The Path to Sustainable Transportation: Green Transit Oriented Development

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Abstract: One of the main objectives of urban planning and building innovation in the low-carbon age is to optimise the spatial organisation of cities to support low-carbon travel. Basic study is required to better understand the structural traits that limit vehicle traffic and encourage energy conservation. We first discuss the known research on the processes affecting how urban spatial form affects transportation-related carbon dioxide emissions. subsequently, using case studies to illustrate our points, we show two urban spatial patterns that are focused on low-carbon transport. We subsequently suggest an updated model called Green Transport System Oriented Development (GTOD). The best way to integrate land use and transportation is to create wedge-shaped green areas to separate traffic lanes and to keep development to a minimum along transit corridors. The proposed urban structural model, which supports low-carbon transport and manages urban growth sustainably, is built on this approach.

Keywords:Green TOD, Sustainable Transportation, BRT System.

I. INTRODUCTION

Human-caused greenhouse gas (GHG) emissions have been a major contributor to the world's climate change. The majority of the net energy-related carbon emissions are caused by cities since they are the hubs of population, construction, transportation, industry, and logistics. Two important steps towards resolving the difficulties are identifying the primary sources of GHG emissions and lowering GHG emissions. The two industries that produce the highest GHG emissions are transportation and construction, and the transportation sector is the major source of GHG emissions. In cities, it is getting more and harder to reduce emissions from the transport sector, particularly in developing nations where the number of automobiles has grown quickly.

There are three main ways to cut down on transportation emissions: (1) using low-carbon energy sources, which reduce emissions per unit of energy; (2) using more energy-efficient vehicles, which cut down on energy consumption per vehicle-kilometer travelled (VKT); and (3) cutting down on VKT by implementing an energy-efficient urban spatial structure, which improves logistics and encourages non-motorized travel, such as walking and bicycling. Energy-saving technologies offer the technical infrastructure for low-carbon transport, but they are insufficient on their own to address the issue of transport emissions.

From the standpoint of the connection between transportation and urban spatial structure, three policies must be investigated: urban public transportation systems, a requirement that all businesses that use vehicles report their energy consumption, and the creation of a new specialised ministerial level agency within the state transportation department. The main element of a city is its buildings, and urbanisation results in more built-up areas. Sustainable urban design suggests a close-knit growth pattern to limit urban sprawl, and an urban green space system is essential to the realisation of low-carbon cities. According to Badiu et al.'s study, the target set for urban green space could not be solely used as an indicator for sustainable cities and the supply of urban green spaces, but the beneficial role of the urban green space system in lowering the city's greenhouse gas content and enhancing the well-being of its inhabitants is undisputed among various fields.

Three sections make up the remaining portion of the essay. The section reviews the theoretical evidence connecting urban spatial structure and transportation emissions, concentrating on the effects of density, the degree of mixed land use, and the linkage between land use and transportation on trip demand. Through case studies, including those of Zurich, Singapore, Hong Kong, and Copenhagen, the section analyses low-carbon transit focused urban spatial organisation and its characteristics. Section presents a discussion of our findings and our conclusions. The following questions are the focus of this study's goal: (1) Do transport emissions depend on the urban spatial structure? (2) What kind of spatial organisation encourages the least amount of motorised travel to advance energy conservation?(Ye et al., 2018)

The transit-oriented development (TOD) model is projected to eventually replace the car-oriented development model that was initially used in urban transportation planning. Many American cities, like Atlanta and San Francisco, are currently being built in the TOD style. Asian cities have long followed the U.S. model, and some local governments there have made deliberate attempts to address the aforementioned urban disease or transportation conundrum by implementing the TOD mode to their major metropolises. It is questionable, therefore, whether the TOD development model takes enough into account of both the ecological and environmental aspects. Urban planning and design should take into account ancillary factors that were previously undervalued, such as ecological diversity, the recycling or reuse of natural energy, and livable habitat, in order to improve urban living.

In order to create advanced development modes that maximise the utilisation efficiency of resources and energy by environmental design and adopt green building techniques for connecting or constructing protected areas, natural ecology, and livable habitats, this study combines conventional TOD and green urbanism. The paper is divided into five segments: segment 1 illustrates the driving force behind the work; segment 2 presents the pertinent information missing from prior literature; segment 3 chooses appropriate Green TOD criteria using the fuzzy Delphi technique (FDT); segment 4 ranks the priority of the evaluation criteria for conducting

built environment planning under the Green TOD; and segment 5 reiterates and explains the main contributions and potential findings from the hybrid decision model developed in this paper.(Huang & Wey, 2019)

II. LITERATURE

It is common knowledge that transportation investments can benefit land development. Rail investments have been aggressively used by cities like Copenhagen (Denmark) and Stockholm (Sweden) to change land use and encourage compact urban growth. Similar investment initiatives are used by other municipalities to rehabilitate and revitalise important inner-city centres. Portland, Oregon (US), Manchester (UK), Brisbane (Australia), and Ottawa (Canada) have all witnessed investments in light rail. Bogota, Colombia, Seoul, South Korea, and Curitiba, Brazil have all recognised BRT.

Businesses at the small-scale can gain from the entrance of more tourists and consumers who would spend money there. Light rail investment improves access to major job centres, aiding in the expansion of the labour market. Because BRT is less permanent and more inaccessible, several academics also doubt its ability to spur urban development. As a result, there is no consensus among researchers regarding how BRT will affect urban growth. This study looks at how public transit (BRT) affects socioeconomic activities, investment strategies, and changes in land use.

In addition to the new economic activity created along the corridor, it focuses on how land use changed and urban density changed as a result of the development of BRT. It pays particular attention to inward investment and the influx of new labour from various parts of the city. The article also looks at how the construction of BRT changed the way land was used and how urban density changed, as well as the new economic activities that were created along the corridor, with an emphasis on inbound investment and new labour from various parts of the city. The study also looks at the new economic activity brought about by the corridor, with an emphasis on inward investment and the influx of new workers from other parts of the city.(Basheer et al., 2020)

The TOD concept has been used in numerous studies for local places near public transit hubs. However, the evaluation of TOD levels using the TOD index is the subject of relatively few investigations. The value of utilising an index in TOD research was studied by Renne and Wells and Evans and Pratt. They agree that the TOD index may assess the TOD levels in a given location and that knowing these levels can aid in effective planning on the part of decision-makers. The TOD concept was examined in a site selection of public transport stations by Wey and Wey et al. They started by creating effective standards for smart growth and the TOD idea for this goal. Once the TOD's criteria had been evaluated, they used the fuzzy analytic hierarchy process (fuzzy-AHP) and fuzzy analytic network process (fuzzy-ANP) to identify the ideal group of public transit stations.

This study has some limitations, including the following: (1) the chosen locations for the public transit stations were not globally optimal; (2) the considered indicators were insufficient and should have been supplemented with some other significant indicators, like diversity and demographic traits; and (3) the indicators were assessed in a qualitative form by experts, which is less accurate than using a quantitative format. It should be mentioned that using Geographic Information Systems (GIS) is necessary to compute the quantitative format.

Singh et al., to the best of our knowledge, carried out the first study on TOD planning. To assess the level of TOD throughout the entire study region, they created a spatial TOD index. These TOD levels were applied to the relevant study area for choosing public transit locations. However, their research contains certain gaps. (1) The authors and other studies emphasise that some other indicators, such as accessibility and street connectivity, should be taken into account in TOD planning. The five indicators that were considered were residential density, commercial density, entropy, land use mixedness, and number of business establishments; Because data collection and municipalities' plans are typically configured in the vector format, the indicators were computed in a raster format, which is not appropriate for urban planning. Additionally, the aggregation method used to combine the indicators and criteria is rigid and cannot account for the uncertainties present in both criteria and indicators.(Motieyan & Mesgari, 2017)

III. ENVIRONMENTAL DEGRADATION:

The vast majority of automobiles in India run on petroleum fuels like petrol and diesel. However, the CO2 emissions from the transportation sector are rising quickly, and CNG and electricity are being introduced as substitutes for fuel and diesel. Additionally, CNG is only offered in major cities, and electric vehicles are a relatively recent trend in India. For instance, Delhi has mandated the usage of CNG for public transport, but most other states do not follow this pattern. Most of the CO2 emissions from fuel use in 2015 were caused by the road transport sector.

Due to increased traffic congestion brought on by rising vehicle ownership, transportation-related CO2 emissions are rising. Personal motorization comes with a hefty price tag, particularly in cities. Since the single industry in the world that uses the most petroleum is motorised transportation, this also highlights the issue of energy security. At the moment, one of the main causes of greenhouse gas (GHG) emissions in India is transportation. The transport sector's CO2 emissions are still not under control. Despite policies, the concerned authorities fail to effectively check the level of car emissions, which causes the environment to quickly deteriorate.

The government has placed a significant emphasis on environmental issues from a policy viewpoint. The environment in India has been improved via the implementation of several policies. The Air (Prevention and Control of Pollution) Act of 1981 has made significant suggestions regarding the pollution emission level from cars and is entirely focused on reforming the transportation sector. Nevertheless, notwithstanding this Act, CO2 emissions are beyond the control limit, indicating that measures are not being completely implemented on the ground.

Other policies, including the National Urban Transport Policy (2006 and 2014), the Road Transport and Safety Bill (2014), the Green Urban Mobility Scheme (2017), the National Policy on Transit Oriented Development (2017), and the Motor Vehicles (Amendment) Bill (2017), have made strong recommendations on how to improve the transport sector in order to preserve the environment. One of their main recommendations is to place more emphasis on enhancing public transport systems, minimising the use of private vehicles, switching from traditional fuels to hybrid and electric vehicles, supporting NMT, and enhancing routes for pedestrians and bicycles, among other things. The GoI has begun working on it based on these recommendations, but nothing has changed. The Petroleum Planning and Analysis Cell (PPAC), an attached office of the Ministry of Petroleum and Natural Gas,

commissioned Nielsen (India) Pvt. Ltd. to conduct an All India Study to estimate the share of petrol and diesel consumption among the various transport and non-transport sector segments sold through retail outlets of Public Sector Undertaking (PSU), Oil Marketing Companies (OMC) on a state-by-state, zone-by-zone and all India basis. According to the report, the transport industry in India alone consumes 70% of diesel and 99.6% of petrol. The 2-wheelers alone consume 61.42% of all petroleum, compared to 34.33% for cars, 2.34% for trucks, 1.51% for SUVs, and 0.39% for 3-wheelers. HCV/LCVs consume the most diesel (retail sale) at a rate of 32.54%, followed by private and commercial cars and utility vehicles (UVs) at 25.52%, buses at 8.26%, and three-wheelers carrying passengers or goods at 7.36%.(Ahmad & Chang, 2020)

IV. GREEN URBANISM

Building designs, waste and water management, and energy production all reflect the green urbanisation of Hammarby Sjöstad. The most stringent criteria for energy-efficient construction are used. Being a Nordic nation with high heating costs and extremely high energy prices, Sweden's building requirements are all extremely energy efficient. 80% of Stockholm's heating requirements are met by the district heating network, which significantly lowers energy loss in the heating system. This heating system uses renewable energy sources for 80% of its energy. Stockholm's annual carbon dioxide emissions are decreased by around 50,000 tonnes thanks to the usage of district cooling.

The residual cold water is utilised for district cooling, such as to replace energy-intensive air conditioning systems in office buildings, once heat has been removed from the warm, purified waste water. Even by Stockholm standards, Hammarby Sjöstad's energy platform is cutting edge. Buildings in Hammarby Sjöstad are expected to use 60 kWh of energy annually, which is a third less than the city as a whole. Walls are well insulated, and all windows have triple glazing. Additional heat insulation, energy-efficient windows, on-demand ventilation, apartment-level individual metering of heating and hot water, electrically efficient installations, lighting control, solar panels, fuel cells, decreased water flow, and low-flush toilets are additional conservation methods.

The completely integrated closed loop eco-cycle model at Hammarby Sjöstad has attracted the most interest in terms of ecology. This innovative system recycles waste and maximises the use of waste materials and energy for cooking, heating, and transportation. The following are some examples of trash management/reuse at Hammarby Sjöstad:

- Glass, metals and plastics are recycled.
- Combustible waste is incinerated and recycled as heat and electricity.
- Organic waste is composted and turned into soil or converted into biogas.
- All newspaper is recycled into new paper.

The three latter waste kinds are managed via a stationary vacuum system for solid trash known as the "ENVAC system." Residents can place waste in vacuum tubes at each building, where they are then transported to pick-up facilities. This reduces truck traffic through the development, decreasing emissions and enabling smaller streets with less truck traffic disruption. In the form of biogas produced from treated wastewater (made in the wastewater treatment plant from digestion of organic waste sludge) and the burning of combustible waste, waste is also transformed into energy for district heating and cooling. Additionally, 1,000 apartments have biogas cookers installed, and biogas is utilised to power the buses. Many buildings have solar PV cells and solar hot water systems. Despite the fact that solar systems only cover a tiny portion of the development's energy needs due to the Nordic environment, solar panels supply 50% of the hot water needs for many buildings.

The way Hammarby Sjöstad manages water is very impressive. All rainwater, snowmelt, and storm water are collected, locally cleansed using sand fibre, storm water basins, and green roofs, and then released into a lake. In order to ensure cleaner air and create a balance to the crowded urban scene, a maintained oak forest, plenty of green space, and planted trees assist absorb rainwater.(Ervero & Sullivan, 2013)

V. CONCLUSION:

A kind of urbanism and mobility known as a "green TOD" prioritises infrastructure for transit, cycling, and pedestrians over that for automobiles. They combine different land uses to provide a lively, busy street life and interior spaces, and they value little waste, low emissions, and energy independence. Hammarby Sjöstad, Rieselfeld, Vauban, and Kogarah in Sweden, Germany, and Australia are a few examples of Green TODs, as are Masdar City in the United Arab Emirates. The ideas of Green TOD should be modified by other communities to fit their unique needs and restrictions. Value capture techniques, such land sales, can be used to finance green TODs. However, Green TOD gives customers additional options for where to live and how to get about, despite the moniker "social engineering" that critics have given it. Due to lifestyle considerations, middle-class households are more inclined to choose Green TODs.

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