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Transit-Supportive Densities and Land Uses: A Case of Kochi Metro

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ABSTRACT: Developing countries consider metro transit as an ideal option to meet the transportation demand of the growing population.[1] For the efficient operation of metro system, different ridership influencing factors should be allocated optimally within the station area to attract maximum number of passengers. Therefore it is important to identify the transit supportive density and land uses, which could help planners and policy makers on further station area development. In this paper, Karl's Pearson's correlation analysis method is used to find out the transit supportive densities and land uses in Kochi city. [2]Some of the ridership influencing factors taken for the study is land use variable, accessibility variable etc. The results of the analysis is highlighted in this paper.

KEYWORDS: Ridership influencing factor,Station area, Density, Land use

I. INTRODUCTION

Kochi being one of the major commercial centers of Kerala has experienced unique urban growth in recent years. [3]Therural-urban migration has changed the land uses, and had led to fast development. However, the availability of infrastructure necessities, such as public transit and facilities, has contributed to a partially balanced development. However, unregulated urban developments are posing some major problems for city dwellers.

Between 1990 and 2000, there was a significant influx of migrant workers from North and North Eastern India due to the growth of Cochin's construction sector. [4] Urban growth towards the North of the city was due to thedevelopment of satellite towns like Aluva and Angamaly. The major growth factor towards the East of the city was due to the expansion of IT industry and the special economic zone. [5] The Kerala government and planning officials has introduced metro rail as a solution to address the transportation demand of the growing populationand started the metro services in 2017. Initially metro corridor connected 22 stations fromAluva to Petta.[6]According to the detail project report of Kochi metro, projected metro ridership is 3.82lakhs.[6]But the existing ridership is only 0.34 lakhs. This means the system hasn't achieved even 10 percentage of the projected ridership. This indicates lower metro preferences of the people. [5]As per the survey conducted by Centre for Public Policy Research in 2019, some of the reasons for lower metro preferences are high ticket fare, dependency on other modes of transport, lack of last mile connectivity etc.

AIM

The research aims to find out the transit supportive densities and land uses of Kochimetro.

OBJECTIVE

- To study the different methods used for delineation of passenger catchment area.
- To study about the different factors influencing metro transit ridership.
- To identify the the transit supportive densities and land uses in Kochi city.

LIMITATION

- Final results may not be accurate since monthly average station wise ridership data was unavailable.
- Ridership influencing factors taken for the study is limited to few variables.
- The study is limited to station area from Palarivattom to Thaikoodam.

II. METHODOLOGY

- Q GIS and isochrones API is used to generate the catchment area of each metro station.
- Station wise ridership in 16 Sept 2019 is used for correlation analysis.

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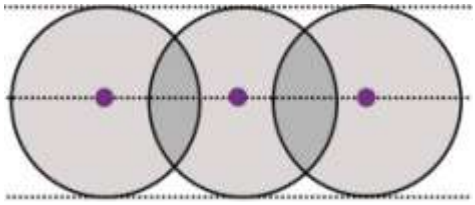
- Karl's Pearson's correlation analysis method is used to find out the transit supportive densities and land uses.

III. LITERATURE

[7] Catchment areas of public transport:In transportation planning, defining the catchment areas are important to estimate the potential ridership demand of the public transport mode. Catchment area can be defined as the area within a maximum walkable distance to or from a transit stationwhich draws majority of the passengers. According to different researches, the value of the walking distance varies from 300m to 1600m.



Public transport catchment area: 600m radius

Public transport catchment area: 300 to 1200m radius

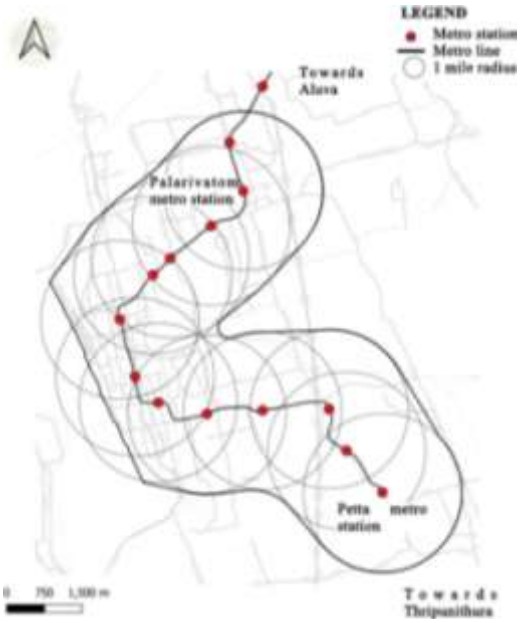
[7] Catchment area delineation:There are two different approaches in catchment area delineation. Simplest method is the circular buffer approach. This approach uses air distance from station for delineation. The second method used is the service area approach, which helps to delineate catchment area using actual road distance. Thus service area method is the ideal one.

[2] Factors influencing metro transit ridership:Some of the factors influencing ridership on public transit are population density and employment around stations, land use type and diversity, proximity to CBD, bus services, Park and Ride spaces, and the walking cost around stations etc. These variables can bemeasuredfor estimating the station wise ridership

IV. STUDY AREA

[5] Transportation needof the populationis provided by an integrated public transport system. KSRTC, KURTC, private buses, auto rickshaws, ferries, and metro rail are all part of the IPT system. The business district and campus zone on the west side of the city, followed by mobility hub in the east, are the major activity centers. The research area includes the station areas that link visitors to the Broadway Market, the campus zone, and the mobility hub (Vytilla hub). Thus, the study is concentrated on station areas from Palarivattom to Thaikoodam.

[8]**Cochin Municipal Corporation & the metro corridor**



Study Area: Palarivattom to Thaikoodam Metrostation area

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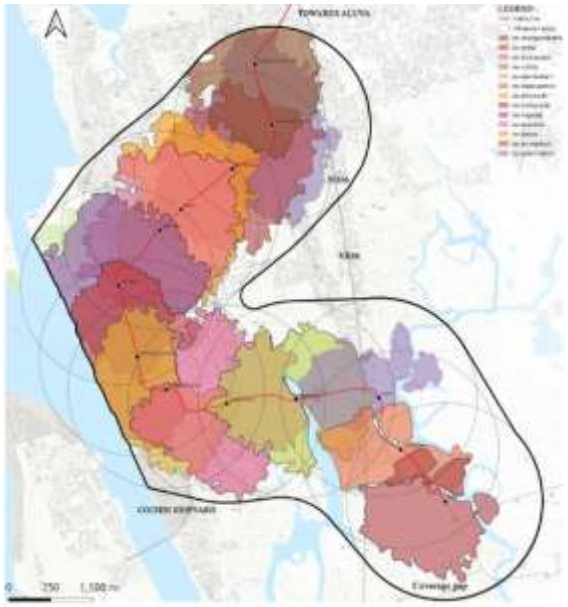
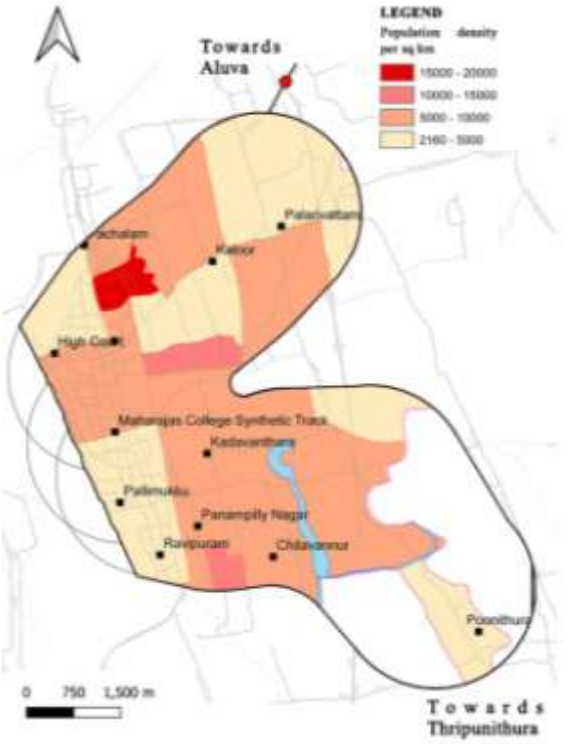
Note: Study area is delineated using circular buffer approach.

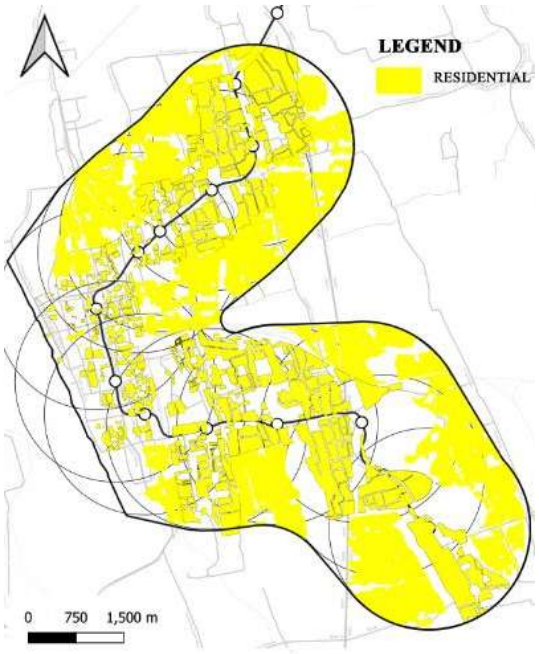


Study Area: Palarivattom to Thaikoodam Metro station area

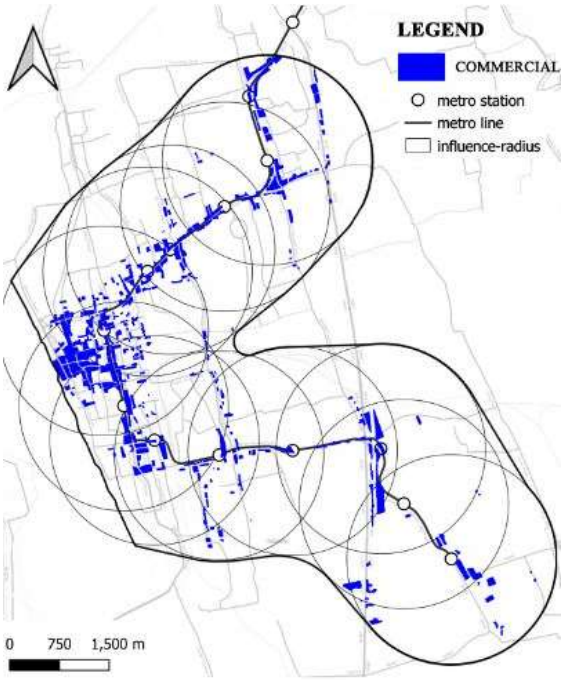
Note: Study area is delineated using service area approach.



[9]**Population Density of the Study Area**



[10]**Residential Land Useof the Study Area**



[10]**Commercial Land Useof the Study Area**

From the above maps we can observe a lower level of commercial land uses in Palarivattom, JLN stadium, Kaloor and Elamkulam station area. Usually Commercial activities and high density residential area attract large number of passengers. So the ridership in these stations is likely to be low.

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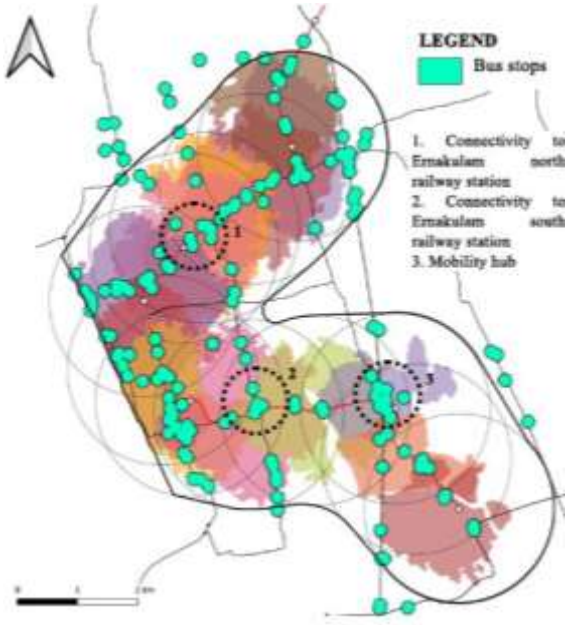
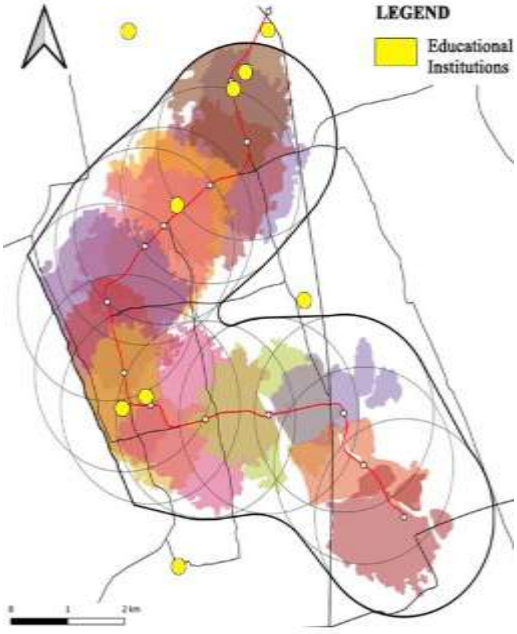


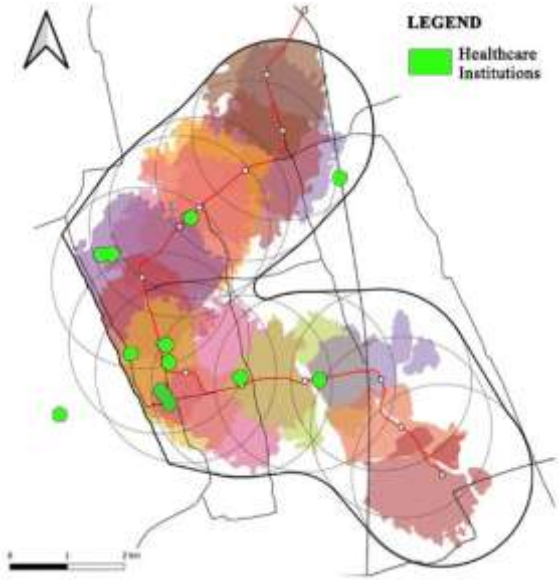
Different modes of transportationin the Study Area

Note: Coloured layers in each map in this section indicate the catchment area generated by service area approach using Q GIS &Isochrone API.

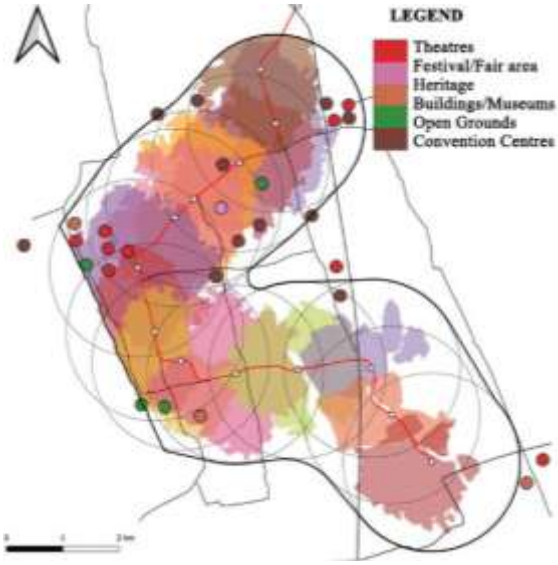


[9]**Educational Institutions in the Study Area**

Note: Destination accessibility to public utilities in the catchment area is found by summing up the number of different institution in each catchment area.



[9]**Healthcare Institutions in the Study Area**



[11]**Creative Infrastructure in the Study Area**

From the above diagrams we can observe that, there is a large service coverage gap inPetta, Thaikoodam, Vytilla and Elamkulam station. This huge gap is present due to lengthy canals and large wetlands which makes movement of people difficult. Coverage gaps in other station areas are present due to theorganic design of road network. As per the different theories in transportation planning, a dense gridironnetwork is the most suitable shape for ensuring walkability of the station area.

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Table 1 Description of the Variables taken for the study

SL.NO	VARIABLES	DESCRIPTION	UNIT
1	Residential land use	Residential land usecan influence public transport ridership.	Percentage
2	Commercial land use	Commercial land use can influence public transport ridership.	Percentage
3	Land use diversity	Presence of different land uses like recreational, commercial, residential etc. can influence public transport ridership.	Nos
4	Road network	Higher the land devoted for road network, higher will be the possibility of on street parking.	Metres
5	Multi-mode connectivity	Multi-mode connectivity indicates the connectivity to different modes of transportation.	-
6	Educational institution	Number of educational institutions within the catchment area can influence public transport ridership.	Nos
7	Healthcare institution	Number of healthcare institutions within the catchment area can influence public transport ridership.	Nos
8	Creative infrastructure	Number of creative infrastructure within the catchment area can influence public transport ridership.	Nos
9	Station wise ridership	This indicates total number of passengers using a metro station as origin station.	Nos

V. ANALYSIS

Table 2Relationship between Ridership [12] and Residential Land Use

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	RESIDENTIAL LAND USE (%) (Y value)
1	Palarivattom	2850	70
2	JLN Stadium	2754	55
3	Kaloor	3054	53
4	Lissie	4735	38
5	MG road	4662	34
6	Maharajas	6855	38

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7	Ernakulam south	4647	29
8	Kadavanthra	3039	63
9	Elamkulam	1385	57
10	Vytilla	3097	29
11	Thaikoodam	4237	77

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is -0.43 i.e. negative correlation. This indicates that the relationship between the above variables is weak.

Table 3 Relationship between Ridership [12] and CommercialLand Use

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	COMMECIAL LAND USE (%) (Y value)
1	Palarivattom	2850	22
2	JLN Stadium	2754	15
3	Kaloor	3054	27
4	Lissie	4735	34
5	MG road	4662	43
6	Maharajas	6855	28
7	Ernakulam south	4647	26
8	Kadavanthra	3039	19
9	Elamkulam	1385	5
10	Vytilla	3097	18
11	Thaikoodam	4237	4

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.548 i.e. moderate positive correlation. This indicates that the there is a tendency for higher ridership variable when there is high commercial land use variable score.

Table 4 Relationship between Ridership [12] and Land Use Diversity

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	LAND USE MIX (Y value)
1	Palarivattom	2850	4

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2	JLN Stadium	2754	4
3	Kaloor	3054	5
4	Lissie	4735	5
5	MG road	4662	5
6	Maharajas	6855	6
7	Ernakulam south	4647	6
8	Kadavanthra	3039	4
9	Elamkulam	1385	4
10	Vytilla	3097	4
11	Thaikoodam	4237	3

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.7762 i.e. strong positive correlation. This indicates that the there is a tendency for higher ridership variable when there is higher land use diversity variable score.

Table 5 Different types of Land uses within the station area

SL.NO	STATION NAME	RESIDENTIAL LAND USE	COMMERCIAL LAND USE	INSTITUTIONAL LAND USE	RECREATIONAL LAND USE	INDUSTRIAL LAND USE	TRANSPORTATION LAND USE
1	Palarivattom						
2	JLN Stadium						
3	Kaloor						
4	Lissie						
5	MG road						
6	Maharajas						
7	Ernakulam south						
8	Kadavanthra						
9	Elamkulam						

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10	Vytilla						
11	Thaikoodam						

Table 6 Relationship between Ridership [12] and Road Network

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	ROAD NETWORK (METRE) (Y value)
1	Palarivattom	2850	14946
2	JLN Stadium	2754	13920
3	Kaloor	3054	7383
4	Lissie	4735	13428
5	MG road	4662	14077
6	Maharajas	6855	9913
7	Ernakulam south	4647	10804
8	Kadavanthra	3039	15597
9	Elamkulam	1385	12605
10	Vytilla	3097	11259
11	Thaikoodam	4237	12065

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is -0.258 i.e. negative correlation. This indicates that the relationship between the above variables is weak.

Table 7 Relationship between Ridership [12] and Multi-Mode Connectivity

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	MULTI-MODE CONNECTIVITY (Y value)
1	Palarivattom	2850	1
2	JLN Stadium	2754	3
3	Kaloor	3054	3
4	Lissie	4735	3
5	MG road	4662	4
6	Maharajas	6855	6
7	Ernakulam south	4647	6

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8	Kadavanthra	3039	5
9	Elamkulam	1385	3
10	Vytilla	3097	3
11	Thaikoodam	4237	2

Note: Station wise ridership on 16th September 2019 is used for the analysis.The transport modes are assigned with different points based on its capacity i.e. point of railway station is higher than point assigned for auto stand.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.6049 i.e. strong positive correlation. This indicates that the there is a tendency for higher ridership variable scorewhen there is high multimode connectivity variable score.

Table 8 Relationship between Ridership [12] and Educational Institutions

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	EDUCATIONAL INSTITUTIONS (Y value)
1	Palarivattom	2850	3
2	JLN Stadium	2754	1
3	Kaloor	3054	1
4	Lissie	4735	1
5	MG road	4662	0
6	Maharajas	6855	2
7	Ernakulam south	4647	2
8	Kadavanthra	3039	0
9	Elamkulam	1385	0
10	Vytilla	3097	0
11	Thaikoodam	4237	0

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.403. Although technically positive, the relationship between the above variables is weak.

Table 9 Relationship between Ridership [12] and Healthcare Institutions

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	HEALTHCARE INSTITUTIONS (Y value)
1	Palarivattom	2850	0
2	JLN Stadium	2754	1

3	Kaloor	3054	1
4	Lissie	4735	2
5	MG road	4662	3
6	Maharajas	6855	4
7	Ernakulam south	4647	4
8	Kadavanthra	3039	2
9	Elamkulam	1385	1
10	Vytilla	3097	0
11	Thaikoodam	4237	0

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.6305 i.e. strong positive correlation. This indicates that the there is a tendency for higher ridership variable scorewhen there is highhealthcare institution variable score.

Table 10 Relationship between Ridership [12] and Creative Infrastructure

SL.NO	STATION NAME	STATION WISE RIDERSHIP (X value)	CREATIVEINFRASTRUCTURE (Y value)
1	Palarivattom	2850	2
2	JLN Stadium	2754	3
3	Kaloor	3054	3
4	Lissie	4735	1
5	MG road	4662	6
6	Maharajas	6855	0
7	Ernakulam south	4647	3
8	Kadavanthra	3039	2
9	Elamkulam	1385	0
10	Vytilla	3097	0
11	Thaikoodam	4237	0

Note: Station wise ridership on 16th September 2019 is used for the analysis.

Correlation type and interpretation: Pearson's correlation coefficient 'R' value is +0.1447. Although technically positive, the relationship between the above variables is weak.

VI. CONCLUSION

Metro rail system plays a significant role in meeting the transportation demands of the growing population in developing countries. In orderto generate maximum ridership, it is important to allocate transit supportive densities and land uses in an optimum manner. This research used a correlation analysismethod to find out the different parameter influencing metro railridership in Kochi.

Results of the correlation analysis shows that variables like commercial land use, land use mix, health care institution, and multi-mode connectivity are positively correlated to ridership variable. Thus it can be concluded that more the influencing variablescore, highercould be the ridership.So optimisation of different land uses and built densities should be done to generate maximum station wise ridership. Benchmark value for optimizing the variable can be taken fromTOD successful projects.

Further studies are needed to identify the catchment area typology.Different treatment can be introduced to ridership influencing variables for achieving maximum ridership.

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