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Original Paper

Designing a Transit Oriented Development with a Trackless Tram System—Case Study Bulawayo

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Abstract

The need for a mid-tier transit system and the opportunities created by 21st century transit technologies like Trackless Trams System (TTS) has been analysed in an earlier paper to show TTS could be a leapfrog solution for the future of sustainable urban development in developing cities. This paper outlines how the TTS can be created as a part of Transit Oriented Development (TOD). Informed by literature, this study identified four factors that are important for enabling transition towards TOD. Using three of these factors a framework for assessing and evaluating TOD is formulated. The study then applies the formulated framework to the potential corridors that could potentially enable a transition towards a successful TOD for Bulawayo and enable the TTS to be delivered in a partnership with urban land development. The findings do reveal that most of the station precincts that are closer to the CBD have a higher potential to enable transition to TOD. This could suggest that the TTS could be implemented in two phases, the first phase covering the high impact station precincts.

Keywords

transit-oriented development, transit-activated corridor, trackless tram systems, sustainable development, station precinct

1. Introduction

The City of Bulawayo is a classic example of an African city struggling to find resources to kick-start its sustainable development agenda. Given the current challenges that the city is going through, for example, massive deindustrialisation, water shortages and a large number of unemployed youths, it is urgently in need of sustainable urban development (Ndlovu et al., 2020). In a previous paper we have argued that there is value in seeking leapfrog technology to act as a stimulus for sustainable urban development and examined the potential for Trackless Tram Systems (TTS) to be such a leapfrog

technology (Ndlovu & Newman, 2020). The TTS lends itself to partnership development, hence the opportunities for partnership can been applied to the TTS initiative for Bulawayo. This paper will look into how a TTS leapfrog technology could possibly create land development opportunities that could also be the basis of financing such a demonstration in the City of Bulawayo through a Transit Oriented Development (TOD) approach alluded by (Newman & Kenworthy, 2006; Renne, 2017).

The TOD approach will be outlined below but at its heart it brings together developments that can be built near stations to increase the opportunities to reduce car dependence, and which can be implemented through partner financing of the land developments. Currently the City of Bulawayo has no capital resources to drive its developmental agenda, hence, the notion of reaching out to the private sector to lead its economic resuscitation and infrastructural renewal is imperative. The TOD approach works well with the inclusion of various developmental parties, especially private investors, real estate developers, the local government (council) and the community. The concept of TOD is ideal for most cities in the developing world doubly so for Bulawayo which lost its major industrial base during the year of 2000 to the year 2010 and is currently facing an imminent environmental collapse (Ndlovu et al., 2020).

This study will assess and evaluate the suitability of the Transit Oriented Development approach for Bulawayo driven by the introduction of the trackless trams on its busiest corridors identified by the City of Bulawayo (2020). Guided by the knowledge acquired through literature this study will formulate a framework for assessing and evaluating the identified station (node) precincts' potential to enable a transition towards TOD for the selected corridors. Identified factors that significantly influence a successful transition towards a TOD will form the backbone of the framework.

2. Methodology

The study has undertaken a literature review to determine the key factors/variables that are necessary to enable transition towards TOD. The identified factors are collated to form a theoretical framework of assessment and evaluation that is used to assess the potential of each station precinct to enable TOD within the identified transit-activated corridor. Utilising the City of Bulawayo as a case study, this framework is applied to evaluate the positive impact that TOD could have on Bulawayo's corridors. Figure 1 illustrates the steps taken to formulate this evaluation framework, and the overall structure of this study.

The first apparent shortcoming with the development of the TOD evaluation and assessment framework is the lack of understanding of the level of significance for each identified factor/variable. A further study is necessary to help in understanding the level of significance of each factor and their weight of significance. However, this study is comfortable with the utilisation of the factors as they have been identified in various studies as core and relevant variables that enable transition to TOD. The data to establish the density and population distribution within this study's formulated isochrones (referred as buffers on TACs' maps) is sourced from the ZimStats (2014) and is illustrated on Table 1. This dataset

enables the identification/approximation of the 10,000 people/residents' density within the formulated travel time isochrones of this study's TOD evaluation framework. There are no residential-codes applied in this analysis but an overview description of the potential and existing commercial development/sites and residential suburbs around the station precincts. This study conducts a qualitative study/research of the potentially identified Transit-Activated Corridors (TACs) based upon the TOD evaluation and assessment framework's qualitative metrics. Therefore, the framework provides only a qualitative assessment and evaluation of the potential of each station precinct's ability to enhance and enable a transition towards a TOD with its related TAC.

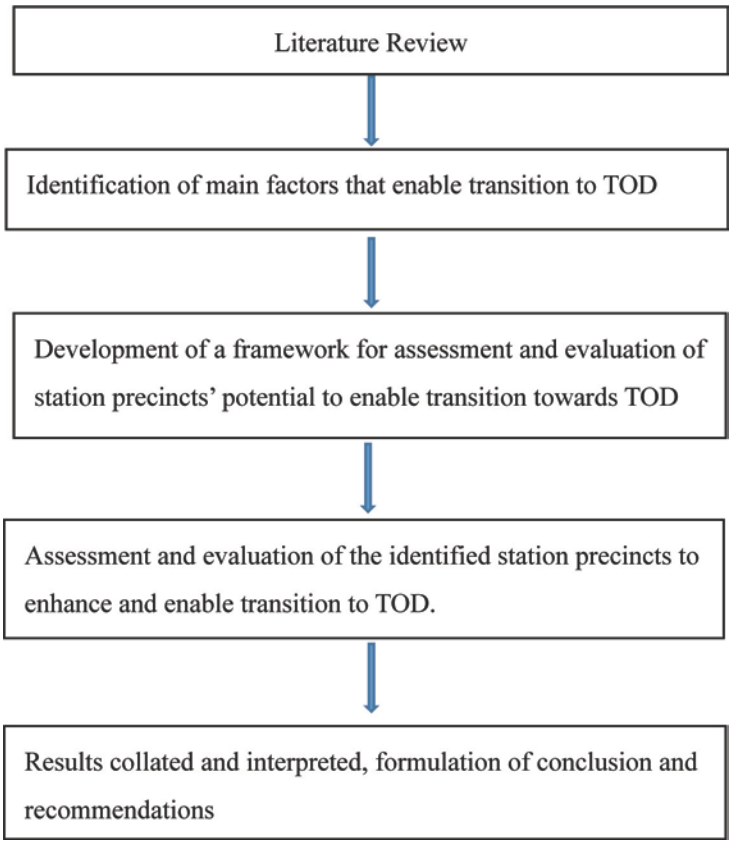


Figure 1. Steps in Formulation of the Assessment and Evaluation Framework

3. Transit Oriented Development

3.1 Literature and Background

According to Cervero (2009) the TOD is a simple concept that focuses on developing around transit stations to enable a densely populated area in order to promote transit riding, increased walking and bicycle travel, thus reducing the propensity to use cars (p. 23). The Scandinavians have of lately utilised this concept very effectively in their development of rail station precincts (Bertolini et al., 2012). Singapore, a developing country in the 1970's was able to build a rail system and utilised the TOD plan which it named "Constellation Plan" due to its radial links to its various "new towns" and a

central core district (CBD). The City of Bulawayo is built on similar physical settings of a radial city, hence is ideally suited for this approach as adopted by Singapore. The TOD approach is more than just the development of the station precincts, Bertolini et al. (2012) describes it as a developmental approach that goes beyond just a single stations. Accordingly, a true TOD should aim at "the re-centering of entire urban regions around transport by rail and away from the car" Bertolini et al. (2012, p. 31).

The redevelopments of the London's King's Cross and Zurich's Neu-Oerlikon are examples that have adopted the TOD concept to rejuvenate their station precincts after they had lost their historic manufacturing base Bertolini et al. (2012). The City of Bulawayo is still recovering from its loss of its industrial capacity brought about by a massive deindustrialisation episode of the early 2000s.

According to Griffiths and Curtis (2017) the most successful TOD strategies are those that provide a full network of interconnected TOD. Bertolini et al. (2012) suggest that successful TODs are the ones that "are less focused on single station precincts and more on developing a polycentric network of station areas of different size and function in an urban regional context" (p. 48). Therefore, station precincts should ideally be planned and developed to stand as new town centres that provide multiple amenities and services as well as housing.

Meidutē and Paliulis (2011) studied the success of Bogotá's BRT project. This project has adopted a very successful TOD approach. According to Cervero (2009) "Bogotá, the Andean capital of Colombia, has gained global recognition for its highly efficient and productive bus rapid transit (BRT) system" (p. 28). This therefore highlights that an efficient and well planned BRT or Trackless Tram System can be setup in such a manner that can promote sustainable development through a TOD approach that would rapidly develop a city as evidenced by the rapid development of Singapore. During its rapid developmental journey Singapore recorded the most rapid GDP per capita growth among the developing economies, driven by its focused "national economic development plan" that extensively utilised the concept of TOD. Similarly, when Bogotá completed its BRT project "Transmilenio" it was recognised as the world's most sustainable metropolises regardless of Colombia's civil unrest (Cervero, 2009). This strategic harnessing of both public transport and land use developments does lead to highly valued urban sustainable development. It is becoming widely accepted that the TOD is an ideal approach to adopt in the pursuit of sustainable development especially in the rapidly developing cities of the emerging economies. This approach to development is likely to reduce reliance on private car usage and promote the culture of using public transport. Accordingly, a real TOD "should also provide employment, housing, public services, and retail opportunities at major rail or bus transit stations" Griffiths and Curtis (2017, p. 392). According to Griffiths and Curtis (2017) the success of the TOD in Subiaco in Perth, indicated that close proximity and connectivity to public transport services, followed by the affordability of using public transport were the main factors that influenced the use of public transport by residents within the spheres of influence of that TOD station precinct (p. 404). To have an effective TOD strategy which works well in successfully promoting an increase in public transport use

over the car, Griffiths and Curtis (2017) show that there is a need to have a well-linked series of TOD stations along a corridor. They documented the importance of an extensive wider transport network that is efficiently well connected. They suggested that "in order for the Subiaco TOD to be successful in increasing public transport use over the car, the wider public transport network must be extensive and flexible enough to provide individuals with an efficient and fast alternative transport option" (p. 405). This therefore does reiterate what many studies have highlighted, that a single TOD precinct cannot be fully functional in isolation but needs a well-integrated metropolitan wide transport network or at least one corridor where there is an integrated system.

Looking at the success of Euralille urban quarter, Bertolini et al. (2012) postulates that many have tried to emulate this famous quarter, but have not succeeded. They suggest that the emulators overlooked the problems and challenges that Euralille faced prior to its implementation of the initiative. According to Bertolini et al. (2012) the main problems that bewildered Euralille included "insufficient infrastructure capacity to deal with the rapidly growing passenger flows, property developments not keeping up with expectations (particularly developments oriented to an international market), and more generally a lack of flexibility in the plan and design in the face of changing external conditions" (p. 39). These challenges are similar to the ones faced by the City of Bulawayo. With these kind of challenges, a TOD strategy is needed that will allow multiple agencies to come together, think, and plan as a group. Euralille also was fortunate in that its mayor also happened to be the president and prime minster of the region. Hence, the politics of the region and the city was very focused and aligned.

According to Curtis and Mellor (2011), the TOD approach does optimise the benefits associated with land-use/transport integration as a means to achieve sustainable accessibility and development. Hence, Curtis and Mellor (2011) posit that modern city planning should evolve from "planning the railway as a transport system to planning the railway as a transit-oriented development system" (p. 146). This view of planning was adopted by the State of Western Australia when it formulated its TOD strategy, and formed the TOD implementation committee to manage this approach.

Another highlight on a potential to develop an effective and successful TOD program is the need to define each station precinct's functionality and purpose correctly. Every precinct must be designed according to its correct functionality as governed by its locality and comparative advantage. Doina and Carey (2015) were able to categorise station precincts into three unique functionalities. The identification and listing of potential station precincts according to their core functionalities can inform and guide in structuring a correct policy that will promote the success of the overall TOD initiative. In their study, they classified Bull Creek station as a transit interchange, the CBD of Perth as both a TOD and a transit interchange, Wellard station as a "new urbanism" precinct, whereas the larger Cockburn Central station precinct had the features of both Wellard and Bull Creek precincts. This approach emphasises the need for development at each station precinct to be targeted differently to avoid the "one size fits all" policy. Curtis (2012) further elaborated this when stating that "state TOD policy must identify which station precincts should perform what role in relation to TOD" (p. 290). To enable

successful transition to TOD, Curtis (2012) advocates a TOD policy that is well formulated and very prescriptive in defining a holistic approach to development not simply based upon residential density but also focused on employment of land use and intensity.

Utilising the same logic as undertaken by Curtis (2012), it should be possible to assess, evaluate and identify potential nodes based upon the Isochrones of 5, 10, and 15 minutes of walking distance. Within those isochrones, this study should determine the potential density and intensity of land use as these are crucial for planning a successful transition towards TOD. The study also incorporates Newman and Kenworthy (2006)'s rule of thumb to evaluate whether within the area covered by various isochrones (*referred to as "buffer from tram station" on the maps of the TACs of this study*) the density of at least 10 000 employees and/or residents is satisfied to ensure the viability of the station precinct.

Numerous studies have documented that lack of resources is one of the main factors that negatively impacts transition to TOD. This usually happens when the state and/or local governments relies on the traditional mode of funding for public infrastructural developments and does not include land development. With the current trend of rapid urbanisation, most governments are facing the challenge of keeping up with the public demand of public infrastructure and services. Given that TOD is becoming central to modern urban planning strategy, the market has evolved and allows the private sector to finance TOD projects (Newman, 2009; Renne, 2017). India is a notable example of a country with a large population and huge market. This makes it ideal for it to adopt the TOD concept for its developmental agenda. Currently India has a significant number of rail projects in discussion and still negotiating various PPP arrangements. The Mumbai Metro and the Rapid Metro Gurgaon are privately funded rail systems on a Build Operate Transfer (BOT) arrangement (Sharma & Newman, 2017). The adoption of the trackless trams by rapidly developing cities should also consider utilising the PPP funding mechanism to enhance the ability to get the projects implemented.

Land Value Capture (LVC) is another funding mechanism that can be utilised to fund TOD projects. The concept of utilising the LVC has been effectively implemented to fund major projects such as the London King's Cross station precinct and the highly successful Hong Kong's Mass Rapid Rail Corporation (MTRC). The Hong Kong's MTRC has fared well with the application of its Rail plus Property development program. Most of its revenues are now coming from the property development along its rail route. According to Sharma and Newman (2017) this approach undertaken by the City of Hong Kong and its MTRC has effectively guided the city's TOD along the corridors, hence promoting sustainable urban development. Yet another classic example that has utilised various LVC funding mechanisms to promote a TOD regeneration project is the New York Subway. According to Sharma and Newman (2017) "the New York Subway has illustrated how alternative financing works effectively with referendum-backed (public participation) bond issues, TIF, air rights and developer contributions" (p. 96). The City of Bulawayo's railway company was built to cater for regional centres and to be a link to the famous mooted Cape Town to Cairo route. Utilising the strategy adopted by New York Subway it can refinance its dilapidated railway infrastructure and regain its railway city status. (Renne, 2018)

In summary, the literature highlights the following factors as the common enablers for a successful TOD:

1). Density:

Density is crucial to enable the viability of the station precincts or new town centres to sustain themselves within a transit-activated corridor. This criteria is suggested inNewman and Kenworthy (1999)'s rule of thumb, to evaluate whether within the area covered by various isochrones (*buffers on the map*) the density there is at least 10 000 employees and/or residents needed for the viability of a node.

2). Existence of a bus station, commercial centre or impending potential development:

The selected station precinct(s) should have a potential for developments or further redevelopment. These centres for re/development should according to Griffiths and Curtis (2017, p. 392) have a potential to provide "employment, housing, public services, and retail opportunities at major rail or bus transit stations".

3). Proximity and connectivity to other public transport services:

Potential nodes should ideally have the outer isochrones of the 15 minutes walking distance (or the equivalence of the 1km buffer on the TACs maps) overlapping so as to enhance and enable development to touch every section of the transit-activated corridor as deliberated by Griffiths and Curtis (2017, p. 404). This will promote transit riding, increased walking and bicycle travel, thus reducing the propensity to use cars (Cervero, 2009, p. 23). According to Griffiths and Curtis (2017) successful TOD strategies are those that provide a fully interconnected TOD and nodes.

4). Transport affordability and TOD policy:

Policies for supporting TOD and transport affordability are an important enabler for transition to TOD. According to Curtis and Mellor (2011) the success of the Subiaco, Perth TOD is largely attributed to the State of Western Australia's formulated TOD strategy that was managed by the TOD Implementation Committee setup by the state government. Euralille is also another example of how the alignment of politics of the region and the city is attributed to the success of TOD.

The first three factors relate to the station precincts' socio-economic and locality dynamics, whereas the fourth factor is generic and policy based, hence it generally affects all station precincts equally. This study will therefore utilise only the first three factors to formulate a TOD evaluation and assessment framework for the best sites in Bulawayo.

3.2 Trackless Tram Systems (TTS)

The emergence into a new economy due to the 2020 pandemic that resulted in an economic collapse of some economies is a great opportunity for some to develop. It could also be a terrible time of uncertainty and hence the future direction of urban development and infrastructure needs to be something that can bring great hope to people in cities across the world as well as in Bulawayo (Ndlovu

et al., 2020). The TTS lends itself to leapfrog sustainable development and hence constitutes a 21st century sustainable urban development initiative as it offers Bulawayo an opportunity to make something special with a true legacy from this difficult time (Ndlovu & Newman, 2020; Ndlovu & Newman, 2021; Ndlovu et al., 2020).

The Trackless Tram and its ability to facilitate development as well as unlock urban regeneration opportunities, has been one of the major targeted projects in the city over the past years since the idea was brought to the attention of the city (Kazunga, 2019, May 09). Communities, investors and the local authority are ready to commit to this new technology and to the new process that could unlock major urban developments and create new jobs and new community outcomes (Ndlovu & Newman, 2020; Ndlovu & Newman, 2021; Ndlovu et al., 2020). The overview of the novelties attributed by the TTS are described by Newman et al. (2020, p. 6) and include the following key factors:

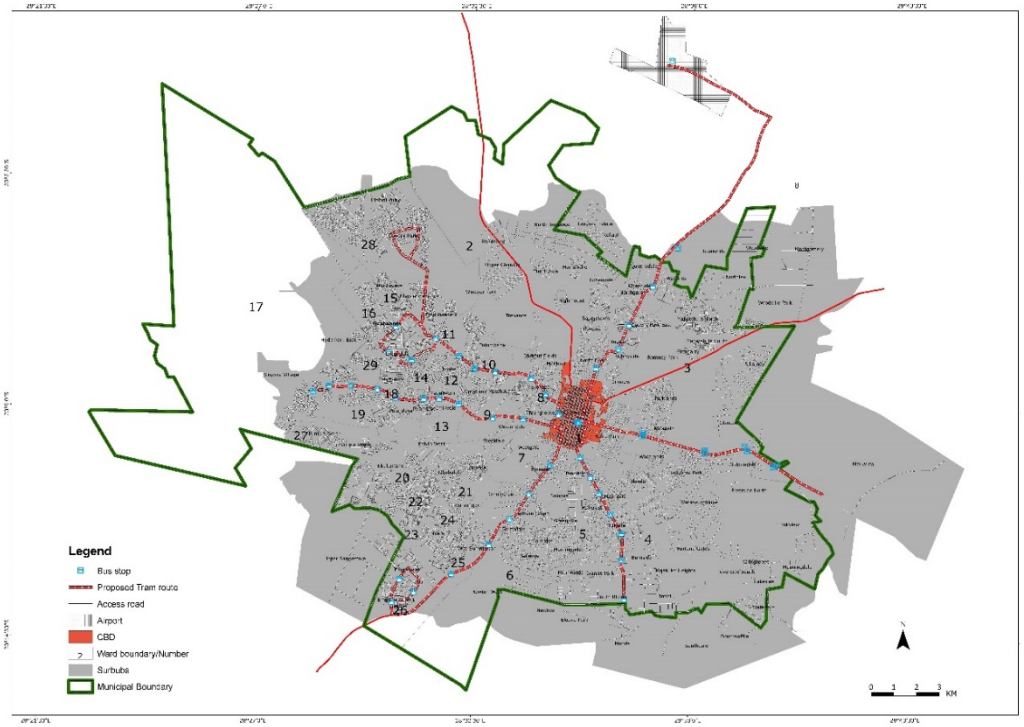
1) The TTS provides an alternative to Bus Rapid Transit and Light Rail as a major mid-tier form of transit that can help shape a city but is not expensive like a Metro.
2) The TTS is electric with batteries on the roof and has no need for steel tracks so it can be implemented over night instead over years with serious impacts on the urban economy along the route.
3) The TTS has ride quality that is like a tram and can carry 300 people in a 3-car system at 70 kph so it has a capacity equivalent to a good rail service.
4) As it is low cost and easily attracts urban development around its stations the TTS lends itself to partnership funding including how to include solar energy as the recharge source at stations and depots.

The TTS routes and their associated station precincts have the potential to create new local centres with a variety of services along a main road corridor—a Transit Activated Corridor (TAC) as discussed by Newman et al. (2020). This means that a TTS is ideal for a post-Covid pandemic Recovery Program as it can be delivered quickly and yet have long-term legacy benefits in terms of a series of urban developments, providing housing at all economic levels, and services that are desperately needed (Newman et al., 2020). Due to its potential of having long-term value generation the TTS have a potential to be financed through partnership funding mechanisms.

As shown on Map 1, the Bulawayo TTS is envisioned as a connector that runs East-West and North-South to meet at critical points within the Central Business District. More importantly, as suggested in the report by Newman et al. (2020), this system has a potential to “unlock major urban development opportunities where major employment can be created, providing a much stronger rationale for urban consolidation” (p. 6).

The effectiveness to enhance the adoption of a leapfrog technology requires developing the capacity and capability to domesticate the technology as was discussed by Ndlovu and Newman (2020). Bulawayo can negotiate in the procurement process with any of the manufacturers of TTS to assemble

the coaches locally and thus create further jobs and enable it to extend the innovations as it learns how best to make the system work there.



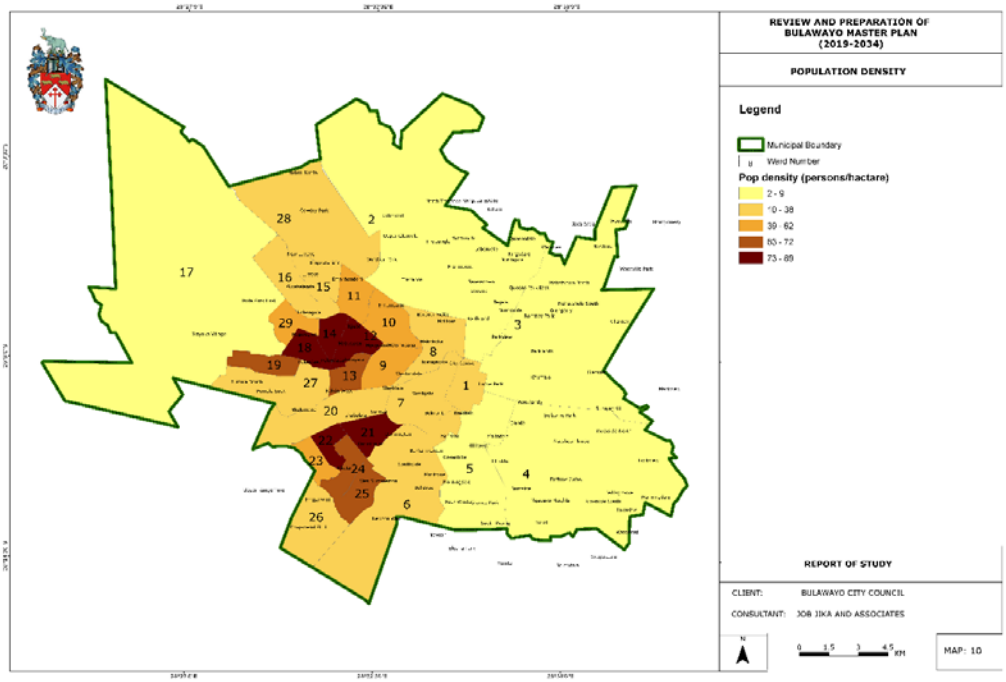
Map 1. **Bulawayo Proposed Tram Routes.**

3.3 Bulawayo Socio-economic Data and Demographics

According to the ZimStats (2014), Bulawayo is a youthful city where people live in relatively small households of less than 4 people. The residents are relatively modern in accessing basic services such as portable (mostly tap) running water and using electricity as a major energy source (ZimStats, 2014). Literacy rates are very high (above 90%) though there are limited opportunities for formal employment. This state of affairs has led to a notable number of Bulawayo residents earning a living in the informal sector.

According to ZimStats (2014) it is estimated that 58% of the Bulawayo population represents the labour force and that 80% of this labour force is active (0.8 x [0.58 x 655675] = 304233). Furthermore, ZimStats (2014) estimated that the informal sector is 94.5% of the labour force. In this regard, the informal sector of Bulawayo may be estimated at 287,500 people (0.94 x 304233). Such a large well-educated labour force plagued by limited formal employment would be relatively cheap and may encourage major investments into the city, especially on the back of the positive attributes of Bulawayo. The private investment will have to move alongside public investments, with the Bulawayo City Council (BCC) focusing on inter-alia social safety nets, education, employment enablers, housing and

recreational needs. Map 2 shows the population density of Bulawayo, and Table 1 gives the city's population distribution by wards.



Map 2. City of Bulawayo Population Density

Source: ZimStats (2014)

Table 1. Bulawayo Population Distribution by Ward

PROVINCE=0 Bulawayo

DISTRICT=021 Bulawayo Urban

		Population			Households	
	ward	Males	Females	Totals	Number	Average size
ward	01	5792	6466	12258	3867	3,2
ward	02	13164	14660	27824	7240	3,8
ward	03	14272	15648	29920	8018	3,7
ward	04	12060	13052	25112	7380	3,4
ward	05	8831	9926	18757	5303	3,5
ward	06	6223	7181	13404	3479	3,9
ward	07	8720	9190	17910	4802	3,7
ward	08	11337	12923	24260	5830	4,2

ward	09	13089	14747	27836	7187	3,9
ward	10	13772	15664	29436	7605	3,9
ward	11	8869	10380	19249	4697	4,1
ward	12	12615	14059	26674	6789	3,9
ward	13	9477	10286	19763	5130	3,9
ward	14	9556	11032	20588	5200	4,0
ward	15	5781	7095	12876	3089	4,2
ward	16	7530	9393	16923	4170	4,1
ward	17	8060	9207	17267	4195	4,1
ward	18	10502	12439	22941	5928	3,9
ward	19	9643	11199	20842	5275	4,0
ward	20	8589	10440	19029	4547	4,2
ward	21	13577	14896	28473	7010	4,1
ward	22	8779	10668	19447	4798	4,1
ward	23	8895	10605	19500	4909	4,0
ward	24	11236	12611	23847	6011	4,0
ward	25	11638	13349	24987	6038	4,1
ward	26	9622	11574	21196	5134	4,1
ward	27	13859	17400	31259	7450	4,2
ward	28	20490	24858	45348	11342	4,0
ward	29	8468	10281	18749	4669	4,0
District Total		304446	351229	655675	167092	3,9

Source: ZimStats (2014)

3.4 The City of Bulawayo and Its potential Transit Activated Corridors for TOD?

As suggested by Ndlovu and Newman (2020) & Newman et al. (2020) the new mid-tier technology Trackless Tram is both good for transit and good for unlocking urban regeneration. In view of the public transport challenges currently being faced by Bulawayo, the city, communities, investors and central government need to embrace this new technology. A detailed feasibility study needs to be undertaken on how the TTS will improve the public transport system as well as unlock major urban developments, facilitate urban regeneration and create new job opportunities and new community outcomes. This study presents how TTS can be implemented within the major transit corridors to enable a rapid redevelopment of the city through a TOD approach, using Bulawayo as the case study.

The study will now look at the implementation options of a Trackless Tram System to enable TOD's along the corridors for the City of Bulawayo. The potential transit activated corridors (routes) to enable TOD for the City of Bulawayo are listed below:

1) The first route will service the residential neighbourhood and National University of Science and Technology (NUST) along the Bulawayo—Beitbridge road—approximately 12km.
2) The second route will service the City—Airport route, which has detailed planning and costing—approximately 25km.
3) The third route will service City to Luveve with a possible extension to Cowdray Park—approximately 18km
4) The fourth route will service City to Pumula—approximately 15km
5) The fifth route will service the City to Bellevue Suburb with a potential of extension to Emganwini—approximately 13km
6) The sixth route will service the eastern suburbs, City to Burnside—approximately 15km.

Curtis (2012) highlighted the importance of having an extensive wider transport network that is sufficiently connected into a well-integrated metropolitan wide transport network. This notion informs the approach outlined below to formulate a holistic TTS based TOD network that covers the entire City of Bulawayo metropolitan network as is portrayed on Map 1.

Utilising the TOD assessment and evaluation framework formulated, this study will assess and evaluate the potential of each identified node (station precinct) to enable TOD on its TAC. The evaluation will grade and determine the corridor's likelihood to enhance and enable transition to a series of TODs.

3.5 Framework for Assessing and Evaluating TOD Station Precincts' Potential

As set out in the literature review, various studies do show the three factors listed below as the most relevant enablers of the nodes (station precincts) to enhance transition to TOD within each TAC. Based upon these factors a conceptual framework for assessing and evaluating each route/corridor's potential is constructed (Table 2).

1) Population density of more than 10,000 people/employees or residents (Newman & Kenworthy, 2006)
2) Existence of a bus station, commercial centre and/or impending potential developments (Griffiths & Curtis, 2017)
3) Proximity and connectivity to other public transport services or nodes (Cervero, 2009; Griffiths & Curtis, 2017)

Table 2. Framework for TOD Assessment and Evaluation

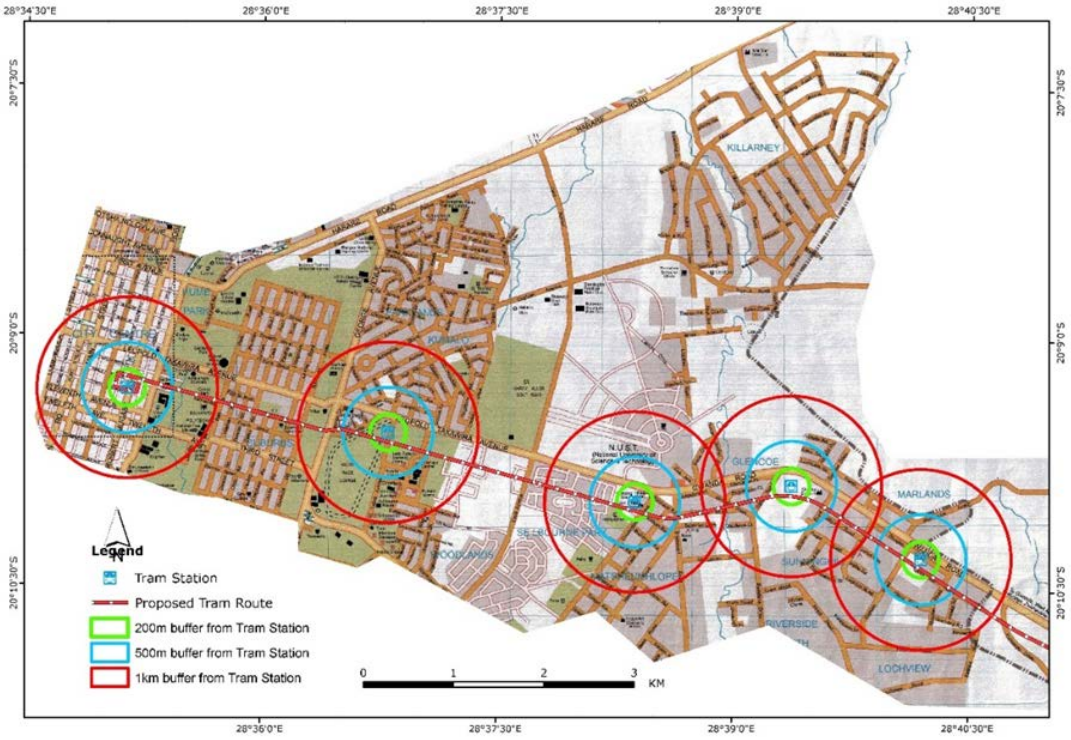
Factors	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5
1. Population Density > 10 000.					
2. Existence of a bus station or commercial centre, impending potential development					
3. Proximity and connectivity to other public transport services					
Overall out of 5 (Corridor's potential measure)					

Factor values: The framework will rank the value of each factor per station precinct out of five points. For example, a factor that aligns fully for a station precinct will be graded five out of five, should the factor rank lowest to the station precinct then it will graded one out of five. Then an overall corridor rating based on the average of the scores is generated to measure the potential of the TOD's viability or likelihood of the TAC's potential. The evaluation should be able to ascertain and identify the high impact precincts along the corridor. This is important in that a different focus (planning policy) needs to be developed for each station according to its potential and local settings as recommended by Doina and Carey (2015). The measure for the first factor (density) is based upon the data provided in Table 1 by the ZimStats (2014) which identifies the council wards that surround the relevant station precinct. The City Council's engineering department provided the measure/information of the second factor concerning the existing nodes, precincts and potential developments. The 200m, 500m and 1km buffers (isochrones) on the TAC maps provide the measures/information for the third factor concerning the proximity of the station precincts to the other nodes.

3.6 Assessment and Evaluation of the Transit-Activated Corridors (TAC)

3.6.1 Route 1: City Centre to Sunninghill

Map 3 shows how a Trackless Tram route could be part of a project that removes the various modes of public transport on the city centre—Sunninghill route and provides a much faster and higher capacity system linking the residential neighbourhoods and the main CBD bus terminus (EGODINI).



Map 3. Transit Activated Corridor 1—City Centre to Sunninghill

Station Precinct 1—National Museums and Suburbs

This will cater for people who will be going to the National Museums—tourists and other office or commercial developments within Suburbs. This route will also cater for the Bulawayo Polytechnic College students. Wards 3 and 4 surrounds this precinct.

Station Precinct 2—Ascot Shopping Centre

This station precinct will largely cater for the Ascot, Khumalo suburb residents, people going to the United Bulawayo Hospital, and students going to Milton High, Khumalo and Masiyephambili Primary Schools. Developments within the immediate vicinity comprises the Ascot Shopping Centre, Holiday Inn. There is a proposal opposite Milton High School for an upmarket hotel development. At the former Ascot Racecourse, there are proposals for the redevelopment in this prime area with a focus to build upmarket housing, entertainment centre and related facilities. Wards 3 and 4 surrounds this precinct.

Station Precinct 3—National University of Science and Technology (NUST)

This station precinct will service the National University of Science & Technology and cater for students and staff members as well as the residents of the Selbourne Park and Riverside suburbs. There is an ongoing mixed land use of residential and commercial activities on this precinct, and it still has great potential for redevelopment to build such structures as the student residential apartments and commercial activities. Wards 3 and 4 surrounds this precinct.

Station Precinct 4—Glencoe

There are some minor commercial activities happening on this potential precinct. There is a fuel station that was recently built. In addition, a new residential neighbourhood is currently under construction. This node will cater for the residents of this newly established residential neighbourhood of Sunninghill and Riverside. Wards 3 and 4 surrounds this precinct.

Station Precinct 5—Sunninghill

This precinct will cater for the residential neighbourhood at Sunninghill as well as for the residents of the proposed development of 7 000 plots by Radar at Farm No 2 up to the boundary with Kensington. Wards 3 and 4 surrounds this precinct.

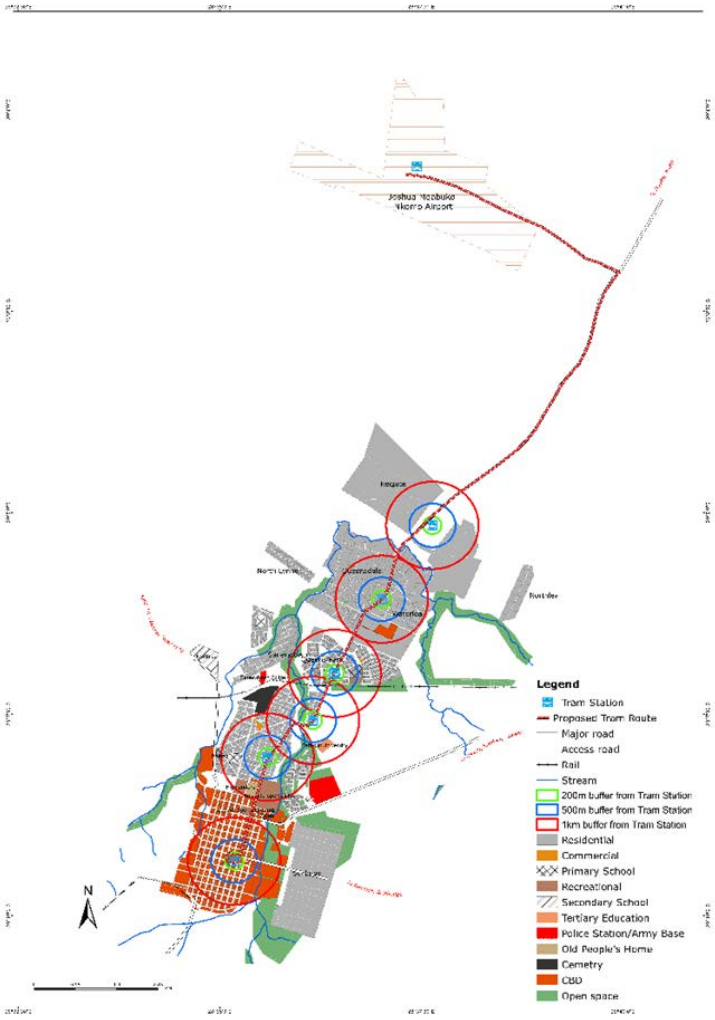
Table 3. Route 1 TOD's Potential—Evaluation Results

Factors	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5
	✓✓✓	✓✓✓	✓✓✓	✓	
1. Population Density > 10 000.	✓✓	✓✓	✓✓	✓	✓
				✓	
2. Existence of a bus station or commercial centre,	✓✓✓	✓✓✓	✓✓✓	✓	✓
impending potential development	✓✓	✓✓	✓✓	✓	✓
3. Proximity and connectivity to other public transport	✓✓✓	✓✓✓	✓✓✓		
services	✓✓	✓✓	✓✓	✓	✓
Average score out of 5	✓✓✓	✓✓✓	✓✓✓	✓	
	✓✓	✓✓	✓✓	✓	✓

Conclusion for Route 1: Station precincts 1 to 3 do reflect a very high likelihood of impact to enhance and enable transition to TOD. They cover a stretch of approximately 6kms of the overall potential transit-activated corridor. Station precincts 4 to 6 seem to reflect a lower likelihood of impact to enhance and enable transition to TOD, they cover the remaining stretch of 6kms, and this last stretch covers some low-density suburbs of semi-farming areas.

3.6.2 Route 2: City Centre to Airport

Map 4 sets out the route that has been determined through detailed traffic studies. The map shows the potential urban development that is likely to happen in the period covering ten years up to year 2031 along the Airport transit-activated corridor. Some land developments have already been initiated outside the Municipal area, i.e., a golf course, commercial development, high, middle and low-income residential areas.



Map 4. Transit Activated Corridor 2—City Centre to Airport

Station Precinct 1—Highlanders sports club

This precinct will cater for people who will be going to recreational facilities at Hartsfield, Amazulu Sports fields, old people's homes at the Coronation cottages, Highlanders sports club, several blocks of flats and residents on the edge of the city centre. Wards 2 and 3 surrounds this precinct.

Station Precinct 2—Catholic University

This precinct will cater for students and staff members at the Catholic University, as well as residents at Tegela, Romney Park and Northend. There exists a filling station at Romney Park along the route—this site has potential for further development into a major commercial node to cater for the residents in the area. Wards 2 and 3 surrounds this precinct.

Station Precinct 3—Queens Park

This precinct will cater for residents in Queens Park East & West. This site will provide an opportunity for the existing commercial node to be redeveloped. Wards 2 and 3 surrounds this precinct.

Station Precinct 4—24/7

There is a commercial node @ 24/7. Residential developments abutting the node are Orange Grove, Northgate, Kingsdale, Orange Grove, Waterlea etc. The areas around the commercial node will benefit from redevelopments of the node. Wards 2 and 3 surrounds this precinct.

Station Precinct 5—Hopeville

This potential node falls outside the jurisdiction of the City Council. However, there are major developments in Hopeville (1 500 stands) and Reigate (1 500 stands). A golf course as well as major commercial developments have been planned along the main airport road. Wards 2 and 3 surrounds this precinct.

Station Precinct 6—Bulawayo Airport

Transport to and from the airport is by means of taxis. TTS would be a convenient means of transport of tourists, visitors and residents to the various parts of the city. Wards 2 and 3 surround this precinct.

Table 4. Route 2 TOD's potential—Evaluation Results

Factors	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5	Station Precinct 6
	✓✓	✓✓				✓✓
	✓✓	✓✓	✓✓✓	✓		✓✓
1. Population Density > 10 000.	✓	✓	✓✓	✓	✓	✓
	✓✓	✓✓				✓✓
2. Existence of a bus station or commercial	✓✓	✓✓	✓✓✓	✓	✓	✓✓
centre, impending potential development	✓	✓	✓✓	✓	✓	✓
	✓✓	✓✓				
3. Proximity and connectivity to other public	✓✓	✓✓	✓✓✓	✓		✓✓
transport services	✓	✓	✓	✓	✓	✓
	✓✓	✓✓				
Average score out of 5	✓✓	✓✓	✓✓✓	✓		✓✓
	✓	✓	✓✓	✓	✓	✓✓

Conclusion for Route 2: Station precincts 1 to 3 and 6 do reflect a very high likelihood of impact to enhance and enable transition to TOD. They cover a stretch of approximately 12kms of the overall potential transit activated corridor. Station precincts 4 to 5 seem to reflect a lower likelihood of impact to enable transition to TOD due to being located on an empty undeveloped land identified to separate the airport from residential areas due to noise pollution. The airport precinct itself reflects a very high level of impact to enhance and enable transition to TOD.

3.6.3 Route 3: City Centre to Luveve

Map 5 shows how a Trackless Tram route could be implemented for the public transport on the busy City—Luveve route, with a possible extension to Cowdray Park. Cowdray Park can benefit from the introduction of this route and stimulate the potential developments that have stalled in this new suburb.

Map 5. Transit Activated Corridor 3—City to Luveve

Station Precinct 1—Nguboyenja

This node will cater for people residing in Mzilikazi, Barbourfields, Thorngrove and Nguboyenja. This is also expected to cater for soccer fans on Saturdays and Sundays when there are matches being played at Barbourfields stadium.

Station Precinct 2—Matshobana

This node will cater for residents of Mpopoma and Matshobana and for the Bulawayo polytechnic students residing at the Rio hostel. There is a large land space available in the vicinity that has a potential to develop into a large “new town centre”.

Station Precinct 3—D-Square

This node will cater for students at Mpopoma High, Entumbane residents as well as Residents at Njube. This station precinct is located between two main roads leading to Entumbane, Mpopoma and Luveve, making this node an ideal interchange station.

Station Precinct 4—Entumbane complex

This will cater for residents of Entumbane, Njube as well as shoppers at Entumbane complex. The complex has a potential for further development especially construction of residential apartments and lighter commercial activities.

Station Precinct 5—Emagetsini

There is a proposed site for a commercial development by the Masiyephambili and Luveve junction and two private hospitals within the immediate vicinity making this node an ideal interchange and new urbanism station. Across, the tram will also service residents of Njube, Old Lobengula and Emakhandeni suburbs.

Station Precinct 6—Chigumira

This node will service Old Luveve, New Luveve, Luveve Stadium and Enqotsheni.

Station Precinct 7—Ko-Maplanka: This station will service Gwabalanda and Magwegwe North.

Station Precinct 8—Lobengula West: This node will service Lobengula West, Magwegwe West and Luveve 5.

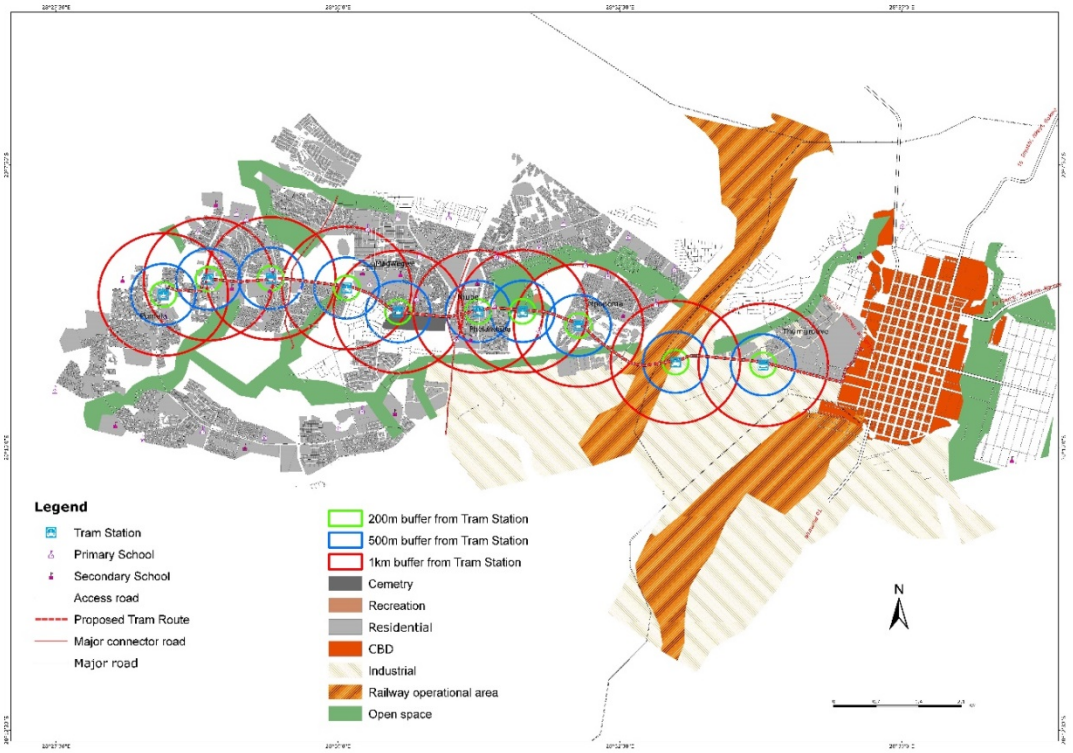
Table 5. Route 3 TOD's Potential—Evaluation Results

Factors	1 Station Precinct	2 Station Precinct	3 Station Precinct	4 Station Precinct	5 Station Precinct	6 Station Precinct	7 Station Precinct	8 Station Precinct
	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
1. Population Density > 10 000.	✓	✓	✓	✓	✓	✓	✓	✓
2. Existence of a bus station or	✓✓		✓✓	✓✓	✓✓			
commercial centre, impending	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
potential development	✓	✓✓	✓	✓	✓	✓	✓	✓
						✓		
	✓✓	✓✓	✓✓	✓✓	✓✓	✓		
3. Proximity and connectivity to other	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
public transport services	✓	✓	✓	✓	✓	✓	✓	✓
	✓✓	✓✓	✓✓	✓✓	✓✓	✓		
Average score out of 5	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
	✓	✓	✓	✓	✓	✓	✓	✓

Conclusion for Route 3: Station precincts 1 to 5 do reflect a very high likelihood of impact to enhance and enable transition to TOD. They cover a stretch of approximately 10kms of the overall potential transit activated corridor. Station precincts 6 to 8 seem to reflect a lower likelihood to enable transition to TOD due to them being small nodes with a potential of being interchange stations only.

3.6.4 Route 4: City Centre to Pumula

Map 6 shows the proposed route to Pumula. This route will pass through the industrial sites catering for the industrial workers along the route. Old Pumula is a very old suburb that urgently needs redevelopment and regeneration, the introduction of the Tram route could be the stimulus that has been missing to kick-start the regeneration of this old suburb.



Map 6. Transit Activated Corridor 4—City to Pumula

Station Precinct 1—Monarch

This precinct will cater for industrial sites around the area and Thorngrove industrial area.

Station Precinct 2—Westondale Industrial Area

This will be an industrial station, catering for the industrial sites around the precinct.

Station Precinct 3—Mpopoma

This precinct to service Mpopoma South, the commercial centre at Mpopoma and some parts of Iminyela and Mabutweni.

Station Precinct 4—White City

This proposed station precinct will service Iminyela and Mabutweni as well as White City Stadium.

Station Precinct 5—Pelandaba

This proposed precinct will service Pelandaba, Sizane and Lobengula High School, Lobengula Extension and some parts of Old Lobengula.

Station Precinct 6—Old Magwegwe

This site will service Old Magwegwe and Pelandaba West.

Station Precinct 7—Pumula East

This proposed site will service Pumula east and some parts of Pelandaba West.

Station Precinct 8—Pumula North

This proposed site will service some section of Pumula East, Pumula North, Amhlophe Secondary School and St Bernards High School.

Station Precinct 9—Old Pumula

This proposed site near the housing office will service the police station, Pumula High and the residential neighbourhoods of Old Pumula, Pumula North and St Bernards High School.

Station Precinct 10—Old Pumula-Hyde Park

This station will service Old Pumula Shops, Old Pumula and Hyde Park suburbs.

Table 6. Route 4 TOD's potential—Evaluation Results

Factors	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5	Station Precinct 6	Station Precinct 7	Station Precinct 8	Station Precinct 9	Station Precinct 10
				✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓
	✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓
1. Population Density > 10 000.	✓	✓	✓✓	✓	✓	✓	✓	✓	✓	✓
2. Existence of a bus station or				✓✓	✓✓					
commercial centre, impending	✓	✓	✓✓	✓✓	✓✓	✓✓			✓	✓
potential development	✓	✓	✓✓	✓	✓	✓	✓✓	✓✓	✓	✓
	✓	✓		✓✓	✓✓					
3. Proximity and connectivity to	✓	✓	✓✓	✓✓	✓✓	✓✓			✓	✓
other public transport services	✓	✓	✓✓	✓	✓	✓	✓✓	✓✓	✓	✓
			✓✓	✓✓	✓✓					
Average score out of 5	✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓
	✓	✓	✓	✓	✓	✓✓	✓	✓	✓	✓

Conclusion for Route 4: The first two and last four station precincts on this transit-activated corridor seem to reflect a consistently low impact towards their potential to enable transition to TOD. The first two precincts are located in the industrial areas, while that last four are not linked well to other roads in city. This route is unique in that the reason it was created was to offer an express access to the CBD by passing through low activity areas especially through the industrial sites.

3.6.5 Route 5: City Centre to Plumtree Road

Map 7 shows the proposed route along the Plumtree road area. The introduction of Trams on this route appear to be a very good proposal, as this once beautiful corridor needs some major redevelopment and regeneration. The proposed redevelopment and extension of the Bellevue suburb will go well with the introduction of Trams leading to an integrated transport and land development proposal.

Map 7. Transit Activated Corridor 5—City to Bellevue

Station Precinct 1—Stanbic

This station will service customers to Stanbic Bank and industrial establishments in Belmont.

Station Precinct 2—Donnington

This station will service, Barham Green residential area, Donnington Police Station and industrial establishments in Donnington.

Station Precinct 3—Southwold

This station will service Southwold, Belmont, and the industrial establishments in Donnington

Station Precinct 4—Bellevue

This station will service Bellevue, Newton West. There is a proposal for Bellevue extension (1000+ stands).

Station Precinct 5—Emganwini 1

This station will service Nketa 9, Emganwini Island and Emganwini residential neighbourhood. There is also a proposal to develop on a piece of land of the remainder of Emganwini (2000+ stands).

Station Precinct 6—Emganwini 2

This station will service Emganwini residential neighbourhood.

Station Precinct 7—Emganwini 3

This station will service Emganwini residential neighbourhood.

Station Precinct 8—Emgwanini Extension

This station will service Emganwini residential neighbourhood, the commercial centre and parts of Rangemore, and will service Emganwini up to the end of the City plan boundary.

Table 7. Route 5 TOD's Potential—Evaluation Results

Factors	1 Station Precinct	2 Station Precinct	3 Station Precinct	4 Station Precinct	5 Station Precinct	6 Station Precinct	7 Station Precinct	8 Station Precinct
	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
1 Population Density > 10 000.	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
	✓	✓	✓	✓	✓	✓	✓	✓
Existence of a bus station or commercial	✓✓	✓✓	✓✓	✓✓				
centre, impending potential	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
development	✓	✓	✓	✓	✓	✓	✓	✓
	✓✓	✓✓	✓✓	✓✓				
Proximity and connectivity to other	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
public transport services	✓	✓	✓	✓	✓	✓	✓	✓
	✓✓	✓✓	✓✓	✓✓				
Average score out of 5	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
	✓	✓	✓	✓	✓	✓	✓	✓

Conclusion for Route 5: Station precincts 1 to 4 do reflect a very high likelihood of impact to enhance and enable transition to TOD. They cover a stretch of approximately 6kms of the overall potential transit activated corridor. Station precincts 5 to 8 seem to reflect a lower likelihood of impact to enable transition to TOD due to the nature of the suburbs being widely spaced.

3.6.6 Route 6: City Centre to Burnside

Map 8 shows the Burnside route that will cater for patrons that will largely be attending the events at the Trade Fair grounds. The introduction of TTS on this route will also cater for residents along the Hillside road all the way to Burnside. The trams could be re-routed during the special times of the day to pass through the tourist areas such as the Hillside dams and Mabukweni gardens.

Map 8. Transit Activated Corridor 6—City to Burnside

Station Precinct 1—Trade Fair

This station precinct will service people who are attending, working and need services at the trade fair ground and Famona residential neighbourhood.

Station Precinct 2—Bradfield

This station will service Bradfield Residents, Famona and people coming for shopping at Zonkizizwe and Bradfield shopping centre.

Station Precinct 3—Mater Dei

This bus stop will cater for residents of Bradfield, Mater dei hospital and Hillcrest

Station Precinct 4—Cecil Avenue

This station will cater for residents of Hillside as well as those going to Hillside Primary School and Hillside shopping centre

Station Precinct 5—Moffat Avenue

This station will cater for residents who reside within the immediate residential neighbourhood, tourists visiting hillside dams, tourist related accommodation and those intending to get services from Tel One.

Station Precinct 6—Whitestone Avenue

This station will cater for residents within the immediate neighbourhood, the abattoir at Whitestone farm and Whitestone primary school.

Station Precinct 7—Filling Station

This station will cater for residents within the neighbourhood and tourist related accommodation within the area.

Station Precinct 8—Criterion Water Works

This station on the edge of the current Municipal boundary to cater residents within the neighbourhood, workers at the Forestry Commission Research, Jairos Jiri farm and Criterion water work.

Table 8. Route 6 TOD's Potential—Evaluation Results

Factors	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5	Station Precinct 6	Station Precinct 7	Station Precinct 8
	✓✓							
	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
1. Population Density > 10 000.	✓	✓✓	✓✓	✓	✓	✓	✓	✓
2. Existence of a bus station or	✓✓	✓✓	✓✓			✓		
commercial centre, impending potential	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
development	✓	✓	✓	✓✓	✓✓	✓	✓	✓
	✓✓	✓✓	✓✓			✓		
3. Proximity and connectivity to other	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
public transport services	✓	✓	✓	✓✓	✓✓	✓	✓	✓
	✓✓	✓✓	✓✓			✓		
Average score out of 5	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
	✓	✓	✓	✓✓	✓✓	✓	✓	✓

Conclusions for Route 6: This route does reflect a very high likelihood to enable transition to TOD, the first three precincts stand out with a higher level of potential than the last three precincts. Station precincts 4 to 5 also do reflect some likelihood of impact to enhance and enable transition to TOD regardless of being located in a low-density residential area, they have many beautiful tourist spots, trams can be used to provide transport for tourists to this area. Station precincts 6 & 8 are largely in sparse farms making them very low with regards to the ability to enable any reasonable TOD.

4. Discussion

Utilising the framework in the assessment and evaluation of the corridors reveals a distinct pattern. The findings do indicate that most precincts that are closer to the CBD have a high level of TOD impact potential than the stations that are further from the CBD. The further the precinct gets from the CBD

the less is its potential impact to enhance transition towards TOD. This revelation could be crucial for the development of the implementation strategy of the TTS for the City of Bulawayo. This suggests that closer precincts should be prioritised to receive the trams as part of the first phase. This first phase of implementation will significantly reduce the number of vehicles entering the CBD and will help expand the CBD to the adjacent suburbs that are catered for by the newly introduced TTS routes. This also will allow major developments within the suburbs that are walking distance from the CBD, thus curbing the urban sprawl. Implementing the TTS in two phases will make the project manageable and deliverable. However, the concept of enabling transition to TOD for the entire metro-wide network should be of priority, if all the identified station precincts are included in the initiative of receiving the TTS it will maximise the economic activities of the city. Value uplift will be recognised by the whole city and will enhance the potential for investment to flow.

The overall economic, social, community, environmental benefits of adopting TTS for the entire metro-wide network are likely to be significant. These are likely to be integrated and will enable the achievement of many SDG's proposed by Ndlovu et al. (2020). The following list of potential outcomes are based on the work in this paper.

1) The provision of Commercial Nodes in each Station Precinct with local shops, local services, local place features, that enable the surrounding areas from each station catchment to have a place to walk and provides a meeting place for various community activities.
2) A local Recharge Hub for any electric vehicle, large and small, and perhaps a local Delivery Hub for on-line shopping parcels as a TTS network would be ideal for distribution service across any city.
3) Affordable and Social Housing in partnership between the developer and the City of Bulawayo, which will vary with the location.
4) Consolidated Housing benefits compared to fringe housing developments, with around savings in infrastructure, travel times, and health benefits due to making more active lifestyles in walkable urban environments to reiterate the view postulated by Trubka et al. (2010).
5) Climate change emissions reductions from transport as the more urban/inner city quality of housing and transport is usually 33% less in greenhouse gases. These can be reduced to net zero emissions if the developer chooses to make net zero housing and all the transport becomes electric with solar recharge as stipulated by Thomson et al. (2017).

The Bulawayo Trackless Trams initiative is an opportunity to provide a post-COVID recovery project that can begin immediately and with great public excitement. Such a project can show that the City of Bulawayo is:

1) Up and running in its new economy,
2) Looking to the future rather than the past,
3) Taking a role as a global leader in innovation.

In 3 years, a new transit system will help make the city network work better, will provide hundreds of new houses and jobs in well located new town (urban) centres, and will enable thousands of jobs to be created for the youthful City of Bulawayo.

Just as elaborated by Newman et al. (2020, p. 12), Bulawayo could also expect to benefit from the innovation of TTS in that:

- It can fit into the present system quite simply (for example its relatively straight forward to fix the roads in preparation for a TTS) ;
- It will bring smart city sensors into transit systems in a way that will need to be applied to all aspects of transport into the future;
- It will enable Bulawayo to be a demonstration of how the very high take-up of roof top solar can be applied to new station precincts and depot rooftops and enable the grid to be stabilized through battery-based Recharge Hubs earning money for the operator;
- By being the first city in Africa to adopt this new transit technology, Local Authorities from across Africa will be coming to Bulawayo to view the new system and professional jobs in the area will be created to service other cities.

As demonstrated by Newman et al. (2020, p. 16) in their study of Perth, Australia, this study of Bulawayo does as well reflect that Bulawayo can also along the same lines explore its strategy to deliver the TTS following the stages below:

- Step 1. Seek Climate Funding and use this as the basis for procuring other partnerships that can deliver a TTS using urban development opportunities as the basis of investment partnerships.
- Step 2 Immediate road works can begin to enable the TTS to be fitted into the main roads at designated station precincts and to demonstrate the support of the city in the development of the project. Most of the roadworks have been planned for a number of years. Introduction of Trackless Trams can begin immediately and be a catalyst for the roadworks to begin. Procurement of the TTS and of other urban developments associated with the TAC can be conducted in parallel along with community engagement to ensure detailed local place issues are part of the final plan.
- Step 3. Bids could be conducted within the first year for which the other stages in the overall plan should be done next.
- Step 4. Full city TTS system with urban regeneration along six TACs completed within 3 years.

5. Conclusion and Recommendations

The findings of the study show that the concept of adopting the TTS on the roads of Bulawayo will initially work extremely well to cater for the station precincts that are on the near outskirts of the City Business District (CBD). Therefore, the adoption of the TTS will more likely regenerate the corridors

from the CBD to the suburbs that are on the outskirts of the city's CBD area. In addition, the introduction of the TTS will drastically reduce the cars and vans that clog the roads within the city centre. This study finds that the City of Bulawayo could significantly improve its ability to achieve sustainable development goals and contribute towards the Paris Agreement. The project is likely to attract climate-related funding and financing.

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