



INFLUENCE OF REGIONAL TRANSPORT ACCESSIBILITY ON DEVELOPMENT OF SETTLEMENTS: A CASE OF VISAKHAPATNAM REGION

Jagrati Jain¹, Sai Sesidhar V², Naina Gupta³

¹ RV COLLEGE OF ARCHITECTURE

^{2,3}*Department of Planning,*

SCHOOL OF PLANNING AND ARCHITECTURE VIJAYAWADA

Abstract

The evolution of road development started with the idea of connecting metropolitan cities with the surrounding region. “All roads lead to Rome” which also shows us that, urban development attracts transport infrastructure. But eventually, settlements started to evolve in close proximity to the roads, which shows that development is followed by a transportation network. This has led to a common debate on what should come first, Opportunities/Settlement or Transport Infrastructure. In view of the existing literature, the interdependency of Regional Development and Transport Infrastructure can be classified under three categories which are 1. Transport system (Infrastructure) follows regional development, 2. Infrastructure development as an inductor of regional development and 3. Equality in development emphasizes balanced economic growth and infrastructure in a region. (Botrić, Šišinački and Škuflić, 2006). This study is an attempt to understand the development of the Visakhapatnam district in a regional context and its relation to the regional transportation network. The relationship between the accessibility of regional transport at the nodal level and the development of major settlements has been studied for the same. After analyzing various indicators of development and transportation infrastructure, an impact assessment of two indicators has been done. One of the indicators to study development is the growth rate in terms of the population of the Visakhapatnam region and the indicator to study transport accessibility is Shimbel's index of major nodes in the regional network. The Geographic Information System has been used as a tool to develop the Road network and to generate the initial connectivity matrix for calculating the Shimbel Index. After obtaining the data related to the indicators of regional development and transportation accessibility, regression analysis has been performed which shows the relationship between the development of major settlements and accessibility.

Keyword: Nodal Accessibility, Shimbel Index, Detour Index, Regional Transport Network, Regression Analysis

¹ Corresponding author

INTRODUCTION

The regional transport network is a web of networks connecting different settlements with other major settlements or CBD areas. This network should be designed such that it becomes accessible to other important nodes in a region. To understand the study well we have taken another south Indian city which is Calicut, so to evaluate the connection and spatial pattern of Calicut's Road network and also to find out whether the network connectivity of a region can explain the geographical pattern of the network structure. The research area's connection and coverage are directly related to the fractality of the transportation network, according to the analysis. Any other connection metric could not predict the fractality of the road network as well as network density. This suggests that the quantity of road network expansion and the geographical structure of the network inside the study region are strongly linked. (Sreelekha, Krishnamurthy and Anjaneyulu, 2016).

LITERATURE REVIEW

Road infrastructure is critical to a region's growth since it provides connectivity, accessibility, and appeal to all adjacent regions. Developers are attracted to these so-called "greenfield sites" because land prices are lower than in the city centre, land assembly is simpler, development expenses are lower, the locations are vehicle accessible, and the environmental quality is believed to be good. Unsurprisingly, investment in new roads outside of city centres has improved the accessibility of property with cheap rates and boundary ROW, putting significant strain on the new roadways. (Transport investment and economic development, 1967) (Singh, 2021)

Highways and airports have been proven to have a crucial role to promote development in an area and population expansion, according to research. The findings demonstrate that the impacts differ between the three types of areas. Population growth in rural areas is increased by making improvements in the Highway network and enhancing the accessibility of airports; The population growth in suburban areas is accelerated by enhancing airport accessibility, but population flows are supplemented by highway accessibility, and neither of both seems to affect changes in growth rates of and population of urban areas. (Chi, 2012)

Table 8: Literature Review

Sl.no	Title	Parameters	Conclusion
1	Analyzing the Dynamic Relationships between Physical Infrastructure, Financial Development and Economic Growth in India By Ranjan Kumar Mohanty -2019	Physical Infrastructure Index, GPD, Employment and Financial Development Index	There is significant impact on economic growth due to improvement of physical infrastructure.

2	Impact of Social Infrastructure and Physical Infrastructure on Economic Growth in Punjab, India By Jagmohan Singh – 2021	District-level Social Infrastructure Index, Physical Infrastructure index and Economic growth.	Physical infrastructure has a major importance in accelerating economic development in Punjab whereas the situation is not same in case of Social infrastructure.
3	Road Infrastructure and Regional Development : An Evidence from Croatia By Valerija Botric -2006	Road network, Average Annual Daily Traffic (AADT), Travel Time, Travel Speed, Employment, Tourism and GDP growth	An increase in road network has a direct positive impact on employment generation and tourism and thus has a positive impact on regional development.

Source: (Bhanumurthy, 2019) (Singh, 2021) (Valerija Botric, 2006)

Accessibility

Accessibility is the term used in urban, regional and rural transport planning and Lanusse studies. Accessibility is generally defined as ‘Ease of Reaching’. It can be measured with respect to location, modes of transport and time period. In this study we will be measuring the accessibility of locations at nodal levels.

Quantification of Accessibility

For studying a transportation network graph theory suggest various measures to quantify the connectivity and accessibility levels as follows.

Shimbel Index

The Simbel index determines the smallest number of routes essential for connecting one given node to all the other nodes in a transport network. The Shimbel accessibility matrix, known as the D-Matrix, shows the shortest path between each conceivable node pair. Basic and extremely practical metric, characterized as prospective accessibility, may be derived from the accessibility measure presented. The lower the value, the more accessible a location is.

Detour Index

The detour index calculates the accessibility of towns in a network based on the shortest distance or straight-line distance between them. It is a metric for determining the effectiveness of a transportation network based on how well it minimises distance or friction of distance. As the detour index approaches 1, the network becomes more spatially efficient. The Detour value between two places in a network is given by the following formula.

$$\text{Detour Value in \%} = (\text{Actual Distance in Km})/(\text{Straight Line Distance in Km}) * 100$$

RESEARCH METHOD

The following method of data collection and technical analysis was used. In order to perform a significant analysis and to develop a relationship Vishakhapatnam region was studied at the settlement/nodal level, the minimum number of links used to connect one settlement to all other nodes is noted, this was done using GIS and Google Earth. After data generation, it was refined in D-Matrix using Ms-Excel. Shimmel index values were recorded. One of the key factors of development is population, so in the analysis populations and population growth rate has been used to develop a relationship. Population data from the last 20 years (i.e from 1991-2011) has been taken from census records. Finally, Co-relation and simple regression have been carried out, to find out the significance of relationship between them.

STUDY AREA

Visakhapatnam is one of the coastal districts located on the Bay of Bengal coast in the state of Andhra Pradesh which is one of the southern states of India. It is one of the important regions because of its transport connectivity. The National Highway 16 (Kolkata to Chennai) passes through the city, Visakhapatnam–Chennai Industrial Corridor (VCIC) is aligned with the Golden Quadrilateral of India. It has a port with a strategic benefit of a natural harbour and the city is the headquarters of the Eastern Naval Command of the Indian navy. It is also referred to as States Financial Capital. It is one of the major tourist attractions in the state with a sea coast, eastern ghats and hill stations like Araku, Paderu etc.

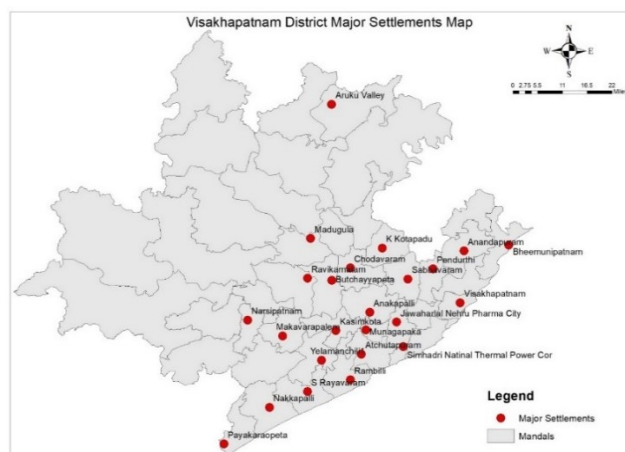


Figure 1: Map of Major settlements of Visakhapatnam district
Source: Produced by author

ANALYSIS

To understand the relationship between development and transport accessibility the data related to indicators which are urban population growth rate and shimbel's index for development and population respectively need to be analyzed for each settlement in the network.

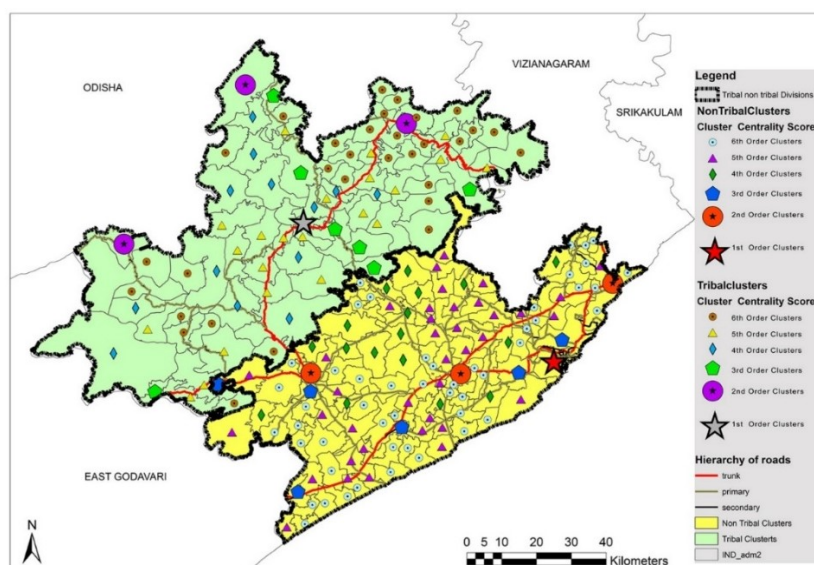


Figure 2: Development map of Visakhapatnam district

Source: Produced by author

Calculation of Population Growth Rate

As the decadal population growth rate is considered an indicator of regional development. The population data of all the settlements are collected from the Census of India – Primary Census abstract and the decadal growth rate can be calculated using the following formula.

$$\text{Decadal Population Growth Rate} = \frac{\Delta P}{P_f}$$

$$\Delta P = (P_f - P_0) = (\text{Final} - \text{Initial Population}) / \text{Decadal Change in Population}$$

$$P_f = \text{Population of } (n+1)^{\text{th}} \text{ Decade } P_0 = \text{Population of Initial } (n^{\text{th}}) \text{ Decade}$$

Calculation of Shimbel Index

Shimbel Index: Shimbel Index is a measure of accessibility among the nodes in a network which are settlements in this case. In the shimbel index, we have an original connectivity matrix (C – Matrix) and Shimbel Matrix (D-Matrix). The original connectivity matrix represents value “1” for cells where origin “i” and

destination “j” are directly connected with each other and value “0” for the cells where origin “i” and destination “j” are not directly connected by a single link.

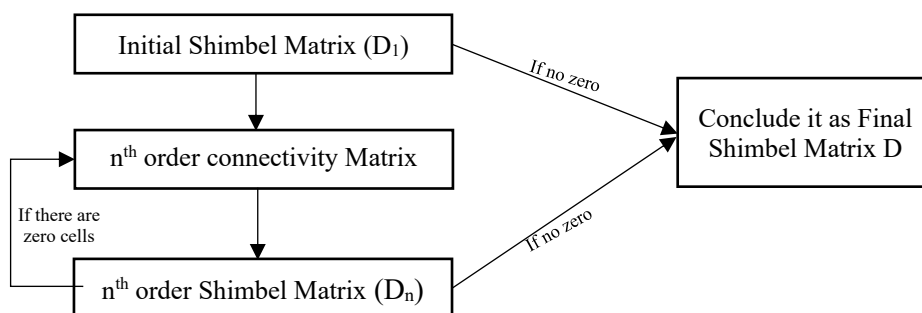


Figure 3: Flow Chart Showing calculation of Shimbel Matrix
Source: Prepared by Author

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z			
1																													
2	Anandapuram	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	
3	Pondurthi	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
4	Saltwateram	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6
5	Bheemunipattam	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
6	Jewaharal Nehru Pharma City Simhadri Natural	0	0	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	6
7	Thermal Power	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
8	K Kotkapadu	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
9	Chodavaram	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	6
10	Butchayyapeta	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3
11	Anakapatti	0	0	1	0	1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
12	Aichalapattam	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1	7
13	Munnappaka	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	6
14	Rambili	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
15	Kasimkota	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	5
16	Madugula	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	4
17	Ravikantham	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	3
18	Makawanpattam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2
19	Velamanchil	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	4
20	S Rayavaram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
21	Araku Valley	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	3
22	Narsipattam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	4
23	Nekkavathi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	4
24	Payalampattu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
25	Visakhapatnam	1	1	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
26		0	3	5	6	2	6	5	3	6	3	7	7	6	1	5	4	3	2	4	2	3	4	4	4	1	6	0	

Figure 4: Original Connectivity Matrix C1
Source: Prepared by Author

From the Initial Shimbel matrix (D_1) it can be observed that 452 cells have a “0” value which means all the corresponding origins and destinations of these cells are not directly connected to each other with one link.

$$A_{ij} = \text{Sum. } L_{ij}$$

A_{ij} is accessibility index between origin i and Destination j^{th} settlement

L_{ij} is a frictional factor between i^{th} and j^{th} settlement which may vary like: Cost of travel, Distance between 2 nodes, Number of links between zone i and j .

RESULTS AND FINDINGS

REGRESSION ANALYSIS OF POPULATION GROWTH RATE AND SHIMBEL:

The relationship between two variables is determined using regression analysis which indicates the level of dependency and association between two variables. The amount of correlation is determined by the coefficient of determination (R^2) Value. Which is given by

$$R^2 = 1 - \frac{\text{Residual Sum of Squares}}{\text{Total Sum of Squares}}$$

Here, the Shimbels index of each settlement has been considered as a parameter for transport network accessibility and the population growth rate of each settlement has been considered as a parameter for development. As we are observing the influence of transport accessibility on the development of settlements, Shimbel index is taken as an independent variable and the Population growth rate is considered as a dependent variable in the regression analysis. (Christian Heumann, 2016) (Abu Bakar, 2019)

Table 2: Shimbel index and population growth rate of Visakhapatnam district

S.No	Settlement	Shimbel	Population (2011)	Growth Rate
1	Anakapalli	54	86519	65.78%
2	Anandapuram	66	66577	12.45%
3	Aruku Valley	58	52110	18.29%
6	Butchayyapeta	67	78165	7.46%
7	Chodavaram	56	72006	31.23%
8	Jawaharlal Nehru Pharma City	55	57568	26.67%
11	Madugula	69	55520	16.96%
12	Makavarapalem	66	33757	5.12%
14	Nakkapalli	65	27001	9.98%
15	Narsipatnam	61	114270	44.22%
17	Pendurthi	56	53913	82.73%
18	Rambilli	75	70761	6.11%
19	Ravikamatam	66	6568	6.64%
20	S Rayavaram	77	86519	5.90%
22	Yelamanchilil	57	66577	34.62%

Source: Produced by author

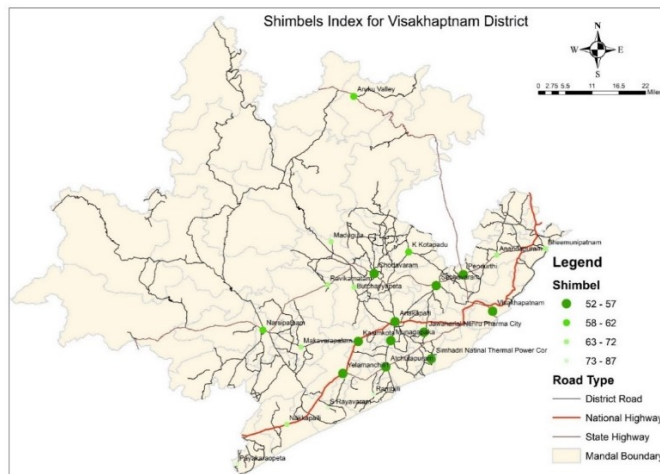


Figure 10: Map showing calculated Shimbel index of Visakhapatnam district
Source: Produced by author

The Settlements with the lowest Shimbel index are considered highly accessible and they seem to have higher population growth rates in the region establishing a positive relationship between accessibility and development. If we talk about correlation then the Shimbel index and Population growth rate have a negative correlation which indicates that accessibility is positively correlated with population growth. The following figure shows the obtained trendline.

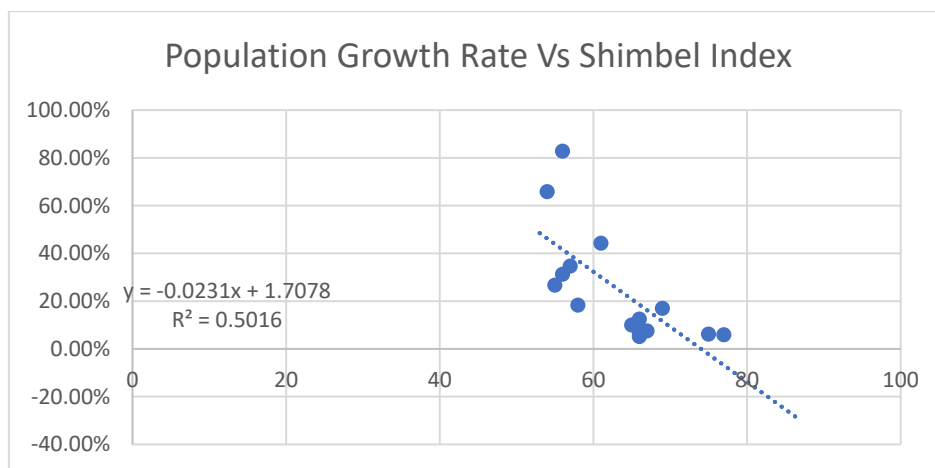


Figure 11: Graph showing Correlation between Population growth and Shimbel Index
Source: Produced by author

$$y = -0.0231x + 1.7078 \text{ and } R^2 \text{ Value} = 0.5016$$

The R^2 score in this model is 50.1 percentage. This means that the regression model explains 50% of the data is fitted. Hence, it can be stated that the plot of the population growth rate and the shimbel index has a reasonably good fit. The coefficient of variable X in the fitted equation has a “Negative” value, this shows that there is an inverse relationship between the variables.

Regression Analysis of Population and Shimbel

Here, the Shimbel index of each settlement has been considered as a parameter for transport network accessibility and also acts an independent variable. The population of settlements has been considered as a parameter for development and acts as a dependent variable as we are observing the influence of transport accessibility on the development of settlements. The results of regression show that with the increase in accessibility there is a subsequent increase in population. The following figure shows the obtained trendline. (Jagrati Jain, 2023)

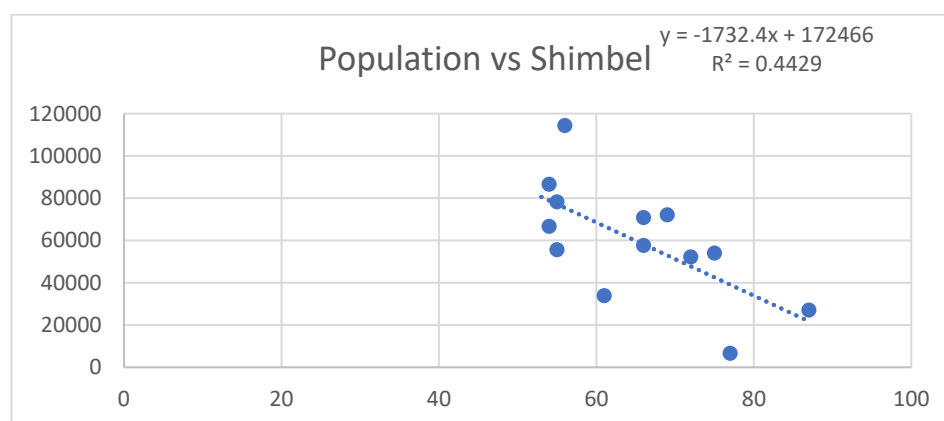


Figure 12: Graph showing Correlation between Population and Shimbel Index.
 (Source: Produced by author)

$$y = -1732.4x + 172466 \text{ AND } R^2 \text{ Value} = 0.4429,$$

The R^2 value in this model is 44.3 %. This would imply that the regression model explains 44.3 % of the fitted data. There is an inverse relationship between the variables and it can be stated that plot of the population growth rate and Shimbel index does not have a reasonably good fit compared to the previous equation.

CONCLUSION

The regression analysis between two sets of variables shows a negative correlation between both sets of variables (Population growth rate, Shimbel index) and (Population, Shimbel Index) with an R^2 value of 0.5016 and 0.4429 respectively. Inverse proportionality of Shimbel index to the accessibility of the

settlement implies that Accessibility and population growth rate are in direct relation. It can be stated that development is in direct relation with the transport accessibility of given settlements in Visakhapatnam regional network. By observing the R^2 values obtained it is evident that population growth rate is reasonable more correlated to accessibility compared to population.

In the research findings, it is understood that the accessibility of a settlement has a significant impact on the development of many sectors like trade, commerce, Industries, tourism, services etc which enhances the development and are directly dependent on the accessibility of a region. The findings can be used to identify the settlements which have lower accessibility measures and improve the same to enhance their development in future. Many researches have proven the positive effect of accessibility on population growth, this has been documented in research like (Duranton and Turner, 2012) and (Beeson, Hirsch and Rewega, 2002). However, many kinds of studies were done at local, urban and regional levels. Depending upon the selection of both the different choices, results may vary and analysis may show mixed results. Some researchers also claim the negative effect of accessibility on population growth, reason being the possibility of out-migration which can be caused by better accessibility. This case was seen in suburban and rural areas. Transport accessibility has a positive effect on population growth and other development parameters and it can have negative impacts as well. (Baum-Snow, 2010). Therefore, scope of the study suggests that the impact of accessibility and connectivity on development can further be investigated involving various other indicators of economic development using the existing results to establish more prominent relations. (Othman, 2021)

REFERENCES

- A.M Abbas, B. H. (2019). Transportation Network Analysis, Connectivity and Accessibility Indices in North East Nigeria. *Journal of research in Humanities and Social Science*, 7(9), 60-66.
- Beeson, P. M. (2002). Successful single-word writing treatment : Experimental analyses of four cases. *Aphasiology*, 473-491.
- Bhanumurthy, R. K. (2019). Analyzing the Dynamic Relationships between Physical Infrastructure, Financial Development and Economic Growth in India. *Journal of East Asian Economic Association*, 381-403.
- Chi, G. (2012). The impacts of Transport Accessibility on Population changes across Rural, Suburban and Urban areas : A Case study of Wisconsin at Sub-county levels. *Urban Studies* , 2711-2731.
- Christian Heumann, M. S. (2016). *Introduction to Statistics and Data Analysis* (1 ed.). Switzerland: Springer Nature .
- Duranton, G. a. (2012). Urban Growth and Transportation. *Review of Economic Studies*,
- Singh, J. (2021). The Impact of Social Infrastrucutre and Physical Infrastructure on Economic growth in Punjab, India. *Journal of Asian and African Studies*.
- Sreelekha, M. K. (2016). Interaction between Road Network Connectivity and Spatial Pattern. *Procedia Technology*, 131-139.

Jagrati Jain, Sai Sesidhar V, Naina Gupta

Influence Of Regional Transport Accessibility on Development of Settlements: A Case of Visakhapatnam Region

Transport investment and economic development. (1967). *Transportation Research*.

Valerija Botric, J. S. (2006). Road Infrastructure and Regional Development : An Evidence From Croatia.

Abu Bakar, A., Mohamed Osman, M., & Abdullah, M. F. (2019). EMPOWERING COMMUNITY MOVEMENT: EMPRICAL EVIDENCE. PLANNING MALAYSIA, 17(10). <https://doi.org/10.21837/pm.v17i10.648>

Othman, A. G., Hj. Ali, K., Yin, I., Tan, M. L., & Mohd Jizan, N. H. (2021). URBANIZATION AND LAND USE CHANGES IN RURAL TOWN: GUAR PLANNING MALAYSIA, 19(19). <https://doi.org/10.21837/pm.v19i19.1055>

Jagrati Jain et al 2023 IOP Conf. Ser.: Earth Environ. Sci. 1129 012045 DOI 10.1088/1755-1315/1129/1/012045

Received: 2nd May 2023. Accepted: 7th June 2023