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Delineating the Zone Potentiality for Convergent Transit Setting of Rajshahi Railway Station

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ABSTRACT

Urbanization is an incessant process involving continuous infrastructural development, ultimately resulting in traffic congestion and an unhealthy transportation system. Rajshahi is home to one of the most convergent traffic routes in the country, and is slowly moving towards a traffic congestion level. This study proposes an integrated GIS approach with five variables aiming to quantify the suitable location of Transit Oriented Development (TOD) to counterpart the convergent traffic with necessary measures by using weighted overlay analysis. Results reveal in a 500 m buffer from the station area, south – eastern quarter showed the highest prospect. Several design principles are recommended in the area for the conversion to walkable neighborhood, and a new route, Auto Rapid Transit (ART) is proposed to ensure connectivity to urban centers. This study will help urban planners and policymakers to understand the necessity and method to evaluate the prospect of a place before implementing a TOD design.

1. Introduction

Urbanization is a key component of economic expansion and it is happening more quickly than ever before. By 2050, 68% of the world's population, which is currently at 55%, is anticipated to reside in urban areas [1]. Since transportation systems determine conurbations, practically most urban areas, especially in the global south have evolved around road-based transportation system, with a heavy reliance on private motorized vehicles [2]. Transit Oriented Development (TOD) has been widely recognized as an effective strategy to promote public transport use and reduce car dependency [3]. By integrating land use and transportation systems, cities become more livable and sustainable [4]. Rajshahi is one of the major cities in Bangladesh with a lot of important offices, schools, colleges, universities. It is also a major transportation hub, and is connected to other parts of the country by a number of roads and railways. As it is the most livable city among all the cities in Bangladesh, people from the neighboring districts come to reside here. Like other divisional cities, Rajshahi is rapidly expanding due to experienced significant population growth and a strong demand for vehicles. It

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exhibits a highly mixed pattern of land use that extends linearly along the main roadways in both the east-west and north-south directions [5]. WHO (World Health Organization) announced Rajshahi city as the top position for tackling air pollution in 2016. A "Zero soil" project has been implemented in this city to cover the dust blown up from dry riverbeds, fields and roads, for preventing further air pollution problems [6].

The **Table 1** describes this study incorporates a significant aspect beside traditional design, i.e., quantifying the prospect of TOD management in the study area upon reviewing on suitable variables. Though numerous studies have evaluated the possibility of TOD in one area, many researchers have not been able to delineate TOD zones in that particular area or have not involved concerned experts. Previous studies like [7, 8] provide a comprehensive review of TOD research and its implementation challenges.

This study will help urban planners and policymakers to understand the prospect of TOD in one place and can accommodate the convergent transit setting for the citywide development, especially in developing countries like Bangladesh. Convergent transit setting means different transport modes concentrated towards a particular landmark. In case of Rajshahi city, different transport modes like bus, train, car, auto-tricycle (6 passengers), auto rickshaw (2 passengers) etc. are concentrated to Rajshahi Railway Station. This study will open the door for further study of the quantification approach and its diversity of associated variables.

Table 1. Study details

Questions	Hypothesis	Objective
1. Which area is the most prospectus for TOD?	1. Several factors influence the potentiality of TOD.	1. To measure the prospect of different zones for TOD

2. Literature review

2.1 Measuring the prospect

To understand the prospect of TOD in the study area, several researchers have used different techniques and their own parameters. Many researchers have taken the whole city as the study area when in the other hand many researchers focused on individual presence of a feature for the possibility assessment. Many researchers have focused on the large-scale urban growth where some focused on the pre historic urban growth trend.

Fard (2013) measured the prospect of TOD based on 5 (five) different criteria including level of density, land use diversity, level of mixed-use development, and economic development with respect to population distribution. The author used modified weighted index named ILWIS SCMA method for understanding the possible locations for TOD. This study primarily focused on the ranking of variables based on the real-life scenario and finding the possible places to conduct a TOD based design. Though several attempts and a complex analysis was conducted, the prime focus of this study was not based on the TOD design and thus lacked the presence of some significant expert review [9].

(Asaduzzaman et al., 2021) discussed about the quantification approach being implemented in Rajshahi. The authors focused on the evaluation of the present policies and the present variables containing the details of the present spatial features. This study focused on the eligibility of the present modal variation and the present factors associated with it. This study proposed a different approach for the prospect measurement approach but did not focus on any particular existing transit mode, rather focusing on the new proposed transit [1].

2.2 Concept of Transit Oriented Development (TOD)

For this study, a detailed review of few particular categories from transit-oriented development (TOD) literature in relation to some existing transportation conditions was conducted to get knowledge for identifying some potential transit locations and their opportunities in Rajshahi city. The aim of TOD development is to create low- to high density, walkable areas with frequent transit stops. The benefits of TOD include easier access to public transportation, lower car emissions, and a higher quality of life [10]. TOD (BRT, LRT, and MRT) stations are established with extensive coverage around transit stops based on an analysis of the existing road network, pedestrian environment, and land-use [24]. The variety of transit options available will make it easy for commuters to choose the most favorable type of transit for their individual needs. The area coverage of a transit station varies depending on the transit type, with BRT stations typically having a coverage radius of 500 m, while stations with railway (MRT, LRT) facilities tend to have a coverage radius of 800 m [25, 26]. On both sides of the transit corridor, it takes 10 to 12 minutes to walk to the station places [11].

Calthorpe first introduced the idea of Transit-Oriented Development in 1993. It is interesting to note that Calthorpe (1993) referred to TOD as an "Urban Village," a "Pedestrian Pocket," or a "Compact Neighborhood Development" [12]. A variety of transit and urban development characteristics were evaluated for seventeen station areas in the Netherlands, and the urban factors were utilized to determine a place index for each station, while transit characteristics were used to establish a transit index [13]. Several late-century US TOD case studies include major projects in Arlington, Virginia, Dallas, Texas, Atlanta, Georgia, and San Jose and San Diego, California. However, the fundamentals for successful TOD precincts may also be found in the transit-rich metropolitan centers of Western and Central Europe. The integrated land use and transportation planning pursued in Europe after WWII gives clear

lessons for present attempts to develop something similar in the new world setting [14]. The focus was on whether land use completely explained the transit-dominated travel pattern in Hong Kong, where the importance of land use on mode choice is clear due to the densely developed area [15].

2.3 Feasibility in Rajshahi

Rajshahi is well renowned for its tremendous contribution to our national GDP for cultivating a large number of crops (vegetables, fruits, and others) in the sub-urban areas throughout the year [16]. Farmers from the suburbs must transport their goods or products to the city center, from whence they are distributed throughout the country or abroad. However, given the absence of an effective transportation system connecting regional, metropolitan, and sub-urban areas, farmers are unable to convey their commodities directly to the city center. On the contrary, increasing travel time produces a large price increase, which is causing problems among the general public. Thus, implementing creative ideas such as TOD, connecting regional to sub-urban areas between Rajshahi city and its surroundings with adequate integration, might be the most efficient answer addressing concerns such as excessive time spent on roads, traffic congestion, and environmental contamination [1].

3. Materials and methods

3.1 Study area profile

The **Figure 1** depicts Rajshahi Railway Station which was considered as the study area, and a 500 m radius was considered for the initial consideration of the study area. A four equal divided segregation was considered for the design area, and a qualitative geospatial analysis was considered for selecting appropriate quarter. Several factors affected the selection of this transit point. The crossing of Rajshahi Railway Station is one of the busiest points of Rajshahi city and produces much traffic in the region that ultimately results in congestion [17], showing the highest potential of transit-oriented development [18]. More than 20 service points were marked with geophysical survey using a geographical positioning system (GPS). Service points included different patterns of commercial, administrative, and residential business services that needed to be incorporated with the theme of transit-oriented development (TOD). All of the service points were recorded individually and multiplied by the appropriate coefficient to understand the proximity distance and its variation. A service point with the recording of residential businesses and other commercial center points needed the most reduced time for travelling while on the other hand, proximity to administrative centers was recorded with the importance of travel mode and speed of vehicle, which was later normalized in the weighted overlay analysis.

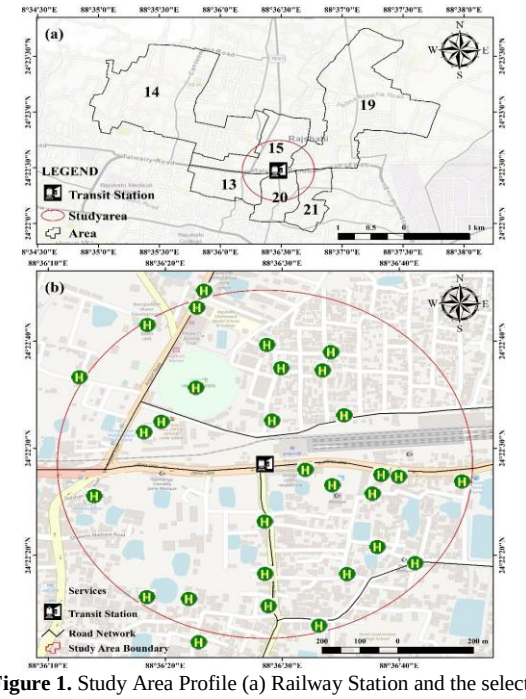

Figure 1. Study Area Profile (a) Railway Station and the selected buffer in different wards (b) Service Points and Road Network inside the study buffer

3.2 Geospatial data collection and normalization

Two types of data were considered for this study where one was acquired for the quantification of the prospect for TOD and the other data was acquired from the secondary sources for appropriate design proportion and calculation. The quantification approach was consisted of collecting distant wise data and physical survey was used to measure the relation of time variable with the distance ratio. After collecting all the service points, proximity to service was initially collected as the distant data that was later normalized with two homogeneous variables, i.e., time to reach the service point and the average walking speed of one person. To understand the prospect of GIS, a total of five categories were selected for the potentiality evaluation purpose. The **Table 2** shows the parameters that was further used for geospatial weighted overlay analysis. Modal split was mainly noticed in two significant modes, one was Auto Rickshaw and the other one was Auto, both of those being a para transit mode. The volume of traffic was also evenly distributed with the most amount of traffic being noticed in the arrival time. This data was represented with the buffer distance where the modal split and volume of traffic was evaluated with the same representation of one map with having a common scale for the same criteria.

Nearness to road or Road availability was evaluated with the Euclidean distance tool as it showed the nearness to

the road network that showed a higher possibility to use the pedestrian traffic route for one resident. This data mainly represented the time required for a person to reach the nearby road network for walking purposes or to get to one vehicle.

Table 2. Selected Parameters for the potentiality evaluation

Parameter	Reference
Proximity to Service	(Stojanovski, 2020)
Modal Variation	(Mees, 2014)
Road Width	(Sulistyaningrum & Sumabrata, 2018)
Volume	(Pan et al., 2017)
Land Use	(Ma et al., 2018)

The land use data, on the other hand, was evaluated with the Normalized Difference Vegetation Index (NDVI) using (equation 1) where it was reclassified in ArcGIS 10.6 as strong vegetation to no vegetation (as shown in **Table 3**) using Landsat satellite data (Landsat 8 OLI) for the year 2024.

$$NDVI = \frac{NIR-Red}{NIR+Red} \quad (1)$$

3.3 Population and feature calculation

As the population present in the study area is consistent with the private sector housing, the proposed density in the Rajshahi masterplan by Rajshahi Development Authority (RDA) is considered for this area primarily for service adequacy identification. As the will only be considered for the quarter of the study area, the total area will be ${\pi r^2}/{4} \approx 48\ acres$.

Gross density for commercial and private sector housing estate 195 persons / acre [5]. Total serving population of one quarter = 195 persons / acre × 48 acre = 9360 persons ≈ 10,000 people. The rounding was considered for the accidental influx of population. The service adequacy data was collected from the Rajshahi masterplan proposed in 2004 following the private residential land use and the commercial land use density. The service adequacy patterns were compared with the proposed Khulna and Dhaka masterplan and written as the service amount per thousand population. For the area calculation, area amount was showed with acre unit for every thousand population.

3.4 Weighted overlay analysis

All of the factors taken for the prospect evaluation were reclassified to a scale 1 to 10, where the lower value meant the worst scenario for that particular feature (either homogeneous or heterogeneous) and the higher value represented the opposite scenario. To understand each of the feature and its distribution, all of the features need to be mapped and evaluated individually. Land Use feature was measured with the NDVI values where the highest positive values were taken for a resemblance to the higher vegetated area and the lower value represented higher concentration of urban area [19]. The prospect of building a TOD design required the presence of already developed area with adequate number of services and around residential land use [8]. Thus, the land use variable was taken to identify the quarter with the higher prospect of conducting a TOD design. The data was later represented in spatial distribution inside the study buffer and later oppositely rescaled to TOD index for heterogeneous characteristics.

Table 3. NDVI value and their rescaled representation

NDVI Characteristics	NDVI Reclassified Value	Rescaled Value
Dense Vegetation	5	1
Moderate Vegetation	4	3
Sparse Vegetation	3	5
Very Low Vegetation	2	7
Urban (No vegetation)	1	10

Volume of traffic and Modal split was two variables that was represented jointly by one spatial distribution. The modal split was firstly evaluated with the physical survey and the result revealed an even distribution of two modes in different roads. Thus, the volume of traffic was rearranged with the present traffic volume survey (TVS) data, previous researches of major intersections of this area [20], and the daily count of vehicles to assign the necessary weightage to the buffer distance. For a higher amount of traffic, the value was higher and the buffer amount was higher. An opposite scenario was noticed for the lesser traffic regions with a much lower amount of traffic. After this process, the buffer distances were unified and later was re-evaluated in Euclidean distance approach while showing the nearness to the much more efficient route with the most amount of traffic. This represented a person's nearness to the most efficient and busy road for any kind of travel and the use of para – transit as this area severely lacked the presence of a public transit mode. Private vehicle counts were omitted in this study as one of the main principles of TOD is to encourage public transport [8, 21].

Road width and the road geometry was evaluated with the same technique followed by a scaling of the data found in the Euclidean distance approach and the better proximity was ranked the highest value. The road width was calculated with the buffer distance approach with having the same value found in Google Earth Pro software with the measure tool and during the physical survey. The higher the road width, the higher the prospect of making a TOD design with enormous amount of pedestrian facility.

Euclidean distance was also applied for the proximity to services feature as the time feature was recorded with the walking distance and ratioed with the average walking speed of one person. Each feature was given a unique value range for by normalizing the distance to minutes required to travel. The time required was not the same for each of the feature but was later normalized using the

relevant importance given, recorded by the secondary sources and authors.

3.5 Suitable area calculation

All of the created layers were then taken to be put under specific weightage for the overlay calculation. Six experts were taken for the expert opinion survey and were asked to give relative importance to the specific feature over another. The six experts were chosen through purposive sampling to ensure a balanced representation of relevant professional perspectives on academia, urban mobility, infrastructure planning, and public policy. A total of five features were taken in consideration for the weightage calculation. After collecting all the responses from the experts, their relative weightage was multiplied with the relative weightage considered for the experts. The weightage was given with the designation level of the experts and the involvement with the masterplan and development of Rajshahi city. After that, an overlay spatial distribution was evaluated and an appropriate quarter was selected for the study.

4. Result and Discussion

4.1 Individual feature overview

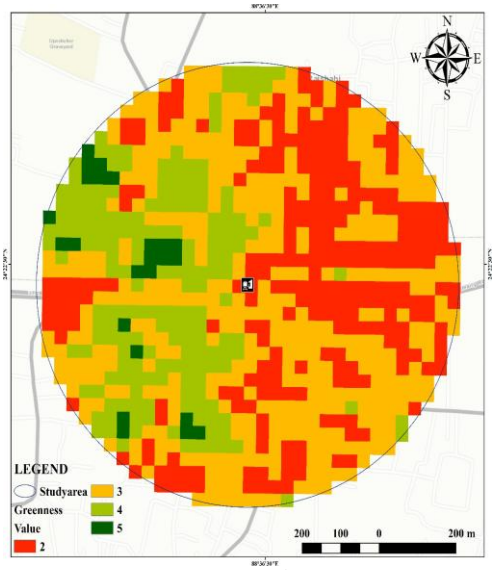

Figure 2. Spatial distribution of greenness in the study buffer

4.1.1 Land Use

NDVI was used to differentiate the areas with the higher amount of vegetation from the urban areas. Near Infrared (NIR) and red band was used to identify the greener areas that should be omitted for the TOD design approach. Results revealed that the western side of the study area had the highest number of urban areas and the opposite side had the highest amount of vegetation.

The concentration of dense vegetation was noticed in the south – western region of the buffer circle due to the presence of horticulture [21], and graveyard in that place. **Figure 2** shows the actual scenario of the NDVI where the lowest value represented the urban areas and settlements.

4.1.2 Volume of Traffic and Modal Split

Two variables, i.e., volume of traffic and modal split was analyzed in the same geospatial distribution pattern. As discussed in the methodology chapter, firstly through the physical survey and analyzing the present and past TVS data, it was noticed that for para transit and public transit, only Easy Bikes (electric, shared mode) and Auto Rickshaws (electric, without paddle, direct hire) were noticed in that region which was distributed quite evenly. After the careful evaluation of the maximum transit, the volume of traffic represented the scenario of the volume of the most used para – transit mode. The road with the lower buffer zone represented the lower amount of traffic volume and the higher buffer zones represented the higher amount of traffic volume for the respected para – transit mode. **Figure 3** represents the nearness to the existing volume of traffic as for reaching to service points of far places, it is necessary to reach the equivalent space in a fast manner.

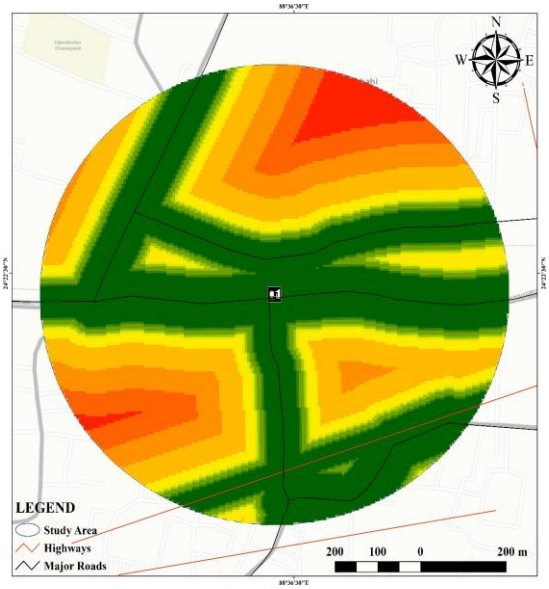

Figure 3. Volume of traffic and modal split scenario

4.1.3 Road geometry and nearness

Road geometry was assessed with the measure tool of ArcGIS 10.6 and with the physical survey already discussed in the methodology section. The result of the road geometry and the nearness to the road network was assessed and shown in **Figure 4**. The green areas represented better proximity to the road network and the red areas represented the opposite scenario.

4.1.4 Proximity to service

In **Figure 5**, all of the service points were normalized with each having corresponding importance value for the differentiation in the probability to travel or eagerness to walk. All of the service points were evaluated with Euclidean distance tool and the higher proximity resembled the green scenario while the red scenario showed quite the opposite scenario.

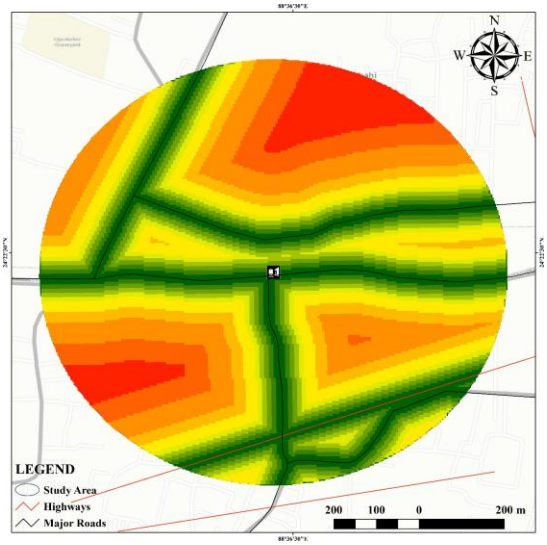

Figure 4. Road width and the nearness evaluation

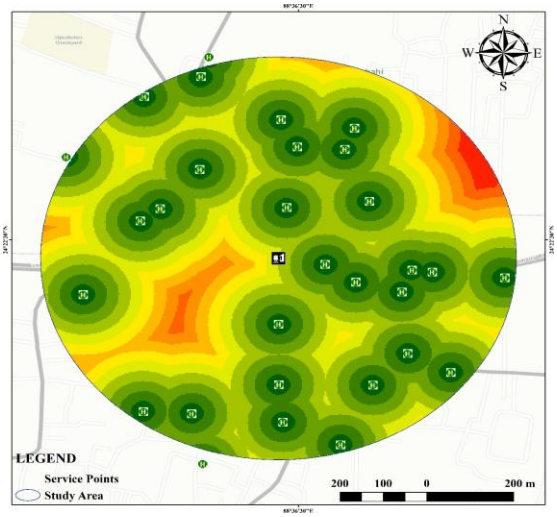

Figure 5. Proximity of service spatial distribution

Results revealed in **Figure 5** that almost all the service points are at a higher range of proximity and people were eager to travel to those places by foot. The northern and the north – eastern part of the study area resembled the best scenario for the proximity evaluation followed by the next best scenario of north – western region. The south – western part resembled the possible worst scenario as there were a lack of services in that region.

4.2 Prospect quantification

All of the responses collected from the experts showed the relative graph for the five selected parameters of the study. The parameters were taken in the ArcGIS 10.6 platform and with the relative importance (**Figure 6**) and the spatial layer, a weighted overlay operation was conducted, which is shown in **Figure 7.**

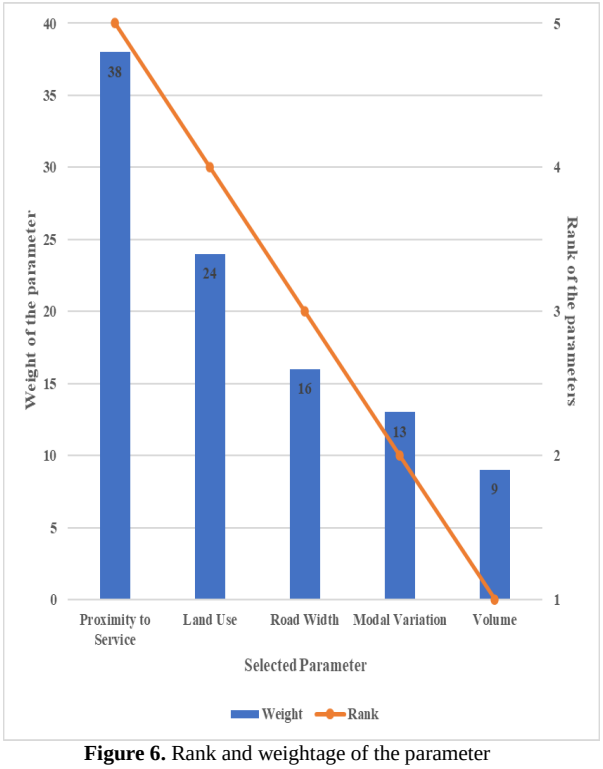

Figure 6. Rank and weightage of the parameter

The weightage factor revealed that the highest importance the experts have given was to the proximity to services followed by the second most important factor, i.e., land use. Road width and the modal variation had nearly same range of weightage followed by the lowest rank for volume. These individual weights were assigned in the weighted overlay tool and the spatial distribution was created that was shown in **Figure 7**. The weighted overlay factor showed a scale of 1 – 10 where the highest value represented the more suitable zone for TOD design. Results revealed that the north – eastern portion of the study area and the two quarters assigned with the area had the most prospect for TOD design with the highest suitable region was recorded in the south – eastern region. This showed the highest possibility for a TOD development in that region. The presence of some vacant lands and the presence of more than 10 service points acted as the catalyst behind the selection of this area.

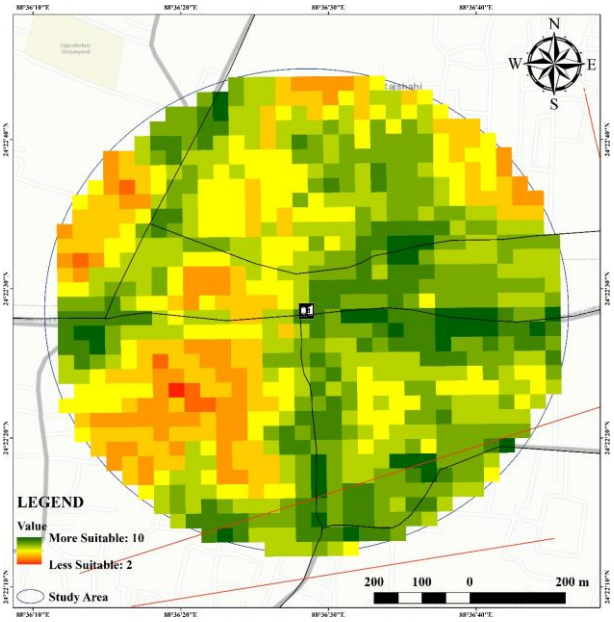

Figure 7. Weighted overlay analysis's result

4.3 Principles to accommodate convergent transit setting

The principles of TOD design include densify, mix, walking, public transport, compact, shift, connect to maximize public transportation options in areas that are mixed-use, commercial, or residential [8, 21]. These principles are incorporated with the TOD design considering Rajshahi Railway Station as the heart of transit along with the 6Ds concept namely Destination, Distance, Design, Density, Diversity, and Demand Management. That's why, some standards to design TOD is required. The Institute for Transportation and Development Policy (ITDP) launched the Transit-Oriented Development (TOD) Standard as an effort to assemble global knowledge and reach consensus on what practices are best for TOD [23]. This includes encouraging environmentally friendly urban transportation while decreasing the use of private vehicles, cutting back on greenhouse gas (GHG) emissions, and addressing other unfavorable externalities related to their use.

4.3.1 Densify

Through densification, areas are made self-sufficient and ensured that there is sufficient economic activity to support transportation services. The other criteria are also supported by densification because it promotes access to areas that can be reached on foot. Density, not overpopulation, is the optimal concentration of people, opportunities, and high- quality housing near sustainable transportation options. The population density in Rajshahi City is – Gross density of 195/ acre, net residential density of 220/acre and net commercial density of 325/ acre. Densification is done by increasing the frequency of TOD facilities like high rise multi-storey building which specifically refers to the mass or quantity per unit area, focuses on effectively utilizing the land resource that is already available. Traditional methods for measuring and displaying density include built density, residential density, and population density. The growth of residential and commercial uses surrounding stations with massive carrying capacities will ensure that all residents and employees have access to high-quality public transit. Only restrictions on access to sunlight, fresh air circulation, parks and open spaces, and the preservation of cultural and natural resources should interfere with concentration.

4.3.2 Compactness

Compact is the underlying organizational tenet of TOD. It entails effectively fusing transit and activities. Mixed-use building zoning is preferred over residential-only zoning. Compact works on this neighborhood and city scale through a transit system supported by density and extensive networks for walkers. People can live close to their places of employment, schools, services, and other destinations by repurposing the existing urban fabric, which cuts down on commute time and emissions. Being physically integrated by public transit systems at the scale of the city, which is embodied in our design, is what it means to be compact. Therefore, diversity and mix of land uses varies depending on the type of TOD. Both metropolitan and neighborhood TODs clearly demonstrate this variation. Neighbourhood TODs are places that have been created with a mix of office space, retail shops, and other retail uses that attract moderate to heavy foot traffic. Public buildings and other land use with high to extremely high foot traffic are examples of city TODs.

4.3.3 Walking

Walk is an important part of TOD. It results from creating complete roadways for all environmentally friendly modes of mobility from a human-centric standpoint. It encourages walkability by providing all people with access and by incorporating design features that boost pedestrian activity, safety, and comfort. Everyone has access to basic mobility because of well-maintained and functional pedestrian paths. Furniture, landscaping elements, and building edges turn walkways into the most vibrant public spaces. It improves the environment successfully despite needing physical effort. The three basic requirements of this philosophy are safety, activity, and comfort. The area was proposed with three types of roads where the major roads (resembling the characteristics of secondary road with a width of 45 m) had the pedestrian walkway of 6 m. Streetlight and benches were recommended in the walkways to encourage resting and security to travel by

foot rather than using a transit mode. The services placed in the region was placed near the service points and a walking proximity of only 5 – 10 mins were recommended.

4.3.4 Para transport

Transit provides access to and proximity to a public transportation system with enormous capacity, allowing pedestrians to connect and unify remote sections of the city. To connect further to the biggest distances, this design will use the rickshaw and the vehicle, which signify better connection. The core of TOD is transit. High-capacity, dependable, regular, and fairly priced transit connecting the neighborhood to the rest of the city serves as a civic hub for the community and its activities. The advantages which are mostly brought about by the benefits that the city receives from using public transportation naturally are effective use of surface roads by transporting more commuters than individual cars reduction in fuel use and pollutants (most world-wide cities now have buses that run on CNG) and accessibility and affordability transportation for the vast majority of the population.

Easy Bikes and Auto Rickshaws, a popular means of internal transportation in Rajshahi City, which are affordable, environmentally friendly, and practical. Due to Rajshahi's reputation as an educational hub, this para transit has grown in importance and notoriety. If consumers choose Easy Bikes (electric, shared modes), they will be considered to be saving money, however if they choose Auto Rickshaw (electric, without paddle, direct hire), they will be saving time.

4.3.5 Connect

By increasing road width and pedestrian pathway, the connection between goods transport and public transport is integrated. Through pedestrian networks, connect gives priority to pedestrians by allowing for flexible routes and detours. Short, diversified, and direct connections produced by a dense network of walking and paths provide access to goods, services, and public transportation.

Regular street corners, smaller right-of-way, slow-moving traffic, and lots of people encourage street activity and local trade. In **Figure 8**, to connect the Court area (administrative hub) and Shaheb Bazar, a new route for public transportation can be enhanced so that all stakeholders (inside Rajshahi City) can benefit from TOD facilities (commercial hub). The new route will be termed as Auto Rapid Transit, (ART), where a separate and dedicated lane will be provided for easy bikes, auto bikes etc.

Figure 8. A new proposed route to connect administrative and commercial center

The students in Seroil, Rajshahi, will be able to connect easily thanks to this. To ensure the proper connectivity with the proposed TOD design with the administrative and commercial center of Rajshahi, a new route connecting the Shaheb Bazar region and the Rajshahi Railway station was proposed. Generally, a design should integrate a walking route to connect the commercial and administrative centers, but the existing condition did not show enough opportunities to do so. Thus, a new route was proposed to not only connect the commercial centers but also the education centers of the area, establishing the recommended purpose of education facilities and recommended amounts.

4.3.6 Parking management

The ‘Shift’ principal is incorporated in TOD design with the parking management facilities. Shift aims to decrease the detrimental effects of private vehicle traffic on safety and health by recovering space from autos and reducing obnoxious noise and emissions. Children's health and the growth of their organs are particularly susceptible to the effects of smog-producing vehicles in crowded public spaces. By reducing parking spaces and implementing parking tax policies that encourage people to use public transportation, this design shift has been included. Reasonable parking fees and a reduction in parking availability promote the use of public transportation, walking.

The new commercial buildings will have very lesser amount of parking to reduce the amount of transit and vehicles in the respective area. Also, the fare for the parking was increased significantly to discourage people from using any mode. The reduced fare of para transit modes in the area would have encouraged the people to use the specific mode but the restriction of any parking in the road will prohibit the chance for that. Overall design reflects the existing prospect of TOD and shows that even in unplanned urbanized regions a TOD design can be implemented.

5. Conclusion

The study summarizes that Transit-Oriented Development (TOD) is a strategy to minimize reliance on automobiles and improve quality of life, which in turn raises the value of real estate implying that TOD goes beyond simply placing transit near densely populated and diverse regions. The proposed TOD location contributes by concentrating urban densities, neighborhoods, and activities within a 5 to 10 minutes walking distance, centering a rail transit station, creating high-quality urban space, and offering easy access to a variety of land uses. To create a more sustainable urban development, TOD combines components of urban design, land use and transportation planning, financing, property price capture, and infrastructure execution. At times, train schedule disruption in Rajshahi Railway Station is observed which becomes boring to intolerable limit of passengers. The TOD study centering the station area will bear the ultimate solution. The passengers can roam around having all the facilities within walking distance.

But passengers may feel uncomfortable to roam around for carrying bag and baggage. For this there will be a provision of a counter where passengers can keep their belongings secured following a ticketing system. The new route developed for TOD will be the life saver of the students of Seroil area in Rajshahi which will connect the commercial hub (Shaheb Bazar) and administrative hub (Court Area). All people should have equal access to the advantages offered by study's TOD facilities and public assets like parks, libraries, and cultural institutions, regardless of their age, income level, race, or ability. This will ensure public ridership program having para transport namely Easy Bikes and Auto Ricksahw where users can choose to become money saver or time saver respectively. New opportunities for neighborhood development having improved air quality as the TOD will ensure limitation of motor- oriented vehicles and encouraging walking. The study indicates that the dependency on private vehicles can be reduced there by promoting public transport (para transport) as the city is in the verge of rising private car ownership.

The study will ensure cheaper transport, better livable environment and quality of life. The TOD study excludes bicycle lane because it will not be convenient for the passengers to use bicycle in verge of travelling with bag and baggage but keeping a provision for bicycle rack so that passengers can roam around a bit if there is any train schedule disruption. The results of this study make a substantial contribution to the literature on TOD planning in the context of developing cities. A balanced consensus from many expert viewpoints and perspectives is presented in this paper. As a result, there will be less risk of disagreement and conflict between the experts groups involved in any TOD project. The report also offers planning elements for the TOD strategy using reference example of TOD development in various city locations around the globe. The study took into account the most important and widely used planning and designing factors for TOD which are universally accepted.

The study's weights can be applied to growing, extremely congested, mixed-use cities that strive for TOD design. All the benefits and scopes of the study's TOD design converge towards the Rajshahi Railway Station, creating a vibrant environment. In order to complete our analysis and further develop the study's findings, future research on TOD planning using the suggested methodology will consider the opinions of developers and other stakeholders in the decision-making process. This hybrid approach will use both qualitative and quantitative indicators to evaluate the TOD-ness of a region. The study will further help the urban planners, engineers, architects, and policy makers to convert the study area's researched location into TOD.

References

[1] M. Asaduzzaman, S.A. Siddique, and Z.H.M. Monjur Murshed, "Measuring the Prospects of Transit-Oriented Development (TOD) to Identify the Potential Zones in Rajshahi City, Bangladesh," Towards Implementation of Sustainability Concepts in Developing Countries (pp. 59–75), 2021. https://doi.org/10.1007/978-3-030-74349-9_6

[2] Sopjani et al., "Shared mobility services versus private car: Implications of changes in everyday life," Journal of Cleaner Production, Vol. 259, 120845, 2020.

[3] T. Kidokoro, "Transit-Oriented Development Policies and Station Area Development in Asian Cities," ADBI working paper 947, 2019.

[4] A.D. Jain, E. Singh, and R. Ashtt, "A Systematic Literature on Application of Transit Oriented Development," International Journal of Engineering and Advanced Technology, 9(3), 2020.

[5] RDA, "Structure Plan, Master Plan and Detailed Area Development Plan for Rajshahi Metropolitan City," 2004.

[6] A. Siddue, "Rajshahi: Modern city with a green heart," September, 2019.

[7] A. Ibraeva et al., "Transit-oriented development: A review of research achievements and challenges," Transportation Research Part A: Policy and Practice, 132(March 2019), 110–130, 2020.

[8] H.M. Taki, M.M.H. Maatouk, E.M. Qurnfulah, and M.O. Aljoufie, "Planning TOD with land use and transport integration: a review," Journal of Geoscience, Engineering, Environment, and Technology, 2(1), 84, 2017. https://doi.org/10.24273/jgeet.2017.2.1.17

[9] P. Fard, "Measuring Transit Oriented Development: Implementing a GIS-based analytical tool for measuring existing TOD levels," M.Sc. Geo-information Science and Earth Observation. thesis. University of Twente, Enschede, Netherlands, Mar. 2013. http://essay.utwente.nl/84747/1/fard.pdf

[10] Y.J. Singh, A. Lukman, J. Flacke, M. Zuidgeest, M., and M.F.A.M. Van. Maarseveen, "Measuring TOD around transit nodes - Towards TOD policy," 56, 96–111, 2017.
[11] MoUD, "National Transit Oriented Development (TOD) Policy," Government of India, 2017.
[12] P. Calthorpe, "The Next American Metropolis: Ecology, Community, and the American Dream," Princeton Architectural Press, 1993.
[13] L. Bertolini, "Spatial development patterns and public transport: The application of an analytical model in the Netherlands," Planning Practice and Research, 14(2), 199–210, 1999. https://doi.org/10.1080/02697459915724
[14] C. Hale, "Making the most of transit-oriented development opportunities," 29th Australasian Transport Research Forum, ATRF 06, 2006.
[15] M. Zhang, "The role of land use in travel mode choice: Evidence from Boston and Hong Kong," Journal of the American Planning Association, 70(3), 344–360, 2004. https://doi.org/10.1080/01944360408976383
[16] Bangladesh Bureau of Statistics (BBS), "Statistical Yearbook Bangladesh 2022", 2023.
[17] M. M. H. Mamun, M. M. Miah, and M. I. Islam, "Present Condition of Road Traffic Accident: A Case Study of Rajshahi City, Bangladesh, International Journal of Computer Applications, 111(7), 36–41, 2015. https://doi.org/10.5120/19554-1279
[18] M. Zhang, "Can transit-oriented development reduce peak-hour congestion?" Transportation Research Record, 2174, 148–155, 2010. https://doi.org/10.3141/2174-19
[19] A.K. Bhandari, A. Kumar, and G.K. Singh, "Feature Extraction using Normalized Difference Vegetation Index (NDVI): A Case Study of Jabalpur City," Procedia Technology, 6, 612–621, 2012. https://doi.org/10.1016/j.protcy.2012.10.074
[20] A. Al Kafy, L. Ferdous, S.A. Poly, M. Arafat, S. Monira, M.S. Rahman, N. Rahman, F. Afroz, F. Mahzabin, T. Ahmed, N.A. Khan, H. Mohiuddin, and N. Hossain, "Estimating Traffic Volume to Identify the Level of Service in Major Intersections of Rajshahi, Bangladesh," Trends in Civil Engineering and Its Architecture, 2(4), 292–309, 2018. https://doi.org/10.32474/tceia.T..02.000145
[21] J.L. Renne, "Public Transport and Sustainable Urbanism: Global Lessons," Transit Oriented Development, 43–56, 2020. https://doi.org/10.4324/9781315550008-10
[22] A. Al Kafy, A. Al Rakib, K.S. Akter, Z.A. Rahaman, A. Al Faisal, S. Mallik, N.M.R. Nasher, M.I. Hossain, and M.Y. Ali, "Monitoring the effects of vegetation cover losses on land surface temperature dynamics using geospatial approach in Rajshahi City, Bangladesh," Environmental Challenges, 4, 2021. https://doi.org/10.1016/j.envc.2021.100187
[23] Institute for Transportation and Development Policy (ITDP), "TOD Standard," New York: ITDP, June 2017.
[24] X. Ma, X. Chen, X. Li, C. Ding, and Y. Wang, "Sustainable station-level planning: An integrated transport and land use design model for transit-oriented development," Journal of Cleaner Production, 170, 1052–1063, 2018. https://doi.org/10.1016/j.jclepro.2017.09.182
[25] T. Stojanovski, "Urban design and public transportation–public spaces, visual proximity and Transit-Oriented Development (TOD)," Journal of Urban Design, 25(1), 134–154, 2020. https://doi.org/10.1080/13574809.2019.1592665
[26] S. Sulistyaningrum, and J. Sumabrata, "Transit Oriented Development (TOD) index at the current transit nodes in Depok City, Indonesia," IOP Conference Series: Earth and Environmental Science, 126(1), 2018. https://doi.org/10.1088/1755-1315/126/1/012217