D), 14
Doti	0.145(B), 46	0.208(B), 61	0.300(B), 54
East Rukum	-	-	0.342(B),49
Gorkha	0.196(B), 35	0.295(B), 44	0.383(B), 39
Gulmi	0.226(D), 30	0.392(D), 13	0.459(D), 28
Humla	0.146(B), 45	0.246(B), 53	0.515(D), 20
Ilam	0.227(D), 29	0.296(B), 43	0.430(D), 31
Jajarkot	0.116(B), 53	0.228(B), 58	0.283(B), 56
Jhapa	0.247(D), 22	0.433(D), 7	0.277(B), 57

Jumla	0.078(B), 62	0.303(B), 38	0.841(HD), 3
Kailali	0.078(B), 63	0.197(B), 63	0.089(HB), 71
Kalikot	0.096(B), 57	0.297(B), 41	0.167(HB), 66
Kanchanpur	0.122(B), 51	0.208(B), 60	0.305(B), 53
Kapilvastu	0.045(HB), 69	0.192(B), 64	0.033(HB), 75
Kaski	0.455(HD), 4	0.592(HD), 4	0.734(HD), 7
Kathmandu	1.000(HD), 1	1.000(HD),1	1.000(HD), 1
Kavrepalanchok	0.432(HD), 5	0.528(HD), 5	0.583(D), 11
Khotang	0.186(B), 39	0.257(B), 51	0.350(B), 44
Lalitpur	0.547(HD), 3	0.701(HD), 3	0.963(HD), 2
Lamjung	0.349(D), 9	0.375(D), 19	0.565(D), 15
Mahottari	0.022(HB), 71	0.029(HB), 73	0.061(HB), 73
Makwanpur	0.174(B), 42	0.330(D), 28	0.326(B), 51
Manang	0.373(HD), 7	0.124(HB), 68	0.772(HD), 5
Morang	0.255(D), 18	0.270(B), 49	0.385(B), 38
Mugu	0.176(B), 41	0.263(B), 50	0.409(D), 36
Mustang	0.363(HD), 8	0.240(B), 55	0.738(HD), 6
Myagdi	0.253(D), 19	0.286(B), 45	0.526(D),17
Nawalparasi	0.234(D), 28	0.408(D), 9	-
Nawalpur	-	-	0.386(B), 37
Nuwakot	0.153(B), 44	0.239(B), 56	0.417(D), 35
Okhaldhunga	0.186(B), 38	0.361(D), 24	0.379(B), 41
Palpa	0.293(D), 13	0.400(D), 12	0.521(D),18
Panchthar	0.191(B), 36	0.380(D), 17	0.459(D), 29
Parasi	-	-	0.162(HB), 68
Parbat	0.383(HD), 6	0.323(D), 31	0.676(HD), 8
Parsa	0.004(HB), 74	0.099(HB), 69	0.084(HB), 72
Pyuthan	0.092(B), 58	0.185(B), 65	0.235(B), 62
Ramechhap	0.051(B), 68	0.366(D), 23	0.442(D), 30
Rasuwa	0.202(D), 34	0.273(B), 48	0.493(D), 25
Rautahat	0.000(HB), 75	0.023(HB), 74	0.048(HB), 74
Rolpa	0.122(B), 50	0.206(B), 62	0.146(HB), 70
Rukum	0.204(D), 33	0.312(D), 35	-
Rupandehi	0.245(D), 24	0.392(D), 14	0.225(B), 63
Salyan	0.090(B), 60	0.154(B), 66	0.240(B), 60
Sankhuwasabha	0.257(D), 17	0.384(D), 16	0.423(D) ,34
Saptari	0.106(B), 55	0.142(HB), 67	0.346(B), 46
Sarlahi	0.060(B), 64	0.000(HB), 75	0.033(HB), 76
Sindhuli	0.128(B), 47	0.344(D), 26	0.317(B), 52
Sindhupalchok	0.091(B), 59	0.232(B), 57	0.343(B), 48
Siraha	0.033(HB), 70	0.095(HB), 70	0.166(HB), 67
Solukhumbu	0.234(D), 27	0.311(D), 36	0.497(D), 24
Sunsari	0.210(D), 31	0.309(B), 37	0.241(B), 59

Surkhet	0.123(B), 49	0.377(D), 18	0.346(B), 47
Syangja	0.316(D), 12	0.424(D), 8	0.636(HD), 10
Tanahun	0.251(D), 21	0.386(D), 15	0.505(D), 23
Taplejung	0.274(D), 15	0.407(D), 10	0.520(D), 19
Tehrathum	0.330(D), 10	0.400(D), 11	0.577(D), 12
Udayapur	0.124(B), 48	0.326(D), 29	0.342(B), 50
West Rukum	-	-	0.298(B), 55

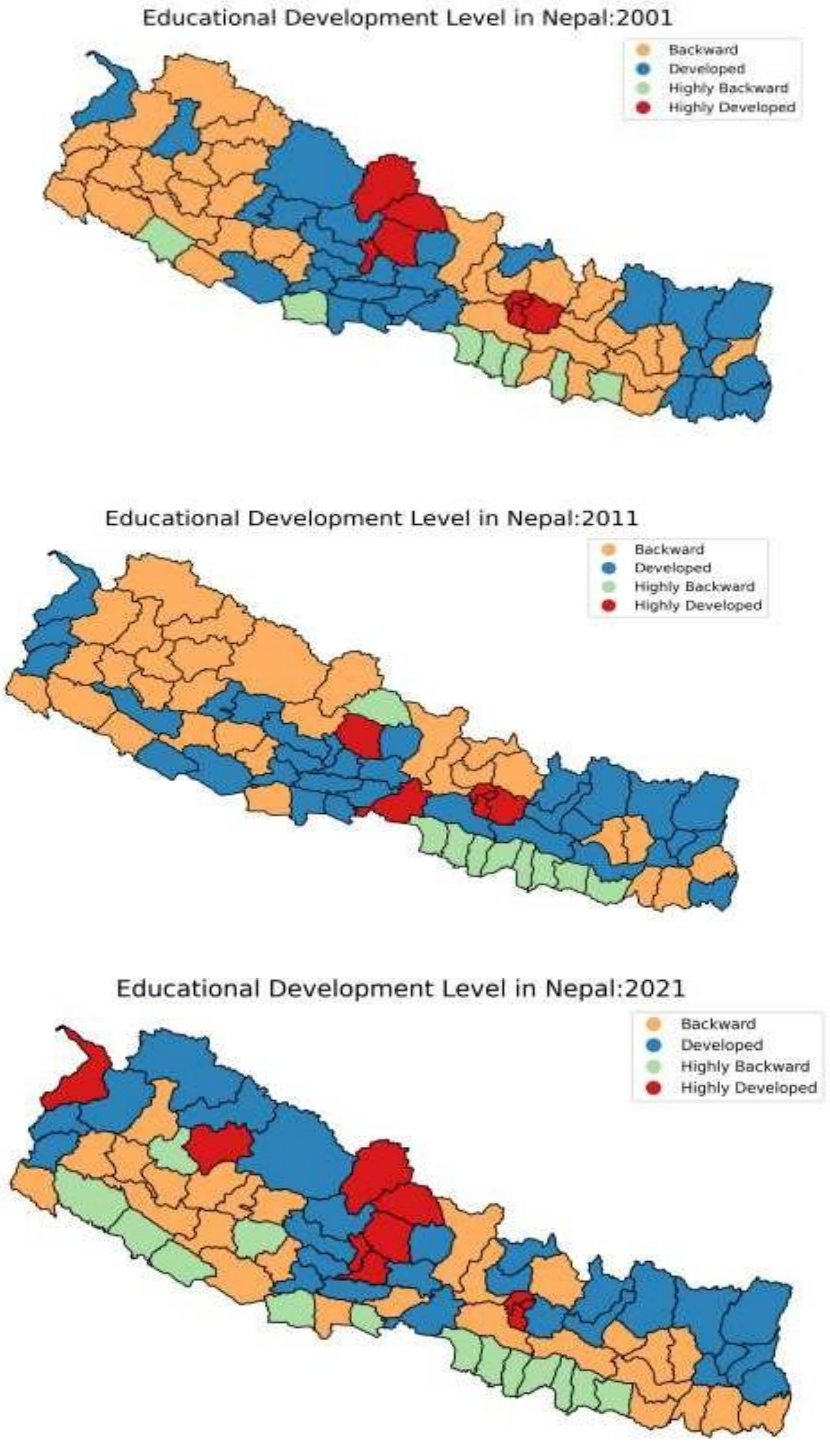

***Figure 4**: Educational Development Disparities of 2001, 2011, 2021*

Table 6: *Spatial Dynamics of Development: Top Five Risers and Fallers in District-Level EDI (2001–2021)*

Rank	District	2001 EDI (Category)	2021 EDI (Category)	Change (EDI)
Riser	Jumla	0.078 (Backward)	0.841 (Highly Developed)	0.763
	Manang	0.373 (Highly Developed)	0.772 (Highly Developed)	0.399
	Humla	0.146 (Backward)	0.515 (Developed)	0.369
	Bajhang	0.113 (Backward)	0.572 (Developed)	0.459
	Darchula	0.253 (Developed)	0.659 (Highly Developed)	0.406
Faller	Banke	0.081 (Backward)	0.183 (Highly Backward)	-0.102
	Dang	0.269 (Developed)	0.240 (Backward)	-0.029
	Jhapa	0.247 (Developed)	0.277 (Backward)	-0.03
	Rupandehi	0.245 (Developed)	0.225 (Backward)	-0.02
	Kailali	0.078 (Backward)	0.089 (Highly Backward)	-0.011

4. Discussion

This study's construction of an Education Development Index for Nepal, spanning two decades (2001-2021), rigorously quantifies the nation's educational trajectory, revealing consistent overall improvement alongside stark regional inequities. The finding resonates with broader literature on educational development, showing that urban centres like Kathmandu and Lalitpur consistently maintain high EDI scores, while remote hill districts such as Jumla and Manang have made significant advancements. Numerous studies underscore enduring rural-urban disparities in educational access and quality, frequently resulting from inequalities in infrastructure and resource distribution (Bhandari, 2018, p. 130; Devkota et al., 2021; Shakya et al., 2018). Conversely, the substantial improvements in some remote areas suggest successful localized interventions, aligning with evidence that targeted programs can effectively uplift disadvantaged regions despite overarching national challenges (Sah et al., 2024, p. 39). However, the continued stagnation of several Terai districts underscores the entrenched socio-economic and structural barriers that impede equitable educational progress, a pattern frequently observed in South Asian contexts where regional disparities persist despite general advancements (Acharya et al., 2023; Neupane, 2017, p. 68). The methodology employed, utilizing PCA and FA to construct the EDI, is a well-established approach for measuring multifaceted development indices and provides a robust framework for such regional analyses (Jana & Sar, 2016, p. 2; Oliveira & Ferreira, 2019; Xiang et al., 2019, p. 91).

A critical insight from this research is the pronounced shift in the primary drivers of educational progress, moving from an emphasis on access and participation in 2001 to institutional quality, efficiency, and learning outcomes by 2021. This transition mirrors a significant trend across South Asia, where, despite improvements in school enrollment, a "learning crisis" necessitates a renewed focus on the quality of education and actual learning outcomes rather than mere access (Asadullah et al., 2019, p. 18; Dündar et al., 2014; Human Capital Development in South Asia:, 2017, p. 10). The analysis reflects the increasing importance of indicators related to quality and higher education differentiation in this global pivot. Factors such as adequate school infrastructure, including functional electricity and sanitation, and effective governance have been identified as crucial for enhancing educational quality and student outcomes (Agénor, 2007, p. 62; Maniar, 2024a, 2024b). The persistent lagging of some Terai districts, for instance, can be attributed to the enduring impact of political instability, insufficient budget distribution, and socio-cultural barriers that hinder sustained educational development, particularly in rural settings (Neupane, 2017, p. 68; Sah et al., 2024, p. 39). Thus, Nepal's educational evolution reflects a maturation from merely expanding educational opportunities to the more complex challenge of ensuring equitable and high-quality learning experiences for all.

5. Limitations

Despite the thoroughness of the study, there are always few things that hold back the results of the research. First, there is always some risk when

utilizing secondary data like census and administrative records might be inconsistent, especially in less populated remote regions. Second, indicator selection and statistical weighting were based on solid methodology. However, the Education Development Index may not reflect fully the qualitative dimensions of education, particularly those related to the quality of learning experiences and their outcomes. Third, results aggregated at the district level may mask significant disparities that exist between areas within districts particularly rural or poor areas compared to urban centres. Finally, the analysis is based on three periods of census data; however localized changes will not be fully captured by this study nor specific policy interventions that occurred between these census periods since it is very difficult to quantify their immediate effects on educational progress precisely. Therefore, these results should be interpreted with caution because they have inherent limitations and only provide information about large-scale spatial and temporal patterns rather than being conclusive assessments about small-scale achievements in education.

6. Conclusion

This study provides a valuable insights of educational inequalities at the district level in Nepal over the past two decades and computes an updated EDI based on the 2001, 2011, and 2021 census data. Results show that the trends of education in the country are unfair and have not changed over time. High EDI urban districts are Kathmandu, Lalitpur, Bhaktapur, and Kaski. Some remote hill districts such as Jumla, Manang, Humla, Bajhang, and Darchula have made big improvements due to special efforts and wise use of resources. Stagnation or regression is now being seen in the districts located in the central-southern and mid-western Terai, such as Banke, Kailali, Rautahat, Rupandehi, and Dang. This indicates persistent educational barriers to progress.

By 2021, the focus had shifted from the expansion of access and higher education, which was a key topic at the start of the 2000s, to improving conditions in schools, student-teacher ratios, and institutional quality. Examining the indicator weights over time reveals that education has shifted its focus to improving quality and efficacy. However, the regional divide is widening. It is evident that targeted policies are urgently required to address the systemic injustices that have long been entrenched in the inner Tarai and far western hilly regions where educational deprivation still prevails. This is because national improvements conceal significant disparities within and between districts. It used quantitative weighting methods to combine secondary and administrative census data at the district level. There are some drawbacks, such as the potential for reporting errors, inability to capture intra-district variation, and exclusion of qualitative learning outcomes. However, these results provide a robust evidence-based understanding of the functioning of educational disparities in Nepal and what policy measures can reduce regional disparities while promoting inclusive and sustainable educational development.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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