International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Demographical and Social Infrastructural Impact on Balanced Regional Development: Derivation of Settlement Orders in a Micro Region

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Abstract: ***Settlement patterns and the spatial distribution of social infrastructure play a fundamental role in determining the level of regional development, accessibility to essential services, and the overall quality of life of the population. Understanding these spatial relationships is particularly important for balanced regional planning, as disparities in the availability of educational, healthcare, administrative, and community facilities often contribute to uneven socio-economic development. This study examines the settlement pattern and demographic characteristics of a Micro Region, which is chosen as a district model as per the Indian context of administrative hierarchies pertaining to regions intermediate between Urban and National. The intervened district for the study purpose of the Research is Udupi District, in Mysuru Sub Division of Karnataka, India for analysing the distribution of social infrastructure across settlements using data from the Census of India 2011, District Census Handbook (DCHB). The research investigates the relationship between settlement hierarchy, population distribution, and the availability of key social infrastructure facilities to identify spatial variations in service accessibility. Demographic indicators such as population size, settlement distribution, and rural–urban composition are integrated with social infrastructure attributes to evaluate the functional importance of settlements within the district. The study adopts a quantitative regional planning approach using secondary data compiled, to assess the degree of infrastructural concentration and identify service-deficient settlements. The findings are expected to contribute towards understanding the spatial organisation of settlements and provide empirical evidence for prioritising infrastructure investment, reducing regional disparities, and promoting balanced and sustainable regional development. The list of settlements gets classified from the adopted methodology of scalogram model, into specific orders pertaining to the social infrastructural weightage.***

Keywords: Balanced Regional Development, Settlement Pattern Analysis, Demography and Social Infrastructure, Micro Region

1. Introduction

Settlement systems constitute the physical and functional framework through which population, economic activities, and public services are spatially organised within a region. The spatial arrangement of settlements and their hierarchical relationships significantly influence regional development by determining the accessibility of social infrastructure, economic opportunities, and public services. In regional planning, the distribution of settlements is closely associated with the equitable allocation of educational, healthcare, administrative, transportation, and communication facilities, which collectively shape the socio-economic well-being of communities. Consequently, analysing settlement patterns alongside demographic characteristics has become an important approach for identifying regional disparities and formulating balanced development strategies. Rapid demographic changes, urban expansion, and increasing demand for public services have intensified the need for scientific assessment of settlement hierarchies and infrastructure distribution. While metropolitan centres continue to attract significant investment, many rural and intermediate settlements remain characterised by inadequate access to essential social infrastructure. Such disparities hinder inclusive regional development and create spatial inequalities in education, healthcare, employment opportunities, and overall quality of life. Regional planning therefore emphasises the need to understand not only population distribution but also the functional role of settlements in delivering social services across different administrative levels. Social infrastructure represents one of the most important indicators of regional development because it directly influences human capital formation and socio-economic progress. Facilities such as educational institutions, healthcare centres, banking services, communication facilities, markets, administrative offices, and public utilities contribute to improving living standards while strengthening the functional importance of settlements. The concentration or absence of these facilities often determines the emergence of service centres and influences patterns of migration, accessibility, and regional interaction. Therefore, examining the spatial distribution of social infrastructure provides valuable insights into the developmental hierarchy of settlements and their capacity to serve surrounding areas.

Udupi District, located in the coastal region of Karnataka, exhibits a distinctive settlement structure characterised by a combination of urban centres, census towns, and numerous rural villages dispersed across diverse physiographic settings. The district has experienced considerable socio-economic transformation driven by improvements in education, healthcare, tourism, fisheries, agriculture, and service-sector activities. Despite these developments, variations in the distribution of social infrastructure across settlements continue to influence regional accessibility and developmental outcomes. A systematic assessment of these variations is therefore essential for understanding the existing settlement hierarchy and identifying areas requiring policy intervention. The findings are expected to provide an empirical basis for balanced regional planning by supporting evidence-based decision-making in the allocation of social infrastructure. Furthermore, the study contributes to the broader discourse on regional development by demonstrating how settlement pattern analysis, demographic characteristics, and social infrastructure distribution can collectively inform strategies aimed at reducing regional disparities,

strengthening rural–urban linkages, and promoting sustainable and inclusive regional development.

2. Study Area and Background

Udupi district is situated along the western coast of Karnataka, India, at the foothills of the Western Ghats, occupying a strategic position within the state's coastal belt. Geographically, the district extends between 13°08′ N and 14°00′ N latitude and 74°30′ E and 75°13′ E longitude, encompassing a total geographical area of approximately 3,582 km². It stretches nearly 98 km from north to south and about 66 km from east to west, forming a long and narrow coastal tract. Administratively, the district is bounded by Uttara Kannada to the north, Shivamogga and Chikkamagaluru to the east, Dakshina Kannada to the south, and the Arabian Sea to the west. This strategic location places Udupi at the interface of the ecologically sensitive Western Ghats and the Arabian Sea, giving rise to a unique combination of coastal and mountainous landscapes. The physiography of the district exhibits considerable diversity, with elevations ranging from approximately 100 m to over 500 m above mean sea level across much of the terrain, while the eastern mountainous belt attains considerably higher altitudes. The district is characterised by a narrow coastal plain that gradually rises eastwards into an undulating plateau before merging with the steep escarpments of the Western Ghats. Along the western margin, the coastline extends for nearly 100 km, comprising sandy beaches, estuaries, creeks, and bays formed by the mouths of several west-flowing rivers. These river valleys contain fertile alluvial deposits that have historically supported agricultural activities and human settlements. In the northern part of the district, particularly around Kundapura, the Western Ghats lie in close proximity to the coastline, reducing the width of the coastal plain to nearly 10 km, whereas elsewhere the coastal belt broadens to approximately 40–45 km. The eastern boundary is defined by the rugged terrain of the Western Ghats, where mountain peaks range between 910 m and 1,830 m above mean sea level, creating a series of steep slopes, parallel ridges, and deeply incised valleys. Among the prominent peaks, Kodachadri, located near Kundapura, rises to an elevation of approximately 1,341 m, serving as one of the most significant physiographic landmarks of the district. This varied topography, coupled with an extensive drainage network and diverse ecological conditions, has influenced the spatial distribution of settlements, land use patterns, transportation networks, and socio-economic activities across the district.

Udupi district is also recognised for its rich marine resources, religious and cultural heritage, tourism potential, and diversified economy based on fisheries, agriculture, education, and the service sector. The interaction between the coastal environment, riverine systems, and the Western Ghats has played a crucial role in shaping the evolution of settlements and the distribution of social infrastructure. Consequently, the district presents an appropriate case for examining the relationship between settlement patterns, demographic characteristics, and the spatial distribution of social infrastructure within the framework of regional planning and balanced regional development.

3. Literature Review

(Kumar Routray, 1993) critically demonstrates that although India has adopted urban and regional planning frameworks since Independence, the implementation process has remained fragmented, sector-driven, and inadequately integrated across spatial scales. The study identifies significant gaps, including the absence of a coherent national urbanisation policy, weak coordination among planning institutions, ineffective urban land management, and inadequate linkage between urban and regional planning. Furthermore, planning initiatives have largely emphasised physical infrastructure while neglecting spatial economic development, environmental sustainability, and balanced regional growth. It also argues that the piecemeal execution of development programmes, weak information systems, financial constraints, and poor monitoring have limited the effectiveness of planning interventions. These shortcomings underscore the need for integrated, decentralised, and regionally balanced planning approaches that strengthen rural–urban linkages and improve institutional coordination to achieve sustainable spatial development. (Jain & Jehling, 2020) identify several critical research gaps in the application of regional planning approaches to rapidly urbanising regions in India. The authors argue that conventional urban growth models have inadequately incorporated socio-economic and infrastructure indicators, thereby limiting their usefulness for evidence-based regional planning. They also highlight the scarcity of synchronised spatial and demographic datasets, weak integration of rural and urban planning, and the absence of effective institutional mechanisms to coordinate cross-border regional development. Furthermore, existing planning frameworks pay insufficient attention to the development potential of small and intermediate cities, despite their growing significance in future urbanisation patterns. The study also acknowledges methodological limitations arising from changing administrative boundaries, inadequate long-term spatial datasets, and the exclusion of emerging factors such as digitalisation from urban growth models. These gaps emphasise the need for integrated, data-driven, and institutionally coordinated regional planning strategies capable of addressing future spatial disparities and promoting balanced regional development.

(Ghosh & De, 2005) identify several important gaps in understanding the relationship between infrastructure development and regional economic growth in India. The authors argue that previous studies have relied on a limited set of infrastructure indicators and relatively short time horizons, restricting their ability to capture long-term regional disparities and convergence patterns. They also note the absence of comprehensive measures integrating both economic and social infrastructure, as well as the lack of reliable state-level data on infrastructure capital investments. Furthermore, the study highlights institutional challenges, including ineffective resource allocation and persistent regional imbalances despite planned development initiatives. The authors acknowledge methodological constraints arising from inconsistent data availability and the difficulty of measuring infrastructure quality across states. These issues underscore the need for integrated infrastructure indices, long-term datasets, and region-specific policy interventions to better understand infrastructure-led regional development and

reduce spatial inequalities in India. (Moulik et al., 2000) emphasise that national planning approaches are often unable to adequately address the diverse developmental characteristics and resource endowments of different regions, thereby limiting the effectiveness of policy implementation. The authors identify several research and planning gaps, including the lack of region-specific analytical frameworks, inadequate integration between regional and national planning processes, and insufficient disaggregated datasets to capture spatial variations in energy demand and resource availability. They further highlight methodological challenges associated with limited state-level data, difficulties in estimating future costs and technological changes, and the dependence on assumptions where reliable regional information is unavailable. The study also notes that centrally formulated planning decisions frequently overlook regional specificities, reducing policy effectiveness at the implementation stage. These limitations underline the need for decentralised, data-driven, and regionally integrated planning frameworks that strengthen national policies while addressing local developmental priorities and regional disparities. (Ortman & Cooper, 2021) identify several methodological limitations in conventional settlement pattern research, particularly in estimating historical population density from archaeological evidence. The authors argue that earlier approaches largely assumed a linear relationship between artifact density and population, resulting in systematic underestimation of smaller settlements and overestimation of larger ones. They further highlight the absence of theoretically grounded models capable of integrating settlement area, population, and socioeconomic interactions into a unified analytical framework. The study also acknowledges uncertainties arising from incomplete archaeological datasets, variations in artifact preservation, inconsistent occupation spans, and limited measures of settlement-level uncertainty. Additionally, the authors emphasise the need for more robust cross-cultural validation of settlement scaling relationships across different geographical and historical contexts. These limitations underscore the necessity for theory-driven, nonlinear, and empirically validated approaches that improve demographic reconstruction and strengthen settlement pattern analysis for understanding long-term spatial development and human settlement dynamics.

(Bhaker, 2014) brings attention to the limited scholarly understanding of the institutional and operational dimensions of NGOs engaged in rural development in India. The authors observe that existing research has largely overlooked critical aspects such as organisational governance, stakeholder participation, long-term sustainability, and the effectiveness of grassroots interventions. The paper further reveals that the absence of a robust theoretical foundation and the overreliance on conventional survey techniques restrict a comprehensive assessment of NGO performance and community engagement. Moreover, donor-driven, project-based implementation is shown to weaken participatory development by shifting emphasis away from locally perceived needs and priorities. The study also indicates that inadequate mechanisms for community ownership and institutional continuity reduce the long-term impact of development initiatives. These concerns reinforce the importance of adopting context-sensitive, participatory, and multidimensional research frameworks to strengthen NGO accountability and enhance the sustainability of rural development programmes. (Paul & Sen, 2018) draw attention to several conceptual and methodological gaps in metropolitan livability assessment, particularly within the context of rapidly urbanising Indian cities. The study indicates that earlier research has predominantly examined livability from physical and environmental perspectives, while comparatively limited emphasis has been placed on the social dimensions influencing community wellbeing. It also points to the absence of integrated analytical frameworks capable of capturing the interaction between urban geographic factors and spatial variations in livability across metropolitan regions. Furthermore, conventional assessment methods are shown to rely on fragmented indicators, offering limited support for understanding intra-metropolitan disparities. The authors also acknowledge methodological constraints associated with the selection of a limited number of Integrated Urban Geographic Factors (IUGFs) and the dependence on expert opinion for clustering analysis. These limitations demonstrate the need for more comprehensive, multidimensional, and empirically validated assessment frameworks that integrate physical, social, and economic dimensions to support informed urban planning and sustainable metropolitan development. (Li & Song, 2020) provide valuable insights into the spatial evolution of rural settlements; however, the study also reveals several research limitations that warrant further investigation. The analysis is primarily based on a single case study of Jizhou District, which restricts the broader applicability of its findings to regions with differing socio-economic and geographical characteristics. While the CLUE-S model effectively simulates future land-use scenarios, the modelling framework predominantly incorporates physical and accessibility-related driving factors, giving comparatively less attention to socio-economic, institutional, and governance variables that also influence settlement transformation. Moreover, the scenario-based projections are dependent on predefined assumptions, introducing uncertainties in long-term forecasting. The study further offers limited discussion on policy implementation and stakeholder participation in shaping rural settlement evolution. These shortcomings suggest the need for more integrated, multidisciplinary, and transferable modelling approaches that combine spatial, socio-economic, institutional, and governance dimensions to support sustainable rural and regional planning.

(Sharapov, 2020) critically examines the effectiveness of existing archaeological survey techniques for regional settlement pattern analysis and identifies several methodological shortcomings that limit accurate demographic reconstruction. The study demonstrates that conventional approaches, including surface collection, aerial photography, and large test pits, are often ineffective in detecting small or low-density settlements, particularly in environments with poor surface visibility. It further points out that unequal probabilities of site detection, inadequate sampling intensity, and the reliance on single survey techniques can introduce significant biases in estimating settlement hierarchy and population distribution. The research also acknowledges practical constraints such as labour-intensive fieldwork, large-area survey requirements, and the limited transferability of existing methodologies

across diverse environmental settings. These limitations underscore the importance of developing adaptive, multi-resolution, and systematically validated survey frameworks capable of improving site detection, demographic estimation, and regional settlement analysis across varied archaeological landscapes. (Tian & Mao, 2022) contribute to the understanding of the relationship between regional integration and urban sprawl; however, several research gaps remain evident. The study primarily focuses on the Yangtze River Delta (YRD), limiting the transferability of its findings to other urban agglomerations with different socio-economic, institutional, and environmental settings. Although the proposed mechanical equilibrium model incorporates urban expansion, socioeconomic development, and urban functions, it provides comparatively limited consideration of governance quality, land-use policy, institutional capacity, and environmental regulations that also shape urban growth patterns. In addition, the measurement of regional integration is largely based on simulated population flows, which may not fully represent the multidimensional interactions of economic activities, technological exchange, and institutional collaboration. The authors also acknowledge constraints related to data availability, administrative-scale analysis, and the temporal limitations of POI datasets, indicating the need for more comprehensive, multi-scalar, and empirically validated frameworks to better explain the complex dynamics between regional integration and sustainable urban development. (Hrynkevych, 2023) expose several research and policy gaps in forecasting human resource requirements for regional development, particularly within the context of regional labour market planning. The study demonstrates that existing approaches in Ukraine remain heavily dependent on normative planning and employer agreements, which fail to capture the diverse interests of stakeholders or the dynamic nature of labour market demand. It further reveals the absence of a unified methodological framework for integrating demographic projections, employer surveys, labour market intelligence, and educational planning into a coherent forecasting system. The research also acknowledges constraints arising from limited data availability, inadequate stakeholder participation, resource limitations, and uncertainties associated with migration and geopolitical disruptions. These shortcomings highlight the necessity for integrated, evidence-based, and multi-stakeholder forecasting frameworks that strengthen regional planning, improve workforce development strategies, and enhance the resilience of regional economies.

(Constanta, 2013) sheds light on several conceptual and implementation-related shortcomings in promoting active European citizenship through local and regional governance. The study suggests that although the European Union has established a legal framework safeguarding electoral rights, significant disparities persist between legislative provisions and their practical implementation across Member States. It also indicates that existing governance arrangements have been only partially successful in reducing the democratic disconnect between European institutions and citizens, resulting in consistently low electoral participation. Furthermore, limited public awareness, inadequate communication mechanisms, and weak citizen engagement continue to constrain the effective exercise of European citizenship. While the paper advocates a multi-level governance approach, it offers limited empirical evidence to evaluate the effectiveness of proposed interventions across different regional contexts. These limitations underscore the need for comparative, evidence-based, and participatory governance frameworks that strengthen citizen engagement, improve institutional coordination, and reinforce democratic participation at both local and regional levels. (Hnatkovych & Smolinska, 2023) bring forward several critical gaps in the existing framework of regional development management, particularly in the context of Ukraine's decentralisation reforms and post-conflict reconstruction. The study reveals that prevailing governance systems continue to suffer from fragmented institutional coordination, ineffective management decisions, inadequate information and monitoring mechanisms, and limited financial and administrative autonomy at the regional level. It further suggests that existing regional policies have not sufficiently integrated strategic planning, digital governance, and evidence-based decision-making to address persistent territorial disparities. Although the study proposes legal, institutional, organisational, and technological reforms inspired by European experience, the recommendations remain largely conceptual and lack empirical validation across diverse regional settings. Additionally, the framework gives limited consideration to stakeholder participation and region-specific governance dynamics. These limitations emphasise the need for more empirically grounded, integrated, and adaptive regional development models that strengthen institutional capacity, improve policy implementation, and promote balanced and sustainable regional development. (Sun et al., 2024) advance the understanding of the relationship between regional economic development and land use change, while simultaneously revealing several limitations that provide scope for future research. The study is confined to Shaanxi Province and Xi'an City, which limits the applicability of its findings to regions with different geographical, economic, and policy contexts. Although nonlinear regression effectively captures the relationship between economic growth and land use dynamics, the framework provides limited quantitative assessment of the economic impacts of specific land use policies due to methodological complexities and data constraints. The authors also acknowledge that the analysis is restricted to two administrative scales and does not adequately examine municipal- or county-level variations. Furthermore, challenges in quantifying the long-term economic benefits of land conversion and sustainable land management remain unresolved. These shortcomings highlight the need for multi-scalar, policy-oriented, and interdisciplinary research frameworks that integrate spatial, economic, and governance perspectives to support sustainable regional development and land use planning.

4. Methodology

The present study adopts a quantitative, descriptive, and spatial analytical approach to examine the influence of demographic characteristics and the distribution of social infrastructure on balanced regional development in Udupi District, Karnataka. The methodology integrates demographic analysis with settlement hierarchy assessment through a Scalogram Model, enabling the identification of infrastructural disparities and functional importance among

rural settlements. The study is entirely based on secondary data obtained from the District Census Handbook (DCHB), Census of India 2011, which provides comprehensive village-level demographic information and inventory of social infrastructure facilities. Udupi District, comprising the three taluks of Kundapura, Udupi, and Karkala, forms the spatial unit of analysis. The research was carried out in three sequential stages: (i) demographic assessment of the three taluks, (ii) preparation of a village-level scalogram depicting the availability of social infrastructure, and (iii) estimation of infrastructural weightage and ranking of settlements to determine their functional hierarchy.

UDUPI DISTRICT - 3 TALUKS (CENSUS 2011)

S. NO.	DEMOGRAPHIC ATTRIBUTES	KUNDAPURA	UDUPI	KARKALA
1	POPULATION			
	TOTAL	398471	562,799	216091
2	SEX RATIO			
	ADULT	1124	1077	1086
	CHILD	961	965	951
3	CHILD POPULATION			
	MALE	16,671	12,916	8,315
	FEMALE	16,018	12,465	7,908
	TOTAL	32,689	25,381	16,223
4	LITERACY RATE (%)			
	MALE	87.96	91.75	90.33
	FEMALE	74.45	82.01	81.37
	TOTAL	80.73	86.60	85.62
5	POPULATION DENSITY (pp/sq.km)			
		259	760	208.8
6	POPULATION			
	URBAN (%)	10.21	46.32	15.12
	RURAL (%)	89.79	53.68	84.88
7	CASTE WISE POPULATION			
	SCHEDULED CASTES	22,759	32843	19,827
	SCHEDULED TRIBES	14,719	26,087	12,091
8	CASTE WISE POPULATION (%)			
	SCHEDULED CASTES	5.71	5.84	9.18
	SCHEDULED TRIBES	3.69	4.64	5.6
9	GROWTH RATE (%)			
	URBAN	42.26	70.79	30.12
	RURAL	2.57	-19.78	1.62
	TOTAL	5.58	6.34	5.10

Figure 1: District and Division Map, Karnataka (Source: DCHB 2011), **Figure 2:** Demographic Table of 3 Sub Districts / Taluks of Udupi District (Source: DCHB 2011)

Demographic Assessment of Taluks

The first stage involved a comparative assessment of demographic indicators for the three taluks using Census 2011 data. A range of demographic variables was selected to understand the population characteristics and development potential of each taluk. These variables included total population, adult and child sex ratio, child population, literacy rate, population density, rural–urban population composition, Scheduled Caste (SC) and Scheduled Tribe (ST) population, and decadal population growth rates. The demographic profile indicates substantial variation across the district. Udupi Taluk recorded the highest population (562,799 persons) and the highest population density (760 persons/km^2), reflecting its greater degree of urbanisation and concentration of economic activities. It also exhibited the highest literacy rate (86.60%) and the largest proportion of urban population (46.32%), indicating comparatively better access to educational and urban services.

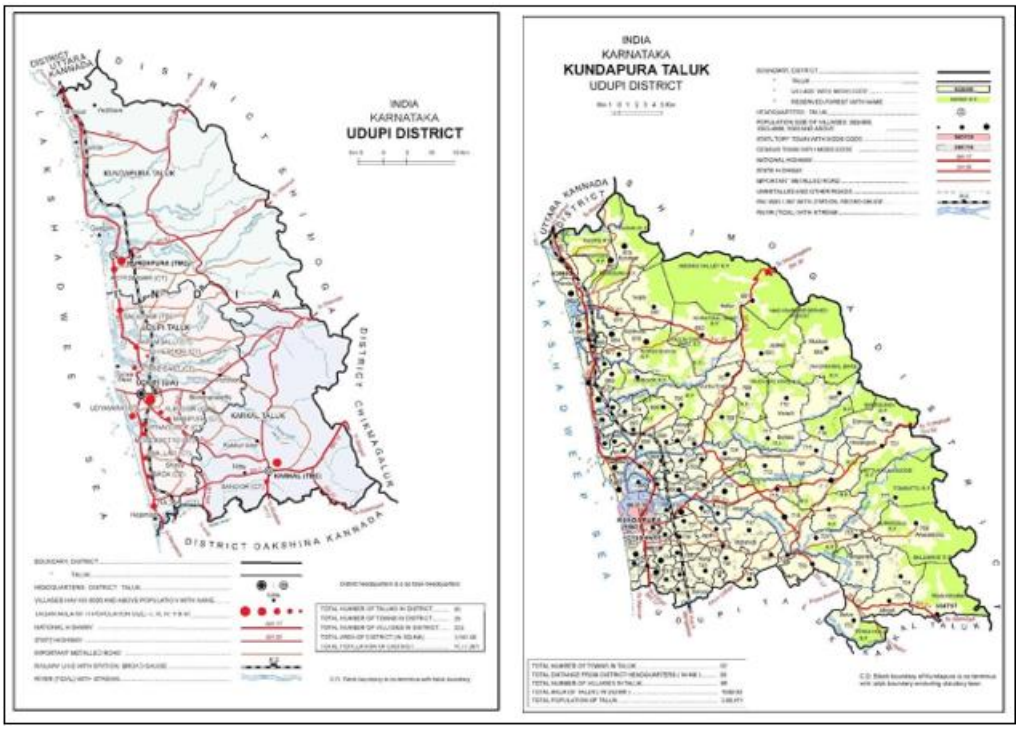

Figure 3: District Map, Udupi (Source: DCHB 2011), **Figure 4:** Sub District / Taluk Map, Kundapura (Source: DCHB 2011)

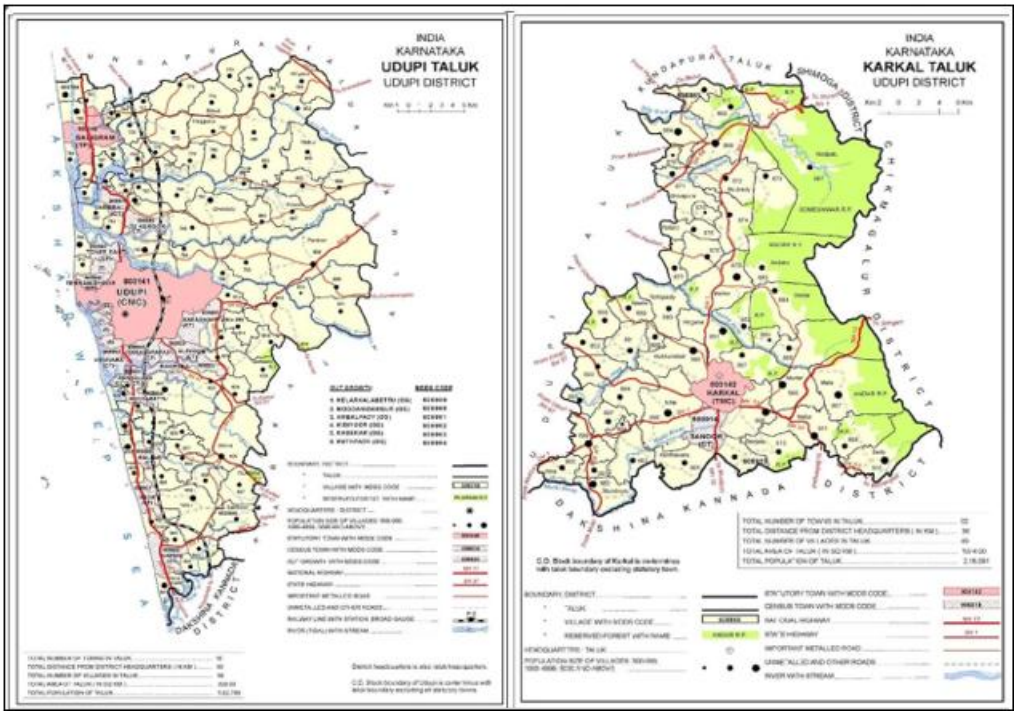

Figure 5: Sub District / Taluk Map, Udupi (Source: DCHB 2011), **Figure 6:** Sub District / Taluk Map, Karkal (Source: DCHB 2011)

In contrast, Kundapura Taluk, with a population of 398,471, remained predominantly rural (89.79% rural population) and recorded a relatively lower literacy rate (80.73%). Karkala Taluk, having a population of 216,091, displayed intermediate demographic characteristics with a literacy rate of 85.62% and approximately 84.88% rural population. Variations were also observed in sex ratio, caste composition, and urban growth rates, highlighting distinct demographic patterns across the three administrative units. These demographic indicators provided the contextual framework for evaluating the distribution and adequacy of social infrastructure within rural settlements.

Selection of Rural Settlements and Development of Scalogram

The second stage focused on analysing the spatial distribution of social infrastructure across rural settlements. From the total villages reported in the District Census Handbook, 121 rural settlements having a population exceeding 3,000 persons were selected for detailed investigation. The population threshold was adopted to ensure that only settlements possessing significant demographic concentration and greater service demand were included in the analysis. For each selected settlement, information regarding the presence or

absence of essential social infrastructure facilities was extracted from the Village Directory of the District Census Handbook (2011). The selected facilities represented the major components of regional social infrastructure and included educational institutions (primary, middle, secondary and senior secondary schools, colleges, vocational institutions), healthcare facilities (primary health centres, community health centres, hospitals, dispensaries, maternity and child welfare centres), communication and postal services, banking and cooperative institutions, markets, public distribution systems, transport and road connectivity, administrative facilities, drinking water supply, electricity, sanitation, and other community amenities. The selected variables collectively represented the functional capacity of each settlement in delivering essential public services (Mukhopadhyay, 2026).

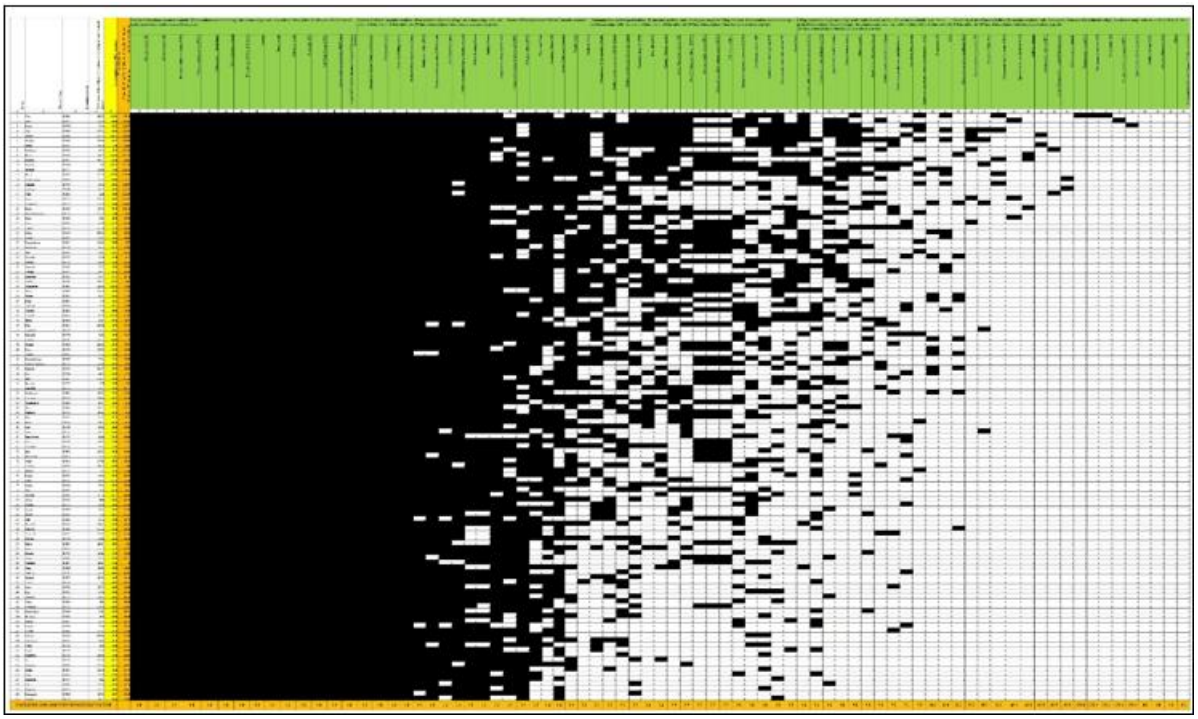

Figure 7: List of 121 Settlements Above 3000 Population Mark with Calculated Infrastructural Weightage, Ranking and Distribution Pattern (Source: Author)

A binary Scalogram Model was prepared by assigning a value of '1' where a facility was available and '0' where it was absent. The resulting matrix arranged all 121 settlements against the selected infrastructure variables, thereby presenting a comprehensive visual representation of the spatial distribution of facilities throughout the district. The scalogram enabled the identification of settlements possessing diversified infrastructure and those exhibiting infrastructural deficiencies. It further illustrated the concentration of higher-order services within larger service centres while highlighting considerable disparities among peripheral rural settlements.

Calculation of Infrastructure Weightage and Settlement Ranking

Following the preparation of the scalogram matrix, the functional significance of each infrastructure variable was estimated through the Mean Weight Factor (MWF) technique. Since all infrastructure facilities do not contribute equally to regional development, individual facilities were assigned weight values based on their frequency of occurrence among the selected settlements. Facilities available in fewer settlements were assigned relatively higher weights because they represent specialised and higher-order services, whereas commonly available facilities received comparatively lower weights. As shown in the developed framework, the calculated Mean Weight Factors ranged approximately from 1.0 for universally available basic facilities to values exceeding 120 for highly specialised facilities, thereby reflecting their relative importance in defining settlement hierarchy. The infrastructural score of each settlement was obtained by summing the respective Mean Weight Factors of all facilities available within that settlement. The cumulative score represented the Infrastructural Weightage or functional capacity of each rural settlement. Based on these scores, all 121 settlements were arranged in descending order to derive a settlement hierarchy reflecting their relative level of infrastructural development and service provision.

S. NO.	SETTLEMENT CATEGORIES	SETTLEMENT NAME	POPULATION	PROPOSED FACILITIES AND AMENITIES IN SETTLEMENT	SCALOGRAM - TOTAL POINTS
1	ORDER- 1 REGIONAL SERVICE CENTRE	Kundapura	30444	Traditional practitioner and faith healer . Public call office (PCO) Medical practitioner with MBBS Degree Community toilet including bath. Connected to national highway(NH) Weekly Haat Maternity and child welfare centre (MCW) Commercial & Co-operative Banks Mandis / Regular market Primary health centre (PHC) T.B. clinic (TBC) Community toilet excluding bath. Birth & Death Registration Office Power Supply for Commercial Use (EC) Internet cafes/ Common service centre (CSC) Self-Help Group (SHG) Power Supply for All Uses (EA) Veterinary hospital (VH) Public Library Public Reading Room Degree college of arts science & commerce (ASC) Engineering college(EC) Polytechnic (Pt) Community bio- gas or recycle of waste for productive use. ATM	URBAN SETTLEMENTS
		Udupi	144960		479.78
		Karkal	25800		239.43
		Nitte	13954		228.57
		Belle	4904		170.87
		Basrur	6613		165.93
		Hebri	6006		158.96
		Perdoor	10957		
		Yellthare	9627		
2	ORDER -2 SUB REGIONAL SERVICE CENTRE	Manur	7796	Power Supply for Commercial Use (EC) Internet cafes/ Common service centre (CSC) Self-Help Group (SHG) Power Supply for All Uses (EA) Veterinary hospital (VH) Public Library Public Reading Room Degree college of arts science & commerce (ASC) Engineering college(EC) Polytechnic (Pt) Community bio- gas or recycle of waste for productive use. ATM Community centre with/without TV Cinema / Video Hall	148.4
		Ketathattu	5173		139.52
		Shirvor	17432		131.19
		Byndoor	5245		130.2
		Gangolli	13014		127.59
		Siddapur	7401		125.22
		Shirva	13396		124.69
		Kambadakone	3806		121.2
		Chasthar	5512		118.99
		Karkunje	4361		118.11
		Neere	3055		112.33
		Arspar	6943		110.43
		Amasebelle	3034		104.87
		Bijoor	8975		102.42
3	ORDER -3 CENTRAL VILLAGE	Shankaranarayana	5144	Water bounded macadam(WBM) roads Traditional practitioner and faith healer . Public call office (PCO) Medical practitioner with MBBS Degree Community toilet including bath. Connected to national highway(NH) Weekly Haat Maternity and child welfare centre (MCW) Commercial & Co-operative Banks Mandis / Regular market Primary health centre (PHC) T.B. clinic (TBC) Community toilet excluding bath. Birth & Death Registration Office Power Supply for Commercial Use (EC) Internet cafes/ Common service centre (CSC) Self-Help Group (SHG) Power Supply for All Uses (EA) Veterinary hospital (VH) Public Library Public Reading Room Degree college of arts science & commerce (ASC) Engineering college(EC) Polytechnic (Pt) Community bio- gas or recycle of waste for productive use. ATM Community centre with/without TV Cinema / Video Hall	96.9
		Talur	3801		96.36
		Nada	4516		92.41
		Uppoor	7823		89.43
		Kollur	3295		89.32
		Belman	5045		86.86
		Bommarabettu	8365		85.7
		Tonse West	8010		85.68
		Padu	5137		84.25
		Nasunda	5749		81.7
		Kavrady	5224		81.11
		Hemmadi	4295		80.88
		Varanga	4011		80.86
		Mundkuru	5747		80.71
		Cherkady	6335		80.6
4	ORDER -4 SERVICE VILLAGE	Kukkundoor	13180	Maternity and child welfare centre (MCW) Commercial & Co-operative Banks Mandis / Regular market Primary health centre (PHC) T.B. clinic (TBC) Community toilet excluding bath. Birth & Death Registration Office Power Supply for Commercial Use (EC) Internet cafes/ Common service centre (CSC) Self-Help Group (SHG) Power Supply for All Uses (EA) Veterinary hospital (VH) Public Library Public Reading Room Degree college of arts science & commerce (ASC) Engineering college(EC) Polytechnic (Pt) Community bio- gas or recycle of waste for productive use. ATM Community centre with/without TV Cinema / Video Hall	79.02
		Mudar	6088		77.95
		Palimar	3319		77.49
		Belpu	4127		77.09
		Hejamadi	8075		76.94
		Ullargoli	5898		76.36
		Uppunda	11456		73.98
		Trashi	3140		73.07
		Eedu	5176		72.46
		Hangaloor	4547		72.29
		Hanehalli	4206		72.17
		Guhvadi	4840		71.8
		Hirgana	5019		71.54
		Belve	5455		70.61
		Kurkalu	5286		70.57
		Kirimanjeshwar	7454		70.05

Figure 8: List of Derived Order of Settlements with Proposed Amenities and Social Infrastructural Facilities (Source: Author)

The ranking process enabled the identification of higher-order rural service centres possessing diversified educational, healthcare, transport, administrative, and commercial facilities capable of serving surrounding settlements. Conversely, settlements recording lower infrastructural weightages were identified as lower-order villages, characterised by limited-service availability and greater dependence on neighbouring growth centres for higher-order functions. This hierarchical classification provided an objective basis for assessing spatial inequalities in service distribution and identifying areas requiring infrastructure augmentation. Overall, the adopted methodological framework integrates demographic analysis, spatial inventory of social infrastructure, Scalogram analysis, and Mean Weight Factor-based settlement ranking to evaluate balanced regional development in Udupi District. By combining population characteristics with functional infrastructure assessment, the methodology facilitates the identification of regional disparities, service-deficient settlements, and emerging rural growth centres. The approach provides a scientifically robust basis for regional planning by supporting evidence-based prioritisation of infrastructure investment, strengthening settlement hierarchy, improving accessibility to essential services, and promoting balanced and sustainable regional development across the district. The present research establishes that the pattern of balanced regional development in Udupi District is intrinsically linked to the functional hierarchy of settlements and the spatial distribution of social infrastructure. The assessment demonstrates that demographic characteristics alone do not determine regional importance; rather, the concentration and diversity of public facilities collectively influence the functional status of settlements and their ability to serve surrounding rural areas. The resultant settlement hierarchy reflects an organised regional structure in which higher-order settlements act as service nodes supporting progressively lower-order settlements, thereby creating an interconnected network of socio-economic interactions across the district.

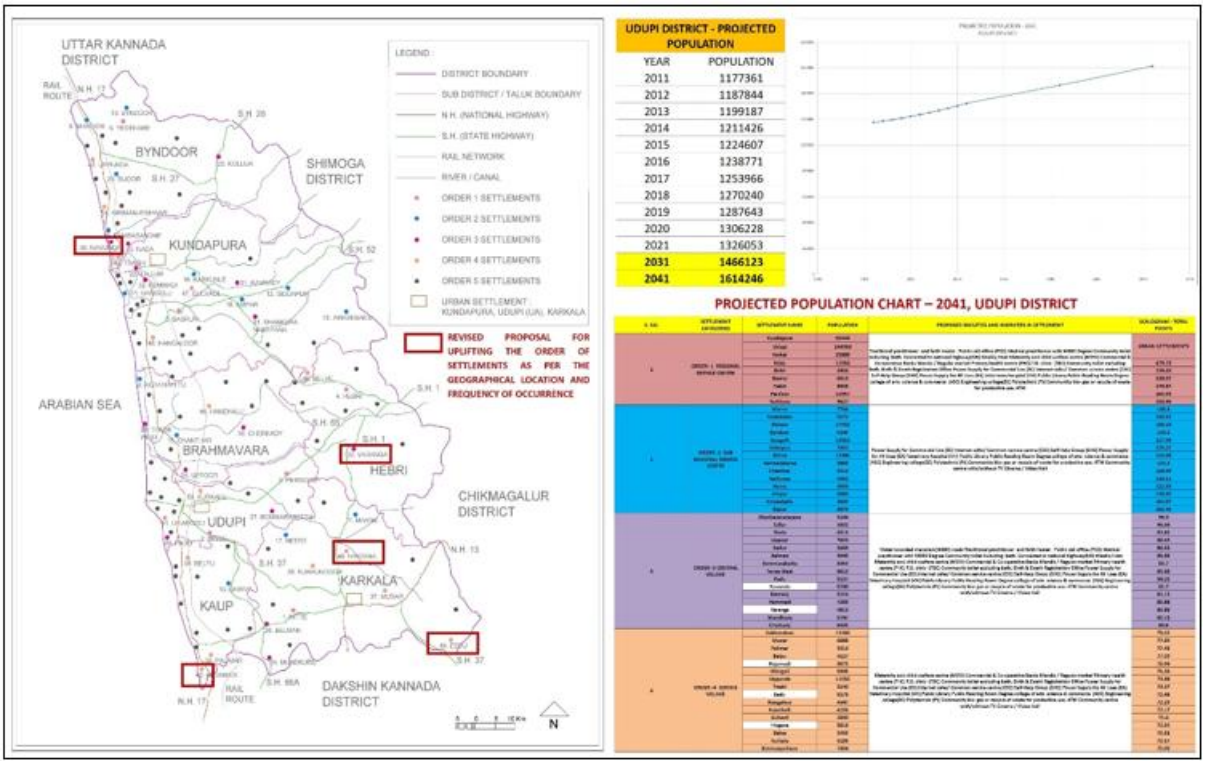

Figure 9: Udupi District Map with Mapped Settlements Hierarchy / Order, Fig.10 – District Population Forecast 2041, (Source: Author)

5. Conclusion

The analysis identifies Kundapura, Udupi, Karkala, Nitte, Belle, Basrur, Hebri, Perdoor and Yedthare as the Order-1 Regional Service Centres, representing the most functionally developed settlements within the district. Their high infrastructural scores indicate their capacity to provide specialised educational, healthcare, administrative, commercial and financial services to an extensive regional hinterland. These settlements already function as the principal growth centres of the district and are expected to remain the primary drivers of future regional development. Their strategic strengthening through higher-order institutions, advanced healthcare facilities, technological infrastructure, administrative services and economic activities will reinforce their role as regional anchors while supporting balanced spatial growth. The study further recognises Marne, Kotathattu, Shiroor, Byndoor, Gangolli, Siddapur, Shirva, Kambadakone, Chanthar, Karkunje, Neere, Ampar, Amasebailu and Bijoor as Order-2 Sub-Regional Service Centres. Owing to their favourable geographical location and relatively higher availability of social infrastructure, these settlements possess significant potential to function as intermediary service centres between the major urban nodes and the surrounding rural settlements. Their planned upgradation would substantially improve accessibility to public services, reduce travel distances for rural communities and decentralise developmental opportunities across the district.

The hierarchy also identifies Shankaranarayana, Tallur, Nada, Uppoor, Kollur, Belman, Bommarabettu, Tonse West, Padu, Navunda, Kavrady, Hemmadi, Varanga, Mundkuru and Cherkady as Order-3 Central Villages, which perform an essential role in providing local-level services to neighbouring settlements. Although these villages possess moderate infrastructural capacity, they constitute important service nodes within the rural landscape and provide opportunities for strengthening decentralised development through targeted investments in education, healthcare, local markets, banking services, community facilities and public administration. Likewise, Kukkudoor, Mudar, Palimar, Belpu, Hejamadi, Uliargoli, Uppunda, Trashi, Eedu, Hangaloor, Hanehalli, Gulvadi, Hirgana, Belve, Kurkalu and Kirimanjeshwar have been classified as Order-4 Service Villages. These settlements represent the foundational tier of the regional settlement system and require priority attention towards ensuring universal access to essential social infrastructure and basic public services that directly influence rural quality of life. The proposed order-wise distribution of facilities reflects the principle that infrastructure investment should correspond with the functional responsibility of individual settlements. Higher-order centres are capable of accommodating specialised institutions and district-level services, whereas intermediate settlements should evolve as decentralised service nodes providing secondary education, healthcare, financial institutions, commercial facilities and administrative support. Central Villages should be strengthened to serve their immediate hinterlands through enhanced community infrastructure, while Service Villages should receive priority investments in basic amenities, including primary education, primary healthcare, drinking water, sanitation, electricity, digital connectivity and all-weather road infrastructure. Such a differentiated planning strategy is likely to improve the efficiency of public investment by ensuring that facilities are provided where they can generate the greatest regional benefit.

The spatial distribution of the four settlement orders further demonstrates that regional development in Udupi District is

influenced by accessibility, transport corridors, demographic concentration and existing service availability. The identified settlements recommended for functional upgradation occupy strategically significant locations capable of extending the reach of higher-order services into presently underserved rural areas. Strengthening these settlements would improve spatial equity, enhance regional connectivity and reduce excessive dependence on a limited number of urban centres, thereby promoting a more balanced settlement system across the district. An equally significant implication of the research emerges from the projected demographic scenario. The anticipated increase in the district population from 1,177,361 in 2011 to approximately 1,466,123 by 2031 and 1,614,246 by 2041 indicates a substantial future demand for educational institutions, healthcare facilities, housing, transport infrastructure, public utilities and employment opportunities. Meeting these demands will require infrastructure planning that is both spatially coordinated and functionally aligned with the settlement hierarchy established in this research. Integrating demographic projections with hierarchical service planning provides a more sustainable basis for accommodating future growth while avoiding excessive concentration of development within a few urban centres.

Overall, the research demonstrates that balanced regional development is best achieved through a hierarchical planning framework that recognises the functional interdependence of settlements rather than treating all settlements uniformly. The identified hierarchy of Regional Service Centres, Sub-Regional Service Centres, Central Villages and Service Villages offers a practical planning framework for prioritising infrastructure investment, improving service accessibility and strengthening rural–urban linkages throughout Udupi District. Beyond its relevance to the study area, the framework provides a replicable model for district-level regional planning elsewhere in India, where evidence-based settlement classification can contribute to more equitable resource allocation, improved public service delivery and sustainable regional development.

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