Underlying Mechanisms of Transit-Oriented Development: A Conceptual System Dynamics Model- the case for Qatar

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Abstract

Transit-oriented development (TOD) is an urban planning approach that facilitates building resilient cities from urban planning and transportation perspective. Developed countries are moving in rapid, constant steps toward switching to a TOD urban fabric, yet developing countries still have challenges especially in the case of introducing new transportation modes such as the metro for the state of Qatar. To that end, the research study analyzes TOD from a system perspective, it analyzes in deep the interrelation between three modules; sustainable transportation. The variables of the three modules, the causal Loops Diagram (CLD), then the Stocks and Flows Diagram (SFD) was developed, then the loops were investigated and analyzed in deeps. These assessments and modeling will crucially draw the lines for the policymaker for a better understanding of the interrelation between the mentioned TOD aspects to provide more effective policies. In this study, a conceptual system dynamics model for Transit-oriented development considering the sustainable built environment, sustainable transportation, and sustainable economy is developed. Typically, Transit-oriented development studies investigate the development around the transit node, but this research study investigates the interaction between defined variables of the defined modules. The main finding of this research study is the causality effects between the selected variables, which leads to a conclusion that the TOD planning should work in a closed cycle of transportation, urban, and economic aspects. Moreover, the model developed in this research study was applied to the Qatar case but could have broader implications in countries that have similar conditions as Qatar.

Keywords
Transit-Oriented Development, urban planning, Transportation, Rail Transit, Land use, Sustainable City and smart growth.

1. Introduction

Transit-Oriented Development became a well know paradigm in recent decades, it has several definitions given by different scholars, the mutual concept among all definitions is that TOD is the process that focuses on developing residential, commercial, and entertainment activities around an existed or newly developed transit node; either rail station or bus stop (Ibraeva et al., 2020; Singh et al., 2017; Schlossberg & Brown, 2004; Li et al., 2010; Hale & Charles, 2007). Then, cox et al (2017) added to that concept that TOD is a comparatively high-dense urban development that has a healthy mixedness of land used that has a walkable or cyclable urban fabric that allows people to switch to walking, cycle, and transit use instead of their vehicles. As such, TOD is a sustainable development approach that pivots land use and public transport integration (Ercan et al. 2017).

Moreover, the Transit-Oriented Development application tends to transform the urban fabric into a resilient one that can fit into changes that happens in the 21st century rapidly. For instance, hosting mega-events in a developing country, as Qatar Case which witnesses an extraordinary urban development. By hosting the World Cup 2022, Qatar has a 285% increase in urban development (Al-Thani et al. 2019). To handle this increase, many transportation modes were implemented, such as the start of introducing Qatar Rail by 2019, which requires new policies to adopt and to align the urban fabric with the new public transportation mode. Moreover, with the introduction of rail transportation, it is not well-known how the urban structure will evolve and how rail transit can operate in the most efficient way (increased ridership). In this context, this research study tries to interpret the causality interrelation among urban and transportation aspects for a better application of TOD. And answer the question of how do the several aspects of Transit-oriented development from urban, transportation, and economic aspects interact and affect one another.

This research study attempts to contribute to the body of knowledge for the state of Qatar and any similar country that has the alike conditions globally, by analyzing TOD from a systematic perspective and trying to find the causality-effect relation. The state of Qatar facing critical problems fronting the rapid urban transformation that results in the need for TOD adoption. Adapting the TOD strategy comes in compliance with Qatar National Development vision 2030. The central aspect of TOD that fits with Qatar's situation is the establishment of urban growth boundaries, which could ensure the efficiency of land use rather than urban sprawl limitation. Since the primary purpose of applying TOD is to increase the community activities and decrease congestion, through adopting mixed-use development. Moreover, the host of the 2022 World Cup could be considered as an important booster to adopt the TOD plan, for which the urban environment of Qatar in parallel with the public transportation network would be capable of hosting such an event.

2. Literature Review and Research motivation

Primarily, TOD aims at a modal shift from vehicles to transit, have been made at different scales for various urban areas, regions, and station areas as found in several case studies in literature Motieyan & Mesgari (2018); Balz & Schrijnen (2009); Jeihani et al. (2013); Cascetta & Pagliara, (2013). These case studies evaluate and discuss the success and failure of TODs. Along the same lines, the literature review showed that discussions in these studies are qualitative with less emphasis on quantitative assessment. It is believed that quantitative analyses did not just serve to compare different areas being evaluated, it also helps to launch performance thresholds that could be set as an aim to optimize the performance.Curtis et al (2009); Thomas et al (2018); Pezeshknejad et al, (2020) tried to propose several indicators that could be in help of aiding this quantitative evaluation for TOD plans; however, these have not yet been used comprehensively. Besides, for Transit-Oriented Development evaluation, Evans and Pratt (2007) also emphasize the assessment of to what extent an area currently functions as TOD using limited relations between defined variables, but didn't investigate how each o these variables affect the other. To fill this important knowledge gap, in this study, the authors proposed a conceptual System Dynamics model that investigates the causality relations between TOD variables in compliance with the TOD index proposed by Singh et al. (2017) that quantifies key TOD characteristics and tries to combine it into a composite unit (TOD Index score). Such a TOD index, when measured and simulated dynamically over dissimilar points of time, could be in the help of gauging if an area is going towards aspirational threshold values or away from them. Thus, it is believed that to more effectively plan for TOD or to evaluate the performance of its projects, system dynamics analysis can be a significant tool.

TOD approach focuses on the application and approaches of increased transportation choices while reducing congestion, poor air quality and promoting pedestrians and cycle paths as community-friendly zones (Cervero, Ferrell, & Murphy, 2002). In this respect, the TODs objective prompts on achieving a sustainable transport system while offering freedom to work, shop, live, and relax conveniently, paving a critical pathway for community development.

Provides a linkage ability for streets and destinations to be closer and with integrated direct routes and frequent services that enhance workers' mobility. Furthermore, the system encourages an increased upsurge of public transport to boost profits and increase rates of business operations near customer traffic areas (Yin, Liu, Dunford, & Liu, 2015). TOD exploits the existing management to offer increased public satisfaction on enhanced and secure walkable paths, as well as landscaping, lighting, setting up parks, adding trees, and enticing architectural features (Wu, 2010).

This increases the chances for a walkable city to improve its liveable aspects by harboring environmental benefits to enable tourists and residents to gain a sense of places in the city (Shamsuddin, Hassan, & Bilyamin, 2012). As Jackson illustrates, a sense of place proves central to the process of development, focusing on how liveability through an area's observation is viable to enhance the area's atmospheres and the quality of its environment. Such a prospect allows identification of a specific neighborhood as a functioned of its features, which provides an indefinable sense of well-being, with a return point on the promoting aspects of sustainability (Jackson, 1994). The TOD associates a sense of place while connecting the place to the characteristic and social assets of a group, thus any resultant sentiment of the physical and social condition to the general populace is appreciated (Hummon, 1992). Furthermore, Hummon (1992) indicates that any sentiment that develops attachment grounds itself in a group's social reaction to the highlights of an environment. In this case, the extent of a group's acknowledgment of the end goal creates satisfaction to the human needs ascribed in a particular area within a social dimension.

Numerous researches incorporated planning strategies of Transit-Oriented Development for station areas. However, comprehensive studies on TOD planning methods still require further development, to assist urban planners. Hence, various authors such as Singh, Flacke, and Maarseveen (2018); Thomas et al. (2018); Kowlesn, Ferbrache, and Nikitas (2020); Liu, Zhang, and Xu (2020); Lang et al. (2020); Trepci, Maghelal, and Azar (2020); Lyu, Bertolini, and Pfeffer (2020); Kumar, Parida, and Sekhar (2020) have conducted studies on these models. Moreover, they have established numerous methods of developed models and dedicated analysis to tackle smart transit development. Furthermore, the different common principles observed among those researches, are; 1) Public transportation efficiency, 2) Land use Diversity, 3) Land use Density, 4)Accessibility, 5) Connectivity, and 6) Property values and many others shown in Table (1).

The need for adopting such a strategy for urban planning development is significantly increasing to help to solve many major problems such as the outstanding urban growth besides the new introduction of rail transit as a new transportation system in the country. The flash for adopting TOD is mainly based on Qatar National Vision QNV 2030, which is established to assure urban growth and land-use efficient utilization that limits the sprawling growth, as well as decrease traffic congestion and increase land use mixed-ness, which will be a step forward to the sustainable growth. Another crucial booster to implement TOD in Qatar is the host of World Cup 2022, in which Qatar is obligated to develop its built environment, public transportation network accordingly (Furlan & AlMohannadi, 2016; Zaina et al., 2016; Furlan et al., 2019). The railway (Doha Metro) in Qatar is recently introduced in late 2019. The Doha Metro project has two phases plan Figure (1). In the first phase, three different lines are operated (Red, Gold, and Green) with 37 stations, the final opening for all stations is in 2022. The second phase is the Blue line with 60 stations to be completed by 2026. The planning of that station's location plays a substantial role in the plan of the TOD line; it emphasizes the practical and cultural importance depending on the line. The Redline represents the coastline passing from Lusial to Al Wakra. The Greenline, known as the educational line, comes from the west and passes through the educational city. The Gold Line is the historic line passing through and with station places in major cultural and historical areas, such as Souq Waqif, Msheireb, and Qatar National Museum (QNM) (Qatar Rail).

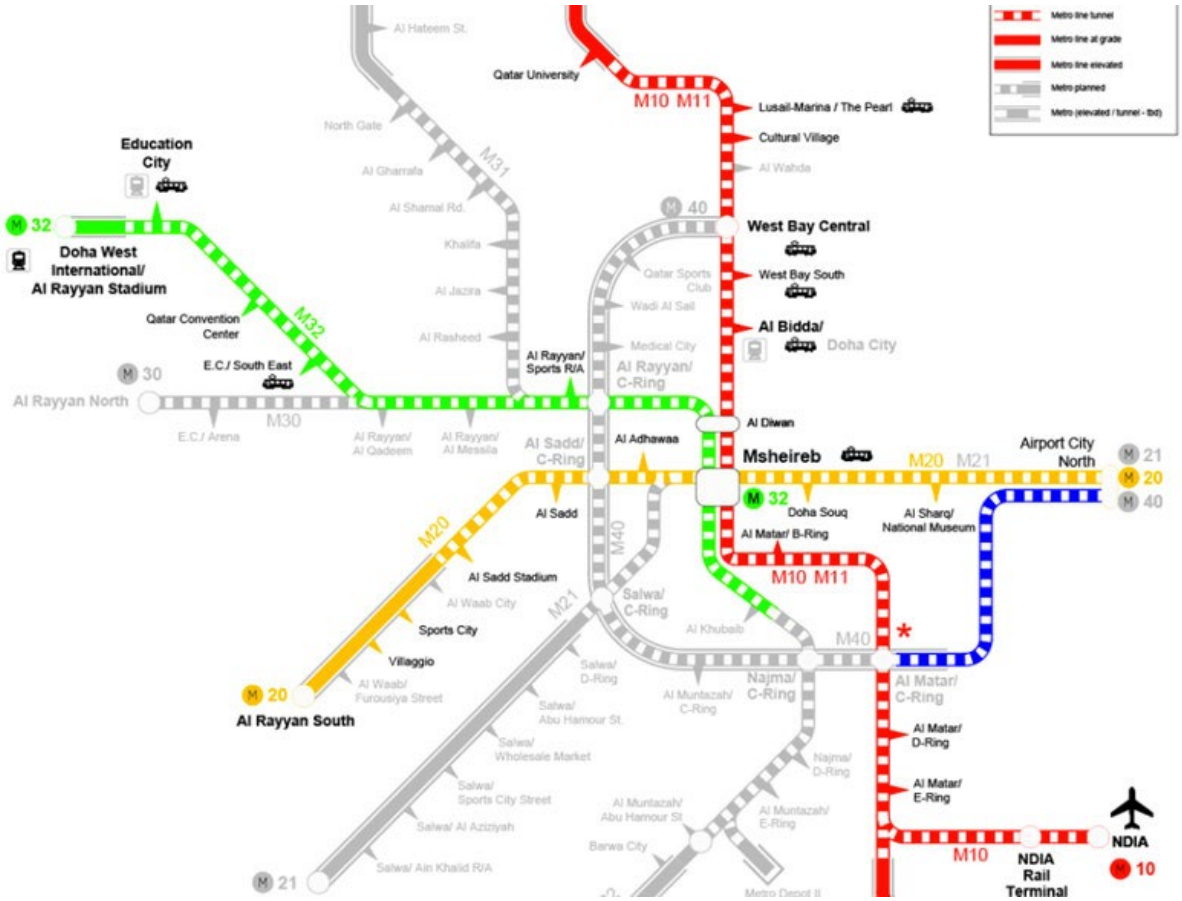

Figure 1. Doha Metro Lines (Source: Qatar Rail

Table 1. Literature Summary

	Zhao et al., (2018)	Motieyan and Mesgari (2018)	Adolphson and Fröidh (2019)	Murakami (2019)	Cox et al. (2017)	Ercan et al. (2017)	Guan, Zhang, and Chen (2020)	Ibraeva et al. (2020)	Ma et al. (2018a)	Oppong-yeboah (2020)	Rana, Routray, and Younas (2020)	Sahu (2018)	Singh, Flacke, and Maarseveen (2018)	Thomas et al. (2018)	Kowlesn, Ferbrache, and Nikitas (2020)	Liu, Zhang, and Xu (2020)	Lang et al. (2020)	Trepci, Maghelal, and Azar (2020)	Lyu, Bertolini, and Pfeffer (2020)	Kumar, Parida, and Sekhar (2020)	Ganning and Miller (2020)
Land use diversity	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓
Land use density	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Walkability	✓	✓			✓					✓		✓	✓	✓	✓	✓	✓		✓	✓	
Streets Connectivity		✓	✓							✓	✓	✓		✓	✓	✓				✓	
Accessibility		✓	✓						✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	
Centeredness	✓	✓	✓							✓		✓			✓	✓			✓	✓	
Road Design	✓	✓		✓				✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	
Public Transportation efficiency		✓				✓	✓		✓									✓		✓	✓
Public Transportation Availability						✓	✓						✓		✓			✓	✓	✓	✓
Trips Length	✓	✓				✓								✓	✓				✓	✓	
Parking supply and Management		✓				✓							✓	✓	✓				✓	✓	
Vehicle ownership					✓	✓	✓			✓				✓	✓					✓	
Property value			✓	✓	✓			✓						✓						✓	
GDP		✓	✓	✓										✓		✓		✓		✓	✓
Currency Stability				✓										✓		✓		✓			
Political stability														✓							
Health care					✓	✓															

According to the literature review, and to the extent of the authors' knowledge no previous research has investigated the transit-oriented development system using a system dynamics approach, to explain underlying mechanisms for TOD. Similarly, there was no attempt to analyze the dynamics of key variables for TOD overtime. For the case of Qatar, all studies in Qatar concentrated more on descriptive analysis from an urban aspect. To the extent of the authors' knowledge, no study has yielded to implement a systems approach for the region, with its unique urban, transportation, and economic characteristics. Furthermore, there is a comprehensive concentration from committees of planning and policymaking in Qatar to develop an approach to analyze the dynamics of TOD policies. Hence, this research aims to explain underlying mechanisms for Transit-Oriented Development around rail stations by proposing a conceptual system dynamics model. With this motivation, the proposed model aims to achieve several objectives; i) to study the land use along the rail corridor; ii) to develop a conceptual system dynamic model to reveal the mechanisms supporting TOD, as well as to encourage Transit-Oriented development around rail stations; iii) to investigate and evaluate relevant policy options associated with land use and public transportation –rail in particular- that could be in the help of achieving sustainable development in the developing countries.

As a case study, we investigated TOD in Qatar, where there is rapid development due to the upcoming World Cup 2022 and high investments in construction projects. Along with the same lines, this research study also aims to assist decision-makers and transportation planners to analyze their policies based on changes over time, for the region and similar regions with similar characteristics around the world.

3. Model Development

3.1 System Thinking Approach

This section describes the methodology the researchers followed to build the SD model (Figure 2); many steps were followed. Starting from problem definition, variables identification, and selection. Then describe and discuss the loops and interrelation were done to build the Causal Loop Diagram CLD and define loops and causality relations between variables. After that authors applied this SD conceptual model as a case study for the Alghanem district starting from defining the reference mode for land use after building the rail, the third step involves identifying the causal loop diagram (CLD) and analyze the causality relationships among variables, then the model was applied and discussed in detail.

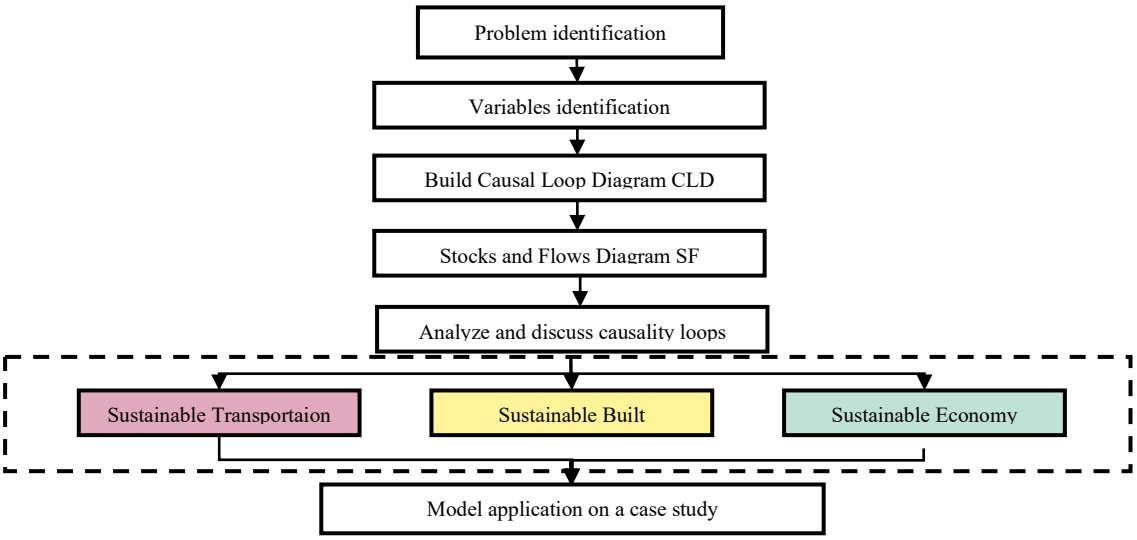

Figure 2. Methodology flowchart

According to various definitions of TOD, several typical physical characteristics that are related to urban development define TOD. These are high densities, high diversity, and attractive design, and such. Thus, measuring TOD indicators based on the concept of 3Ds (Density, Diversity, and Design), as discussed by Renne, (2003) since they are affecting transportation demand, mode choice, and reduce peak-hour congestion levels (Curtis, Renne, and Bertolini 2009). Since transit also plays a crucial role in creating TODs, it is vital for measuring transit characteristics that affect travel behavior. As mentioned before, the potential TOD Index is measured independently of the location of transit nodes based on grid cells, which is why only development characteristics should be measured for this index. This identifies those areas with the development having a high orientation to use of transit. Later such identified areas' access to high-quality transit will be assessed. Various indicators proposed by Singh et al., (2017) and others were also studied in detail for finalizing a list of measurable

or quantifiable indicators of TOD to measure the development as well as transit characteristics. These indicators are not specific to this research study' case study and can be used to measure TOD around any transit node in any city around the world, Table (2) shows the selected variables, its type, and the description for each variable. This also could include a frequent transit service, access to transit and its facilities, a user-friendly system, comfort, and others.

Table 2. Variables selection and identification

Variable	Type	Interrelated variables
Diversity	Endogenous	Land diversity refers to the mixdness of land use in the neighborhood, the increase in diversity decreases per capita miles travel and increases walkability, accessibility, and public transit efficiency, which allow alternating among different traveling modes.
Density	Exogenous	Density refers to the number of residents, the building of jobs per land unit, density has many effects on various variables of the TOD system, according to Peng et al., (2017) the increased density tends to decrease miles per capita, and increase walkability and cycling, moreover, the increased density reduce trip length. The increased density decrease parking supply and management hence the land value will increase. Density has also associated the diversity and regional accessibility (Adolphson and Fröidh (2019); Chang and Murakami, (2019))
Walkability	Endogenous	Increasing the conditions that promote walkability tends to decrease the use of private vehicles, which will decrease the private vehicle's ownership, which will eventually decrease per capita miles travel.
Connectivity	Endogenous	Roads connectivity reduces per capita miles travel, decrease traffic congestion, and increase walkability.
Accessibility	Endogenous	Regional accessibility refers to the relative location to the center of the district, it is affecting per capita miles travel in a negative relation (-) Rana et al., (2020), while the more accessibility the urban fabric designed in the less per capita travel miles needed, (Litman 2012). Moreover, the more centeredness that allows residents to drive 10-40% less the more accessibility results (Ma et al. 2018b).
Centeredness	Endogenous	Urban fabric centeredness increases the rail transit efficiency since it allows to alternate between different transit modes. When centeredness increase this means that walkability will increase and accessibility to the rail as well (Rana et al. 2020).
Road Design	Endogenous	Road design quality improves walkability and rail transit efficiency, it also reflects positive effects on the economy, and increase density since people will be more willing to stay at their neighborhood more (Furlan and AlMohannadi 2016).
Rail efficiency	Endogenous	The increase in ridership efficiency decreases the trip length and decreases private vehicle ownership because traveling using rail will be more efficient than using private cars (Litman 2012). Moreover, road design quality increases rail transit efficiency.
Rail Availability	Endogenous	The increased rail transit availability increases its efficiency and decreases private vehicle ownership. On the other hand, increasing rail transportation efficiency and availability gives a positive index about state infrastructure and economy.
Trips Length	Endogenous	Trips length is affected by network connectivity, while trip length increases when connectivity decreases, and trip length decrease when rail transit efficiency increase.

Variable	Type	Interrelated variables
Parking supply and Management	Endogenous	The increase in parking supply and management decrease walkability, and increase Vehicle ownership.
Vehicle ownership	Endogenous	The increased density within the neighborhood decrease the parking supply and management which eventually decreases the ownership of the private vehicle,

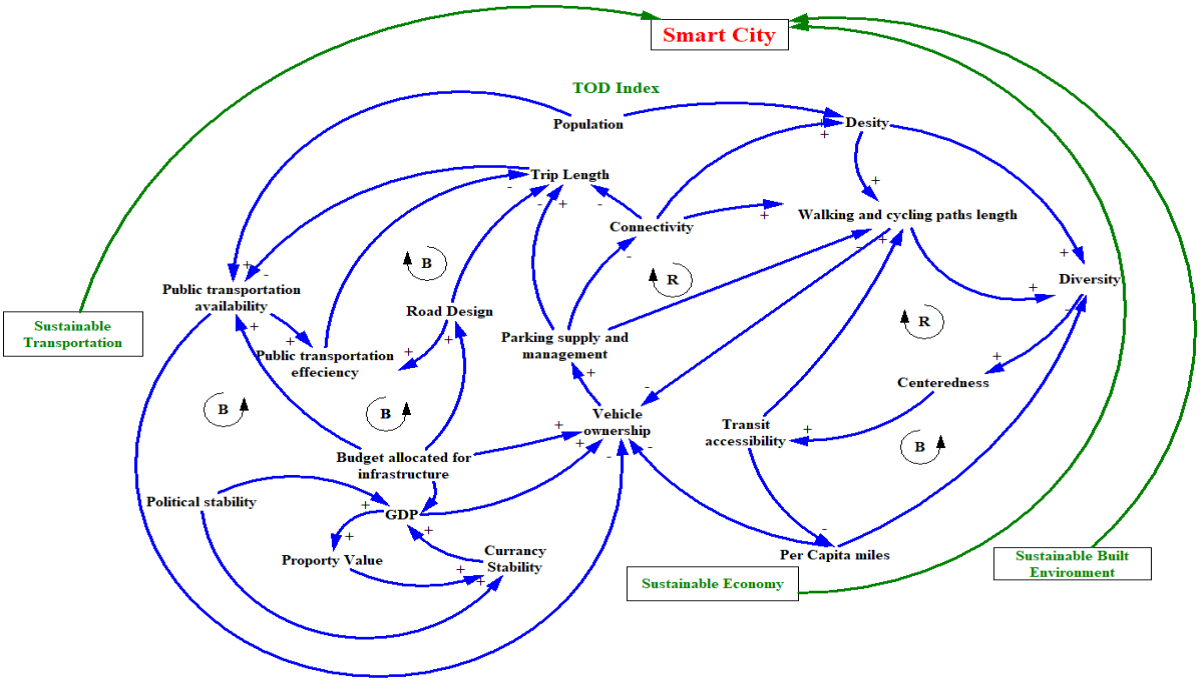

Figure 3. Causal Loop Diagram (Source: Authors)

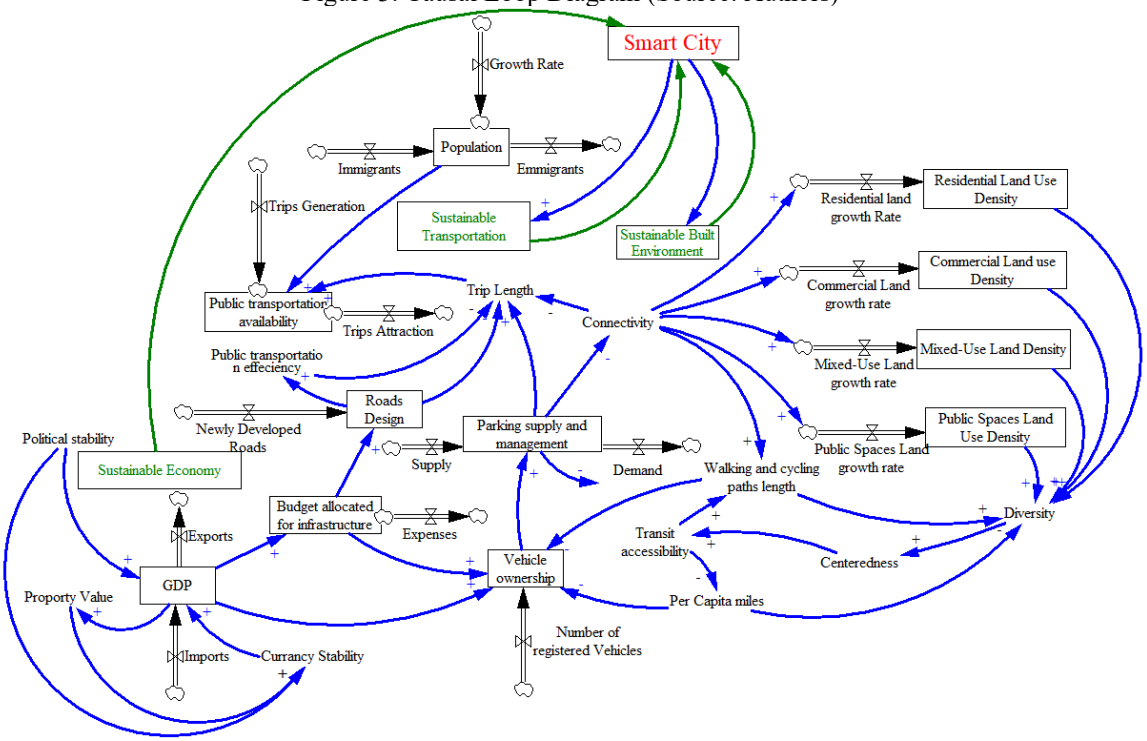

Figure 4. Stocks and Flows Diagram SFD (Source: Authors)

4. Results and discussion

4.1 System Effectiveness through System Thinking

Analyzing the behavior of a system as a whole in terms of built environment transportation, and economic system requires a durable analysis method, which can connect many influencing parameters that contribute to the decision-making via complex relations and feedbacks (Struben & Sterman, 2008). Feedback is a crucial attribute for continuous improvement, so analyzing the real-world system could be the help of giving feedback for decision-making in the forms of qualitative and quantitative data. the following section provides a discussion of the loops generated from the causal loop diagram.

(L1) Diversity→(+) Centeredness→(+) Transit accessibility→(+)Per Capita miles→(+) Automobile ownership →(+) Parking supply and management→(+) connectivity→(+)Density (Balancing)

Nahlik & Chester, (2014) measured the vehicle ownership measures, his results showed that the number of trips per capita stayed constants, while the automobile mode shares and per capita vehicle travel declined, walkability increased, and when urban density increase total daily minutes of travel significantly decreased when the urban density increase. One of the most important findings of Nahlik & Chester, (2014) is that the increased density leads to a decrease in vehicle ownership, and it partially affects regional accessibility, land use mixed, centeredness, connectivity, and public transportation modes (Guan, et al., 2019).

(L2) Diversity →+Centeredness →+ Connectivity → - per capita miles travel → -Diversity (Balancing)
Centeredness refers to the portion of employment, commercial, public spaces, and any other major activities centered in a multi-modal city center (Oppong-Yeboah and Gim, 2020). Kuzmyak et al., (2012) conducted a comprehensive model that indicated that urban density grained the connectivity of the street. the increased connectivity of the streets will reduce per capita miles, which is vice versa decreased by land-use diversity.

(L3) Public transportation availability →+ Economy →+ Road design →+Trip length →- Public transportation Availability (Reinforcing)
The increased rail transit availability increases its efficiency and decreases private vehicle ownership. On the other hand, increasing rail transportation efficiency and availability gives a positive index about state infrastructure and economy. Trip length is affected by network connectivity, while trip length increases when connectivity decreases, and trip length decrease when rail transit efficiency increase (Kuzmyak et al., 2012).

(L4) Public transportation availability →-GHG→- Automobile ownership →+ Economy →+ Road design →- Trip length →+ public transportation availability (Balancing)
Research by Sahu, (2018) shows that TODs inhabitants normally possess about semi as many vehicles, generate half as many vehicle trips, moreover rely on cycling, walking, and public transportation more than in vehicle-oriented communities. The study quantifies the impact of transit on GHG emissions and energy use—less automobile ownership reduces GHG, moreover, vehicle ownership is increased by the increase of the economy. The better countries' economic situation means an increase in the road's design quality. A higher road quality leads to a reduction in the trip length, which leads to more availability in public transportation.

(L5) Parking supply and management→(-) connectivity→ (+)Density→(+)Walking and cycling paths length→ (+) Diversity→(+) Centeredness→(+) Transit accessibility→(-) Per Capita miles→(-) Automobile ownership (Reinforcing)
Appropriate management, allowing increased development density and mix, increasing walkability conditions, can reduce parking supply needs (Nahlik & Chester, 2014). Efficient parking pricing (vehicles owners pay direct costs of providing parking facilities), unbundling (rent parking spaces that are separate from the building) and cash-out (travelers who use non-auto modes receive cash benefits equivalent to parking subsidies provided to motorists) could be significant in help of the reduction of automobile ownership and use. parking supply and management are negatively affected by street connectivity, the more connectivity of streets leads to an increase in density and walkability, which eventually increases land diversity, centeredness, and accessibility (Merlin et al. 2020).

Considering the existing land use characteristics of the district as shown in Table 3. The master plan is developed strategically incorporating distinct factors throughout the planning phases that aim to provide a hub for the enhanced lifestyle and breaking the stigma of the area in being a rundown decayed old city center that is culturally detached from its context in addition to establishing a new setting for living, working, and development that

embraces the current occupants by a fair level. The development plan will deliver new, vibrant and accessible city district solutions and urban environment with a coherent and self-sustaining mix of residential, mixed-use, commercial, retail, and recreation areas that will not only enhance the occupants' livability but also enhance the economic development of the area by planning through a set of clear concept goals that will be elaborated in the following points. The district is planned to attract visitors through its mixture of commercial and leisure-accessible lines while restricting unnecessary traffic flow into the residential areas.

4.2. Implications of System dynamics on Alghanim Distrist (Case Study)

Starting with the most significant encounters, which is the drastic transformation in the urban fabric. Transmutation in this region put into consideration traditional built environment designs. These designs sufficed because they satisfied the requirements of the residents as well as well-adjusting to their surroundings. The plots had one to two levels and needed a minimum of one plot space. As a consequence of different historical backgrounds, the unpredictable state of the economy, the low income of the citizens, and life cycles, the population of this region increased. This situation resulted in the demolition of buildings, which caused the area to lose its metropolitan fabric balance to integrate the new transport system introduced to the city (Doha metro).

Land use and facilities; As shown in Figure 5. and similar to other old districts in Doha, Al Ghanim, is famous for its diverse use of land. A mixed-use environment characterizes the diversity of the land uses in Al Ghanim. The wide-ranging land use is exhibited in the region's commercial and governmental segments. The figure below shows the reality of the image painted earlier. The roads are small, and the highways are jammed and utilized as social entertainment joints. (Facilities) yet, the factors that support the district users are not shown in this plan. the district lacks social activities and amenities, for instance, gathering points, parks, gardens, and green spaces. The absence of these features has made the region less alluring to guests. Also, the situation has turned the district into the least convenient residential area for families due to the gender population, of which 87% were male and 13% were female. As a result, it has significantly halted the economy of this region.

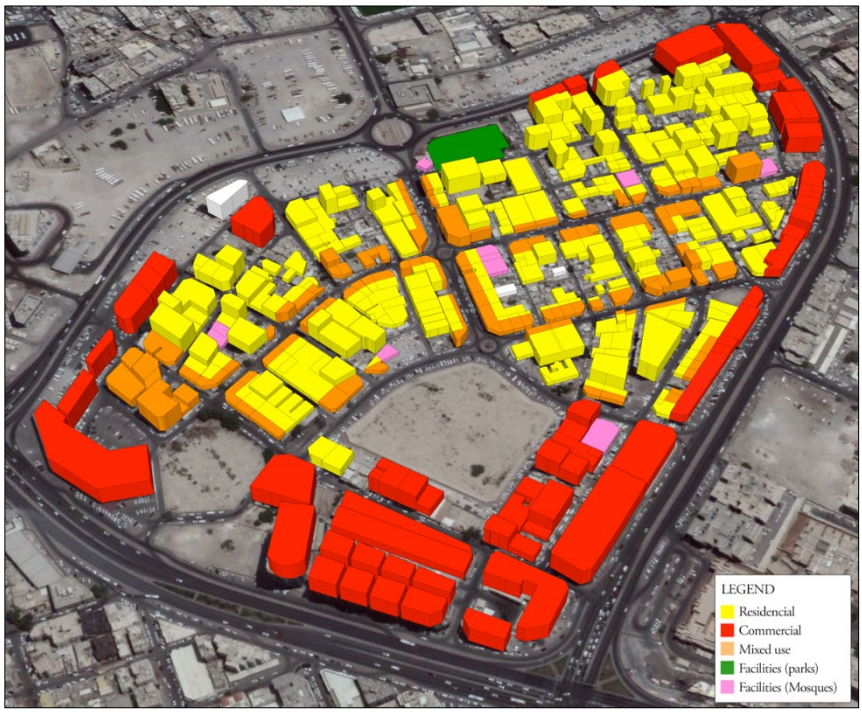

Figure 5. Existing Land use in AlGhanim District (Source: Authors)

Car parking supply and management; A policy introduced by the Ministry of Development Plan announced that the better part of this area, including the main road cutting into Ras and Abu-Abood Road, would ease being used for parking. The objective of this policy is to transform the land use to align with the future vision of the built environment planning of the state. This transformation will make parallel parking a requirement for car users, whether the locals or guests to the city. The impact of this policy will be heightened crowding and reducing the distance of the car path between residential and commercial stretches, which eventually generates the need for public transportation enhancement.

Traffic and hazard; Yet, the existing situation of the district regarding confusing use of the district roads are yet to be solved in a way that encourages walkability and cyclability and now considered as one of the most obvious problems facing this district, in which, both visitors and residents wrongly use open spaces and unused spaces as parking lots. Consequently, this misuse results in high congestion daily, leading to escalating levels of danger for pedestrian mobility.

Connectivity; The arrangement and conveyance structure in the district is among the features of the Doha transportation structure. Al Ghanem District is influenced by the existence of the public transport station (for Karwa Buses), which is new to this zone. This area is considered a crucial factor for the flexibility of transport development as a part of the town's transportation system Figure 6 shows street connectivity in the study area.

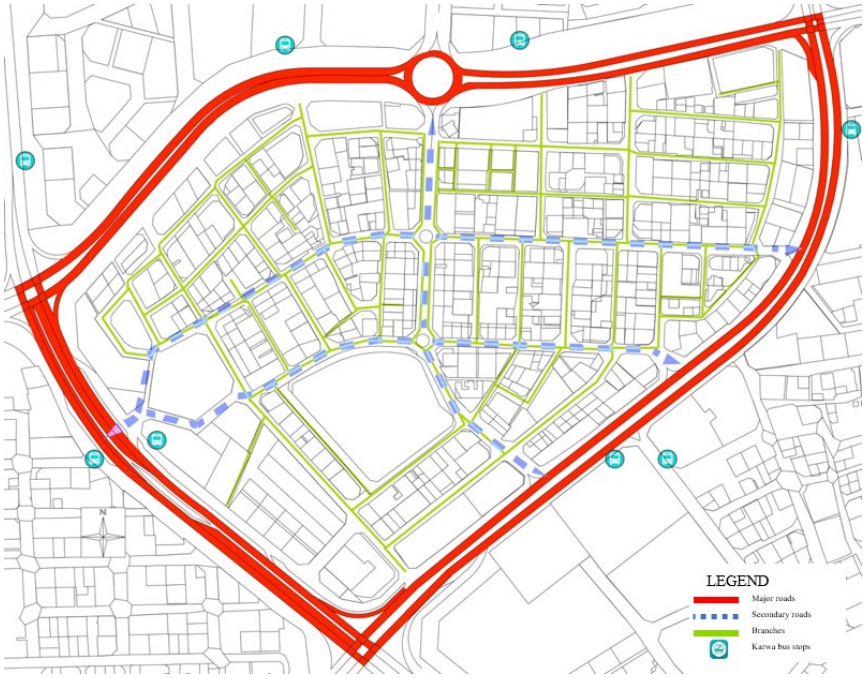

Figure 6. Connectivity lines. (Source: Authors)

Vehicle diversity and / accessibility; The better part of the transportation variety used by the targeted people is the acknowledged public transport system. The majority of Al Ghanim residents are low-income earners who mainly rely on taxis and buses. However, it is hard to spot a cab except when one is called for via network methods, for example, Uber.

Bus Stops; There are two bus stops and one rail line located in the confines of the study area, which are mostly utilized by the residents and city users. However, the number of buses given by the Muwasalat was not adequate for the district's users, the rail transport is served via three stations. This state was more so evident during peak and rush hours when traffic was high. Passengers often seek convenience and speed, but public transportation operators flopped to provide these as a result of insufficient facilities and the overwhelming population, as a result, the economic advantage produced by those district residents is much faster and productive when it is located within their district and less and slower beyond.

Public transportation; Traffic is anticipated to lessen due to the metro station immersed at the C-ring road. The station is also expected to allow movement without relying on buses and cars. Cars and vans are the primary modes of transportation in Al Ghanim. However, the new rail plans are expected to reduce some of the challenges in transportation. This effect has been realized and indisputable in the previous months' reduction in the use of private cars. But, this change has been gradual because other transportation means are being utilized. This state is due to the range between Al Ghanim and its neighboring metro stations.

Figure 7. Roads Design (Source: Authors)

This move has reduced dependence on personal cars and raised the need for outside amenities to sustain prevailing pedestrian reliance while paying attention to modern road designs. Road design; Even though larger roads are more useful as they link different areas, the secondary road policy is a crucial concept of the growth plan. Although the district has several concerns in the neighboring regions. A heightened number of people in the alley roads is among the challenges encountered. The alleys are small, and in some areas, they have a capacity of two cars as shown in Figure (7), and they lack movement and direction controller. Hence, there is unnecessary traffic and subdued convenience in most parts, causing uncontrolled and confused pedestrian movement.

Landscaping and Design; The most significant change apparent in this district is the shift from tall commercial buildings (owned by the existing business and service center projects that define the area) to low residential buildings with traditional models and placement. That said, car and automobile pathways in the neighborhood are currently is not efficient, if not decaying due – as mentioned above- the level of construction placement, design, and density, in which the application of excess formation walls withdraws from the streets' image. Nevertheless, the positioning of the structures – on the other hand- promotes social interaction and ease pedestrian movement around the region.

5. Conclusion

Changing the regulation into a Transit Oriented Development to encourage development and adjust the streetscape character to meet the needs and objectives of the local culture including the context of the affected parties, result in the interaction between the sustainable built environment, sustainable transportation system, and sustainable economic system. An important component in the original study is the land use and current zoning regulation regimes. In towns such as Al-Ghanim, the regimes favor pedestrian development, this also makes it easier to implement TOD even though additional requirements might be implemented. Some of these additional considerations include requiring excessive off-street parking, maximizing of uses, and restricting density.

The best approach to address the current issues is the implementation of a "TOD-by-right" is by planning based on a well understanding of the causality relation amongst all system aspects. These other uses include low enough permissible parking rations, diverse enough permissible mixes of uses, and high enough permissible densities. The objective is to create a system that an investor can easily acquire land within the area, redevelop the structure to support a transit-oriented model leading to profitability. The objective is to prevent complications such as site plan review process, variances, and rezoning, which usually inhibits the development of the region. With the need for continuously improving the transport networks in the design of the neighborhoods, it is important to consider factors such as shorter and fewer daily drips. It creates the interconnection in which individuals can move easily from one location to the next. Active transport also addresses emissions, reduces congestions, and expands opportunities for access throughout the city. The long-term outcome of TOD is the reduction of public and individual spending, which automatically leads to a better quality of life.

The design and subsequent construction have to create a circulation system in which people can move around and engage with others easily. The design has to balance the needs of recreation, work, and home while also focusing on the fundamentals of the neighborhood, which includes togetherness and association. It is easily achieved through enhancing and transforming points in sidewalks. Other processes include the choice of sustainable transport, street furniture, shaded provisions, and shortening the walking distance routes. The design applies to areas around the metro stations. The objective is to focus on car parking, bus stops, and buildings, which supports and sustains physical movement. It is crucial to enhance transport, for visitors, ease the travel arrangements of the visitors, design, and focus on density, incorporate the fundamentals of land usage diversity, and improve the economy, which easily contributes to the long-term development of the district and the city.

In Al-Ghanim district, it is important to incorporate designs that champion the needs and rights of the pedestrian. The friendly urban design would easily enhance and improve the accessibility of the station. The objective is the improvement of transmitting performance while also improving the effect of bus transport connections, which makes it easier for passengers to move around. Walking into the station and walking away from the station should be easy and comfortable. Enhancement of bus service stops incorporates components such as Bus Rapid Transit (BRT) and Light Rail Transit (LRT), ski top service, and or limited stop.

The use of mixed land use is appropriate when it comes to TOD. Affordable housing developments are usually not located near commercial or urban settings. It means that redesigning the area would allow the construction of economic housing, which would be near the facilities and services. However, the region does not have the population or target group that needs such structures and facilities. The existing gap in the provision of resources and services negates the objectives of governments and the people. Poor designs and construction of transport systems increase the costs of transportation such as an increase in fares while the area would not be able to generate appropriate income. Conversely, mixed land usage spurs economic development in addition to diversification of services and goods making them easily available.

6. Limitations and future work

One of the important limitations of this research effort was the lack of long-term time-series data for Qatar. Therefore, our methodology provides a practical solution to explain the TOD behavior in such places (no data—newly developed place, no long history of TOD, etc.) The authors in this research study proposed a conceptual System Dynamics SD framework for TOD in Qatar further research, may include building a quantitative SD model built upon the conceptual model proposed in this research study, by investigating similar regions in the world, with a history of TOD around railway stations—to further investigate the sensitivity of each policy intervention point. Finally, each policy requires the allocation of resources, and the effectiveness of each policy needs to be assessed, quantitatively, throughout a time. The effectiveness should investigate the relationship between resources allocated for a certain policy and its long-term performance in terms of contribution to TOD, how much resource is allocated versus to what degree the outcomes are achieved.

Conflicts of Interest

This research study was approved by all authors that they have no conflict of interest to declare.

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