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Demographic and socio-economic drivers of migration in the Indian Himalayan region: A study of Uttarkashi district, Uttarakhand

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Abstract

Migration has become an indispensable demographic process in molding social, economic, and developmental dynamics in regions. The current research takes Uttarkashi district, perhaps the most inaccessible and strategically crucial area of Uttarakhand, as its focus. Constituted officially on 24th February 1960, Uttarkashi is in the northwestern corner of the Uttarakhand state. between 30.73°N–31.28°N latitude and 78.06°E–79.01°E longitude. It is bordered by Kinnaur district of the state of Himachal Pradesh in the north, the Chinese province of Tibet in the east, Tehri Garhwal in the south, and Dehradun district and portions of Himachal Pradesh in the west. Due to its distinctive geography, socio-economic issues, and restricted livelihood opportunities, the district has also been experiencing diverse patterns of migration that need systematic statistical interpretation.

This research utilizes Principal component analysis (PCA) to investigate population demographic attributes and migration patterns of the population in Uttarkashi. The dependent variable, Migration Pattern, is defined into five categories that are mutually exclusive and distinct from one another: No Migration (reference category), Permanent Migration, Temporary Migration, Seasonal Migration, and Return Migration. All these categories offer a wide-ranging framework for interpreting the different forms of population mobility. The Multiple logistic regression (MLR) model was applied to estimate the likelihood of individuals belonging to each migration category as determined by socio-economic and demographic predictors like employment prospects, level of education, environmental factors, and family status. Controlling for other variables, the model measures the independent contribution of each predictor to the probability of migration. This analytic strategy facilitates a greater comprehension of determinants of migration both in terms of structure and behavior. The results of the study will contribute to enhancing migration scholarship by providing evidence-based answers regarding mobility drivers within Uttarkashi. The results will also provide useful information to policymakers and planners in designing regional development, labor market planning, and livelihood strategies in remote Himalayan blocks.

Keywords: Logistic regression, migration patterns, multinomial logistic regression, Uttarkashi district, population mobility, socio-economic determinants

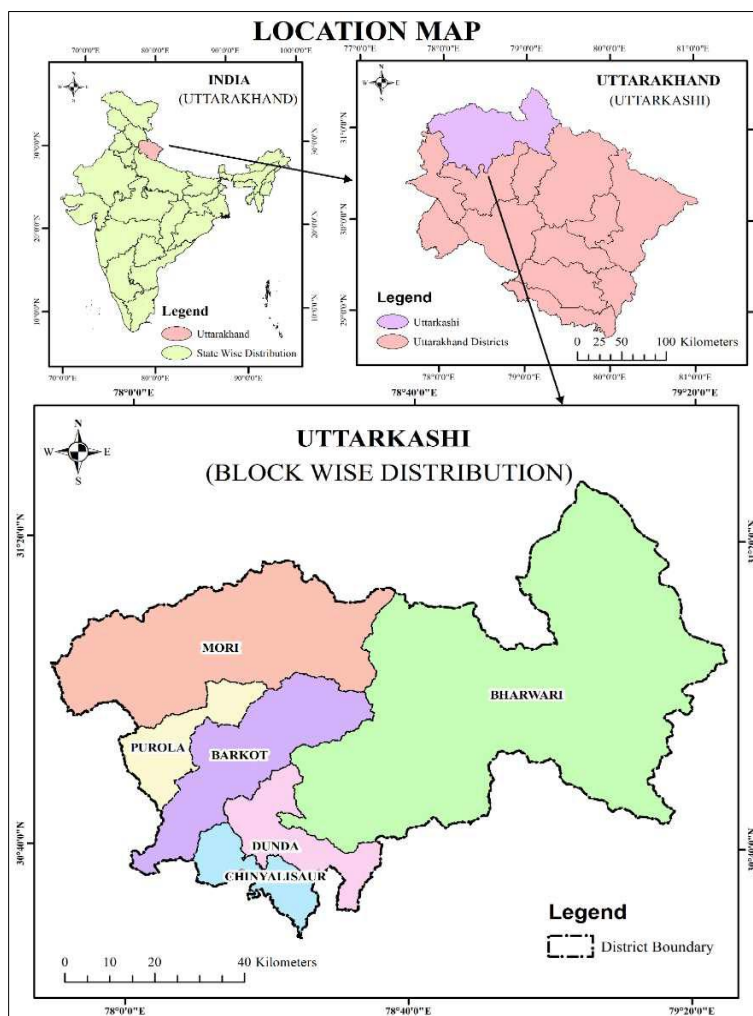
Introduction

Uttarakhand was established on November 9, 2000 when it was separated from the northwestern region of Uttar Pradesh under the Uttar Pradesh Reorganizations Act, 2000 (Government of India, 2000) ^[1]. The state is predominantly mountainous, located in the central Himalayan region, and is renowned for its scenic beauty, rich biodiversity, and diverse cultural heritage. It shares international boundaries with the Tibet Autonomous Region of China in the north and Nepal in the east, while Himachal Pradesh borders it in the northwest and Uttar Pradesh in the south (Government of Uttarakhand, 2022) ^[20]. Administratively, Uttarakhand is divided into two major geographical regions—Garhwal and Kumaon. The state comprises 13 districts, 102 tehsils, 95 development blocks, 670 Nyaya Panchayats, and approximately 7,950 Gram Panchayats (Government of Uttarakhand, 2022) ^[20]. According to the Census of India (2011) ^[7], Uttarakhand has 16,793 villages, of which 15,745 are inhabited and 1,048 are uninhabited (Registrar General & Census Commissioner of

India, 2011) ^[8]. The growing number of uninhabited villages has emerged as an important demographic concern, reflecting increasing rural out-migration and developmental disparities in remote mountainous areas (Planning Commission, 2014) ^[9]. The present study focuses on Uttarkashi district, one of the most remote and strategically important districts of Uttarakhand. Uttarkashi was constituted as a separate district on 24 February 1960 (District Administration Uttarkashi, 2022) ^[19]. Geographically, the district lies between 30°73' N and 31°28' N latitude and 78°06' E and 79°01' E longitude. It is bounded by Kinnaur district of Himachal Pradesh in the north, the Tibet Autonomous Region (China) in the east, Tehri Garhwal district in the south, and Dehradun district along with parts of Himachal Pradesh in the west (District Administration Uttarkashi, 2022) ^[19]. The district covers an area of approximately 8,016 km², making it one of the largest districts in Uttarakhand. Administratively, Uttarkashi consists of six tehsils, six development blocks, 677 revenue villages, and 427 Gram Sabhas (Uttarakhand Open Data

Portal, 2021) ^[16]. This decentralized administrative structure plays an important role in the implementation of rural development programmes and local governance, particularly in geographically inaccessible mountainous regions. According to the Census of India (2011) ^[7], Uttarkashi district has a total population of 330,086, comprising 168,597 males and 161,489 females, with a sex ratio of 958 females per 1,000 males. The district records an overall literacy rate of

approximately 65.2%, with 128,237 literate males and 86,889 literate females, indicating a considerable gender gap in literacy (Registrar General & Census Commissioner of India, 2011) ^[8]. This disparity has often been attributed to inadequate educational infrastructure, difficult terrain, socio-cultural factors, and the out-migration of educated youth from the region.



Objectives

To study about the trend, pattern and main factors of Demographic and Socio-Economic Drivers of Migration in Uttarkashi District, Uttarakhand.

Research Methodology

The study employed Principal Component Analysis (PCA) in order to reduce dimensionality and extract latent factors influencing migration patterns. Multinomial Logistic Regression (MLR) was used to estimate the likelihood of various migration categories based on socio-economic predictors

Results and Discussion

PC1: Demographic Component

The initial principal component (PC1) primarily reflects a demographic framework that influences migration patterns in the Uttarkashi district. This component shows a strong negative loading for age (-0.870), a strong positive loading

for marital status (0.914), while a moderate positive loading for occupation (0.430). Statistically, these loadings reveal that the variance in migration data associated with PC1 is predominantly explained by life-cycle stage-related variables. The inverse correlation with age indicates that younger individuals contribute more significantly to this component, likely due to greater mobility or economic aspirations. The notable impact of marital status suggests that marriage serves as either a push or pull factor for migration in this context. While occupational status has a moderate contribution, it further emphasises the significance of employment-related mobility. Consequently, PC1 can be understood as a latent demographic construct that accounts for the variability in migration linked to age, marital obligations, and occupational engagement.

PC2: Socio-Motivational Component

The second component (PC2) is regarded as a socio-motivational aspect, showcasing a very strong loading for the

reason for migration (0.980) and a moderately strong negative loading for education (-0.689). From a statistical perspective, this component encompasses a substantial portion of the variance tied to personal motivations and socio-economic backgrounds. The robust nature of the reason for migration variable indicates that this dimension is mainly driven by individual aspirations, like job opportunities, education pursuits, or infrastructure deficiencies. The negative association for education suggests that individuals with lower educational attainment may demonstrate higher migratory tendencies due to a lack of local opportunities, whereas those with advanced education may migrate through organised pathways. From the viewpoint of statistical modelling, PC2 underscores the influence of personal motivational factors in clarifying variance within the multivariate context.

PC3: Economic-Gender Component

The third principal component (PC3) encompasses both economic and gender-related variance, exhibiting a strong positive loading for household income (0.883), a strong negative loading for gender (-0.615), and a moderate loading for reason for migration (0.400). This component reveals a significant linear relationship between economic status and migration behaviour, where households with higher incomes have a greater capacity to facilitate out-migration. The negative loading for gender, assuming binary coding (e.g.,

male = 1, female = 0), points to a gendered trend in migration, with men more prominently represented in income-driven migration. The inclusion of the reason for migration variable again, though with less magnitude than in PC2, suggests overlapping variance between motivational and economic aspects. In statistical terms, PC3 delineates a distinct latent structure that explains the interaction between economic capability and demographic characteristics such as gender in understanding migration behaviour.

PC4: Spatial Component

The fourth principal component (PC4) is particularly notable as a spatial latent variable, demonstrating a very high loading from village type (0.981) and showing no significant input from other variables. The statistical interpretation in this case is clear—this component isolates the spatial or geographic aspect of migration, elucidating nearly all the variance related to the village-type variable. Considering the low uniqueness value (0.039), this variable is practically entirely represented by this component. This indicates that variations in geographic location, especially regarding remoteness or rural-urban classifications, play a statistically significant role in shaping migration patterns. Therefore, PC4 can be viewed as a pure spatial variable that elucidates structural inequalities in access and opportunity that drive mobility decisions throughout the district.

Table 1: PCA four Component

Variable	PC 1	PC 2	PC 3	PC 4	Uniqueness
Age	-0.87	.	.	.	0.277
Education	.	-0.689	.	.	0.36
Gender	.	.	-0.615	.	0.545
Household income	.	.	0.883	.	0.333
Marital Status	0.914	.	.	.	0.204
Occupation	0.43	.	.	.	0.331
Reason_of_migration	.	0.98	0.4	.	0.182
Village Type	.	.	.	0.981	0.039

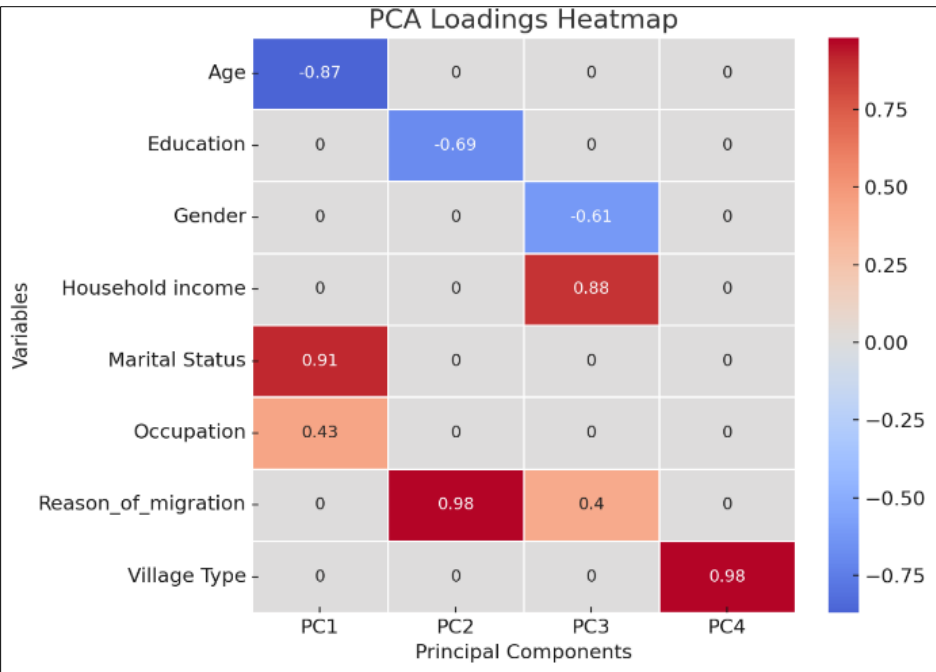


Fig 1: PCA Heatmap

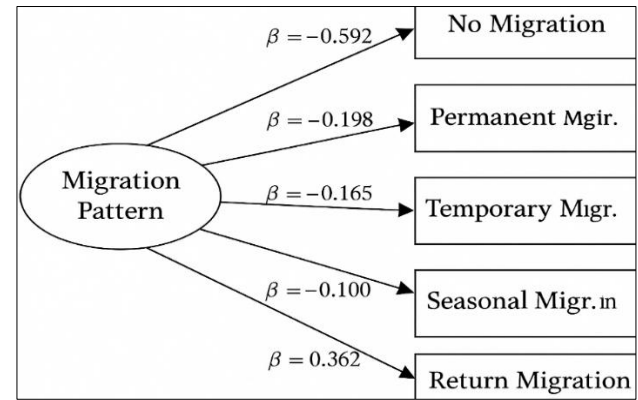


Fig 2: Migration Pattern

Component Correlation Matrix

The component correlation matrix provides valuable insights into the relationships among the extracted principal components (PCs) from the demographic and socio-economic dataset of Uttarkashi district. In an ideal Principal Component Analysis (PCA) with orthogonal rotation (such as varimax), one would expect the components to be uncorrelated, with off-diagonal elements close to zero. However, the observed matrix indicates slight to moderate correlations among some components, suggesting a minor overlap in the latent constructs they represent. Specifically, PC1 and PC2 show a weak negative correlation of -0.176, which implies that these two components have a small inverse association. Meanwhile, PC1 and PC3 exhibit a weak positive correlation of 0.201, indicating some shared variance. Additionally, there is a moderate negative correlation of -0.376 between PC2 and PC3, suggesting that these components may capture different dimensions of variation within the dataset. The correlations involving PC4 are negligible, ranging from 0.026 to 0.050, which reinforces its statistical independence from the other components. Overall, while the components are largely orthogonal, the presence of small but non-zero correlations suggests that there may be a slightly oblique structure. This warrants further examination of the underlying latent dimensions influencing migration related behavior in rural Uttarkashi. Migration pattern has predominantly negative associations with no migration, permanent migration, temporary migration, and seasonal migration, while showing a moderate positive association with return migration.

Table 2: Component Correlations and Chi-squared Test

Component Correlations				
	PC 1	PC 2	PC 3	PC 4
PC 1	1	.	.	.
PC 2	-0.176	1	.	.
PC 3	0.201	-0.376	1	.
PC 4	0.026	-0.026	0.05	1

Chi-squared Test			
	Value	df	p
Model	2330.88	2	<. 001

Conclusion

The principal component analysis (PCA) of migration data from Uttarkashi district revealed four distinct latent dimensions influencing migration patterns. PC1

(Demographic Component) highlights the role of age, marital status, and occupation, indicating that life-cycle stages and socio-demographic status had significantly impact in migration. PC2 (Socio-Motivational Component) emphasizes personal motivations and socio-economic background, especially the reasons behind migration and education levels. PC3 (Economic-Gender Component) identifies the intersection of income and gender, suggesting that economic capacity and gender roles shape migration dynamics. PC4 (Spatial Component) isolates the geographic context, showing that village type strongly determines migration patterns due to spatial disparities. Collectively, these components provide a comprehensive understanding of the demographic, socio-economic, motivational, and spatial factors that drive migration in the region. component correlation matrix reveals that while the principal components are largely orthogonal, there are minor to moderate correlations among some of them, indicating a partially overlapping structure. These weak inter-component relationships suggest that the demographic, socio-motivational, and economic-gender factors influencing migration in Uttarkashi are not entirely independent but share some variance. In contrast, the spatial component remains statistically distinct. Overall, the correlation patterns point toward a mildly oblique structure, implying that future analytical models such as Structural Equation Modeling should consider potential interdependencies among latent variables to more accurately capture the complexity of migration behavior in the region.

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