

**School of Design and the Built Environment**

**Trackless Trams and Emerging Economy Cities: Is it a Leapfrog  
Technology?**

**Case study - City of Bulawayo**

by

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**A thesis submitted to Curtin University  
to fulfil the requirements for the degree of  
Doctor of Philosophy**

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## Author's declaration

I certify that to the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made. This thesis contains no material that has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research – updated May 2020. The proposed research study received human research ethics approval from Curtin University Human Research Ethics Committee Approval Number: HRE2018-0144.

Vinnet Ndlovu, PhD candidate

Date: 31/12/ 2020

# Statement of contributors

All of the written materials submitted as part of this PhD by Publication were conceived and coordinated by Vinnnet Ndlovu. I also undertook the majority of the writing and case study analysis for each publication.

Signed detailed statements from each co-author relating to each publication are provided.

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# Abstract

Rapid innovation and development of modern technology has brought about the opportunity for developing economies to technologically leapfrog. This research assesses literature to show what technological leapfrogging is and the key criteria used to enable it to occur in developing countries. Literature shows that the criteria that enable technological leapfrogging include being ‘economical enough’, ‘less technical’, ‘lends itself to partnership’, ‘lends itself to community engagement’, ‘enables co-development’ and ‘fulfils the sustainable development goals’. The research examines the new mid-tier transit technology called Trackless Trams and applies the six criteria to it. The case is strong for Trackless Trams (TTs) to be part of the future in developing cities to technologically leapfrog in a way that can enable multiple development objectives including the SDG’s.

The City of Bulawayo is currently emerging from the collapse of its public transport and water distribution systems, once the envy of and benchmark for many local authorities in the country, and has detailed SDG plans for the future. Using the City of Bulawayo as the case study, the research investigates the localisation of the SDGs and evaluates how the adoption of leapfrog technology especially Trackless Trams, could enable a developing city like Bulawayo to better attain its SDGs. The research creates a multi-criteria framework from the literature review on the localisation of the SDG agenda, and applies it to Bulawayo.

Through the utilisation of the public-private partnership (PPP) concept, the research shows that Bulawayo has the potential to deliver the TTs project in a timely and cost-effective way and sets out a delivery approach. This research creates the basis for a potential PPP with a trackless tram/solar energy project in Bulawayo with potential to bring mobility, a new solar power system and other multiple economic and social benefits, especially demonstrating the intention of Bulawayo to leapfrog into a 21st century future. This research designs a PPP model referred to as a Three Multifaceted PPP Model (TMPM) that will enable the implementation of the Trackless Tram project in Bulawayo. The TMPM model is composed of three layers of players each required to structure a separate PPP arrangement. The Bulawayo City Council would lead the first layer responsible for road construction. The private investors would lead the second layer and be responsible for the construction of station precincts especially the construction of a solar-based Transit Mall and the surrounding residential properties. The Trackless Tram

consortium and the public transport agency would be tasked with the management and operation of the Trackless Trams.

The research shows that Bulawayo has a strategic planning basis to successfully pursue a Trackless Tram project combined with urban regeneration projects in a transit-oriented development (TOD) model. Informed by literature, the research identified four factors that are important for enabling transition towards a TOD-based approach to urban development using the benefits of wide streets in Bulawayo. A framework for assessing and evaluating TOD is formulated and applied to the potential corridors in Bulawayo. The project seeks to identify for Bulawayo a successful network of Trackless Trams and station-sites that need precinct-based regeneration which could be delivered in a partnership with urban land development. The findings show that the station precincts that are closer to the central business district (CBD) have a higher potential to enable transition to TOD. This could suggest that the TTs should be implemented in two phases, the first phase covering the high impact station precincts.

The research shows that Bulawayo can serve as a planning model for localisation of sustainable development goals through utilising the leapfrog technology of trackless trams with solar-energy based urban regeneration. It suggests that the partnership approach developed to deliver this could be part of the future of developing cities in emerging economies.

**Keywords:** Sustainable Development, Trackless Trams, Leapfrog Technology, Transit-Oriented Development, Three-Multifaceted PPP Model.

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## List of acronyms and abbreviations:

BCC	–	Bulawayo City Council
BOO	–	Build Own & Operate
BOT	–	Build Operate & Transfer
BRT	–	Bus Rapid Transit
CoB	–	City of Bulawayo
ICT	–	Information and Communication Technology
LRMT	–	Light-Rail Metro Transit
LRT	–	Light-Rail Transit
M&E	–	Monitoring & Evaluation
MEAL	–	Monitoring, evaluation, Accounting and Learning
NUST	–	National University of Science and Technology
PESTLE	–	Political, economic, social, technological, legal and environment
PP	–	Public-Private
PPP	–	Public-Private Partnership
SDGs	–	Sustainable Development Goals
TACs	–	Transit-Activated Corridors
TOD	–	Transit-Oriented Development
TMPM	–	Three Multifaceted PPP Model
TT	–	Trackless Tram
TTs	–	Trackless Trams
TTS	–	Trackless Trams Systems
TTT	–	Trackless-Trams Transit
TTS-PV	–	Trackless Trams Systems & Photovoltaics
UN	–	United Nations
UNDP	–	United Nations Development Programme

# List of Publications submitted as part of this thesis

## **Publication 1**

Ndlovu, V., Newman, P. and Sidambe, M. (2020) Prioritisation and Localisation of Sustainable Development Goals (SDGs): Challenges and Opportunities for Bulawayo, *Journal of Sustainable Development*, 13 (5) 104-118. <https://doi.org/10.5539/jsd.v13n5p104>

## **Publication 2**

Ndlovu, V. and Newman, P. (2020) Leapfrog Technology and How It Applies to Trackless Tram. *Journal of Transportation Technologies*, 10, 198-213.  
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## **Publication 3**

Ndlovu, V. and Newman, P. (2021) Designing a Transit Oriented Development with a Trackless Tram System – Case Study Bulawayo. *Urban Studies and Public Administration* Vol. 4, No. 2, 117-145. <http://dx.doi.org/10.22158/uspa.v4n2p117>

## **Publication 4**

Ndlovu, V. and Newman, P. (2020) A Public-Private Partnership procurement approach to sustainable transport - Zimbabwe case. *The World Bank Research Observer Journal* (submitted)

## **Publication 5**

Ndlovu, V. and Newman, P. (2021) How Would the Trackless Tram System and Public-Private Partnership (PPP) Apply to Bulawayo? *Current Urban Studies*, 9, 17-30.  
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# 1 INTRODUCTION

This thesis by publication is based on five papers, which in turn are based on the five research questions that makeup this study. The five questions are formulated in order to address the main question of the thesis, **Are Trackless Trams a leapfrog technology for emerging economy cities like Bulawayo?** The main purpose of this thesis is to explore the possibilities of cities in developing economies to adopt leapfrog technologies, in particular a new transit technology, called Trackless Trams, to enable them to meet their multiple economic development goals and in particular their Sustainable Development Goals (SDGs). The papers, though developed individually, are linked to make a full story on how developing cities could adopt the Trackless Trams (TTs) technology to enhance their ability to attain their SDGs. The findings of this study will contribute to the body of academic knowledge and policy-making on leapfrog development, and because it has a practical application to Bulawayo, it should be easily applicable to other cities in developing economies to assist with their development programs.

The thesis consists of five academic papers which are in the Appendix and this Exegesis which explains the basis of the papers, how they are integrated and what are the basic approaches being taken to elaborate on the thesis question.

The Exegesis will first set out why this research is needed by setting the context through the City of Bulawayo as a typical developing city in an emerging economy. This will be a substantial overview of the literature and will be provided from a personal perspective of one who has been involved in the city at various times in the past few decades. This outline is a necessary background to all the papers.

The next section of the Exegesis will be a Literature Review covering key concepts that underlie all aspects of the thesis. Four key concepts will be examined:

1. **Sustainable Development Goals (SDG's).** This will set out the basis of the Sustainable Development Goals and why they need to be part of the context for this research.
2. **Trackless Trams (TT's).** This will set out the background to the Trackless Tram in order to evaluate their capability or potential to be a leapfrog technology as this will underlay much of the research in the papers. The Exegesis will further outline how

Trackless Trams could be implemented on developing cities' corridors using Bulawayo as the case study.

3. **Transit Oriented Development (TOD).** The fundamental concept behind how the Trackless Trams can be implemented is the TOD and this is explained to show it can assist urban development and at the same time enhance cities to develop sustainably and hence achieve multiple economic developmental goals including attaining their SDGs targets.
4. **Public Private Partnerships (PPP's).** Given the background of the emerging economies' cities, most of them are struggling to find the capital necessary for their developmental programs. Therefore, a fundamental concept underlying the thesis is how innovative funding mechanisms could be utilised to enable the emerging economies' cities to deliver their potential infrastructure projects, including Trackless Trams, through the Public-Private Partnership (PPPs) arrangements.

The Literature Review in the Exegesis is therefore divided into these four main areas of studies, SDGs, TTs, TODs and PPPs, which if all properly integrated can show how developing cities can develop sustainably and achieve their SDGs targets using technologies like Trackless Trams.

## **2 RESEARCH QUESTIONS AND OBJECTIVE**

The questions that are behind this thesis:

### **2.1 Main Question: Are Trackless Trams a leapfrog technology for emerging economy cities like Bulawayo?**

- a. **Sub Question 1:** How can the SDGs which are the globally accepted new approach to economic development be implemented in a city like Bulawayo?

Despite the fact that it has been almost five years since the adoption of sustainable development goals (SDGs), there is no strong evidence of localisation of the global development agenda. To answer the above question, this paper will provide answers or shed light to the following key questions and issues:

- Can Bulawayo develop sustainably, as per the Sustainable Development Agenda? If so, what progress has been made by the City of Bulawayo towards localisation of such an approach to development (articulated through the Sustainable Development Goals)?
- What constraints, if any, impede the operationalisation of the SDGs by the municipality of Bulawayo?

The main benefits to be derived from the case study are to identify the factors/elements that municipalities can leverage on for effective operationalisation of the SDGs and thus make sustainable development a reality, especially in a developing city context.

The paper will undertake a literature review on municipalities in relation to localising the SDGs. A multi-criteria framework for planning and implementing the achievement of SDGs will be outlined using a four-step process: raising awareness of SDGs; establishing a local SDGs agenda; planning implementation of the SDGs agenda; and, monitoring and evaluation. This is then applied to Bulawayo in outline only, showing that the municipality has a potentially solid foundation for pursuing a well thought out domestic SDG agenda.

- b. **Sub Question 2:** How can developing cities leapfrog into the future with a technology like Trackless Trams?

Rapid innovation and development of modern technology has brought about the opportunity for developing economies to leapfrog technological. The smart phone is the most recent example. This paper assesses literature to show what technological leapfrogging is and the key criteria used to enable it to occur in developing countries. The paper then examines the new mid-tier transit technology called Trackless Trams, and evaluate its potential to enable or enhance the attainment of SDGs by the developing cities. To address the sub-question the paper is structured in a manner that address the questions:

- How can leapfrog technology be defined?
- What are the key requirements for enabling leapfrog technology?
- What is a Trackless Tram System (TTS)?
- How does TTS apply to leapfrog technology requirements?

- c. **Sub Question 3:** How would a Trackless Tram System be delivered in Bulawayo?

Utilising the findings of the previous papers and the latest released research conducted in Australia on how to enable trackless trams, this paper will look at the practical applicability of this project in Bulawayo. Three years of study across Australia has confirmed that communities, investors and governments in small regional towns like Townsville, big cities like Sydney and Melbourne, and a consortium of local governments across Perth, 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 (Newman, Mouritz, et al., 2018; Newman et al., 2020). Zooming in on the lessons learnt from these studies, this paper conducts a comparative study on the developing City of Bulawayo's context and illustrates the potential sustainable development to be expected through the transit-oriented development (TOD) on the city's corridors. The paper highlights how the expected benefits could be utilised retrospectively to attract the funding of the project through the land value capture concept.

- d. **Sub Question 4:** Would PPP financing and management of infrastructure like a Trackless Tram be the better option for the future in a city like Bulawayo?

Zimbabwe is currently facing serious financial constraints with a huge debt overhung, weak institutions and limited domestic resources. Given its poor credit ratings and debt servicing history, the only viable option for the central government and its local authorities to successfully implement public infrastructure projects is through engaging the private sector through public-private partnership arrangements. To explore the potential of this funding concept, this paper initially identifies potential projects including the Trackless Tram project, which could boost the socio-economic resuscitation of the country and its cities to achieve their SDGs targets. The paper explores various PPP arrangements widely documented and available for utilisation for the identified potential projects. To answer the sub-question the paper is structured to address the questions:

- What is the Public Private Partnership (PPP) concept and how has it progressed over time?
- Which are the high impact projects that can be successfully implemented through the PPP concept in Zimbabwe?

- What are the key requirements to enable greater adoption of PPPs in Zimbabwe and its local authorities?
- e. **Sub Question 5:** How would the Leapfrog innovation of a Trackless Tram System and PPP's apply to Bulawayo?

This paper explores and researches for an ideal PPP arrangement that will enable the implementation of Trackless Trams in Bulawayo and other potential developing cities. In this paper the PPP model referred as “Three Multifaceted PPP Model” is formulated for the City of Bulawayo’s Trackless Tram initiative. The uniqueness of the Three Multifaceted PPP Model is its emphasis on the split of the project into smaller segments in-order to minimise the capital risks by spreading it among various players through reducing the size and scope of the project per player, while in essence the whole project is still being implemented. This PPP model could easily be replicated to other developing cities.

### **3 CONTEXT - THE CITY OF BULAWAYO**

#### **3.1 History and Demography**

The background of the City of Bulawayo (CoB) makes it an ideal case study for this research. The CoB has a strong history as a developed city in the history of British colonial urban history (Mbiba & Ndubiwa, 2006). Bulawayo is the second largest city of Zimbabwe. It is located in the southern region and it represents an important international transportation link for traffic flows between South Africa and countries north of the Limpopo river (Helmsing, 1999). During Rhodesia, Bulawayo was the largest and most important urban centre. When Harare (formerly Salisbury) became the capital city of the then ‘self-governing colony’ and later became the capital city of Zimbabwe it overtook Bulawayo in status.

In the post-colonial era Bulawayo continued to thrive based on the robust administration structure that was largely inherited from its colonial history (Zaaijer, 1998). According to the ZimStats (2014) Bulawayo has a population of 738,600, this figure has been disputed by the Bulawayo City Council (BCC). The BCC conducted its own survey and population projections presented on Table 1.

**Table 1:** Bulawayo population projections by the city council.

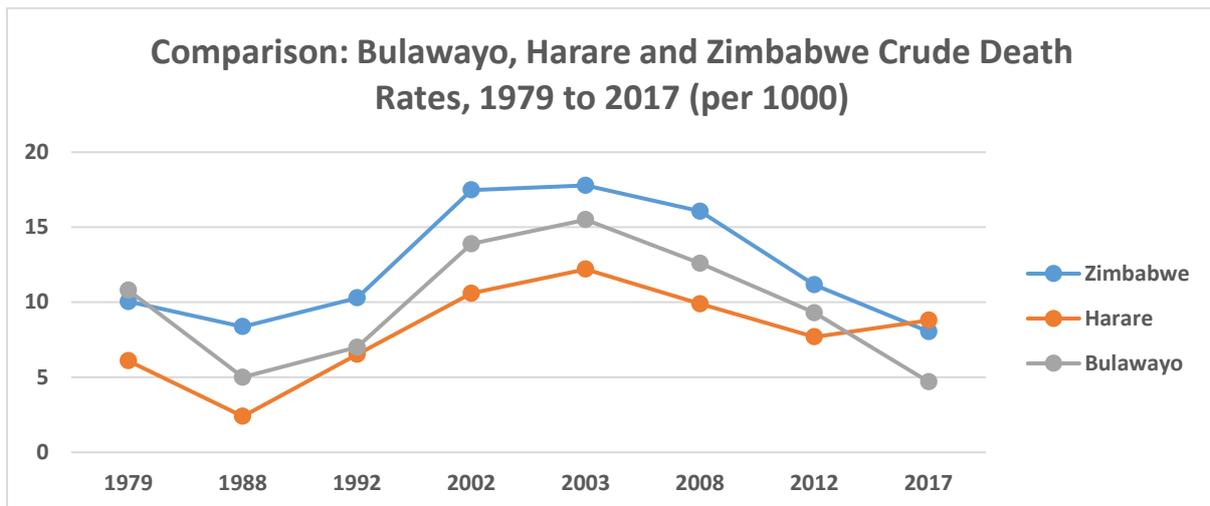
<b>Year</b>	<b>Population</b>	<b>Growth</b>
2014	1244366	
2015	1266765	22399
2016	1289566	22802
2017	1312779	23212
2018	1336409	23630
2019	1360464	24055
2020	1384952	24488
2021	1409881	24929
2022	1435259	25378
2023	1461094	25835
2024	1487394	26300
2025	1514167	26773
2026	1541422	27255
2027	1569167	27746
2028	1597412	28245
2029	1626166	28753
2030	1655437	29271

**Source:** City of Bulawayo

### **3.2 Bulawayo during Mugabe times.**

Bulawayo's journey in post-colonial era has been very hard. The Mugabe regime unleashed its private army immediately after the country attained its independence in the early 80s on the people of the Matebelend provinces and the citizens of Bulawayo. In the mid-90s to mid-2000s the HIV virus wreaked havoc to the city's population, and from the mid-2000s the Zimbabwe government again seized land from the commercial farmers leading to the collapse of the country's economy as this area was a major source of raw materials for the industry and agricultural production (Compagnon, 2011).

During this phase of the commercial farms' seizures by the Zimbabwe government and economic collapse of the country, the City of Bulawayo experienced a large episode of deindustrialisation. All these tumultuous times impacted on the lives of the City of Bulawayo citizens as illustrated in figure 1. Bulawayo went from 5 deaths per 1000 population (similar to a developed country) to 15 deaths per 1000 in just 15 years. This was due to a combination of causes including the HIV pandemic, but it was obviously related to the poverty induced by the deindustrialisation and overall economic decline of that time.



**Figure 1:** Death rate in Zimbabwe 1979 to 2017 .

**Source:** ICDS 2017 – Harare & Bulawayo (data); World Bank – Zimbabwe (data) (Ndlovu et al., 2020)

During its era as an industrial hub of the country, Bulawayo contributed approximately 30% of total manufacturing employment in the country. Table 2 gives an overview of the composition of formal sector employment for Bulawayo from 1980 until mid-90s, before the collapse of Zimbabwe's economy when the Mugabe regime invaded the commercial farms (*hence, no data is available for the period after the late 90s*) leading to the country's highest unemployment rate of between 80% to 95%.

**Table 2:** Bulawayo formal sector employment and average annual growth rates.

	1980	1985	1990	1994	80-85	85-90	90-94
Agriculture	80	123	265	77	9.0	16.6	-26.6
Mining	107	85	86	0	4.5	0.2	-100
Manufacturing	45676	44578	56452	62116	.05	4.8	2.4
Energy	1478	1552	1650	1482	1.0	1.2	-2.6
Construction	7321	1938	4346	9743	-23.3	17.5	22.4
Financial services	1977	2219	2197	2481	2.3	-0.2	3.1
Distribution	13664	13954	16007	16655	0.4	2.8	1.0
Transport	14550	16066	14285	12108	2.0	-2.3	-4.0
Public admin.	9320	9192	8597	7154	-0.3	-1.3	-4.5
Education	3732	4896	9943	10295	5.6	15.2	0.9
Health	3185	3652	4130	4239	2.8	2.5	0.7
Domestic workers	23098	21521	22375	22364	-1.4	0.8	0.0
Other services	8763	11679	13866	15620	5.9	3.5	3.0
Total	132951	131455	154199	164334	-0.2	3.2	1.6

**Source:** CSO, various years, Quarterly Digest of Statistics. Harare and unpublished CSO data

Before Zimbabwe's economic collapse Bulawayo's manufacturing sector employed 38% of the city's workforce. After the economic meltdown that began in the early 2000s, Bulawayo experienced a rapid deindustrialisation (Helmsing, 1999).

Bulawayo was once renowned as one of the most forward-looking cities in terms of planning and provision of low cost housing. Among other virtues, Bulawayo was known for its commercial abilities and the ability to establish partnerships with government. Since 1913 the Bulawayo city council has been involved in liquor production and selling in order to control illegal brewing and selling (Zaaijer, 1998). However, over recent years, the city's revenues have dwindled due to the drastic reduction of government grants, and the 85% tax imposed on the city's liquor production by the central government. Bulawayo also used to run its own electricity supply company profitably, until in 1987 when its electricity supply was taken over by the national parastatal, Zimbabwe Electricity Supply Authority (ZESA). All these undertakings by the central government have financially crippled the Bulawayo City Council's operations and its ability to fulfil its mandate required of a municipality. Its roads,

water and energy networks necessary for driving economic development have literally collapsed. This thesis is designed to help with the rebuilding of Bulawayo.

As a person who had to flee from this situation it was very sad. I was not alone as millions of people migrated during this period (Betts, 2017). All of the turmoil finally led to the City of Bulawayo's "environmental and economic collapse" defined in the study by Alberti and Susskind (1996). The city's roads, public transport and water networks, which once were the envy of many municipalities in Africa are currently in a deplorable state, as outlined in the sections below. The economic recovery for the city is its top priority as discussed in its currently released Report of Study for the Master Plan 2019–2034 (City of Bulawayo, 2020b). This study is motivated by the need to assist in the recovery outlined in the Master Plan. It is not an easy task as shown in the following sections that indicate the extent of the personal suffering involved in the daily routines of life in Bulawayo.

### **3.3 Water Crisis in Bulawayo**

Zimbabwe's municipalities' mandate is to plan and develop their cities. They have to supervise implementation of developmental programs, and have wide ranging powers to enable them to initiate and implement their economic development agendas through the local economic development (LED) initiative (Mbiba & Ndubiwa, 2006). Bulawayo has the potential to develop economically if the right policies are developed and implemented. However, Bulawayo and the surrounding Matabeleland region have been experiencing a perennial water problem and suffer from persistent droughts. This perennial problem has been a threat to the future economic growth of the city.

Water shortages are having a significant negative impact on the city's little remaining industry and the manufacturing sector, which requires large volumes of water in its daily operations. Bulawayo water usage for industrial purposes is estimated at 37 per cent of the city's total consumption. This consumption is expected to increase proportionately to growth in that sector. The heavy competition between Bulawayo and the neighbouring farming community, which uses underground water for agricultural purposes, is illustrative of the problems that will have to be faced in the future as industry reopens and grows in the metropolitan area. There are concerns on the current levels of water extraction by the Bulawayo City Council from the aquifer at Nyamandlovu, that it may be drawn down to

levels that will not sustain current farming activities in the area. The potential Matabeleland-Zambezi Water pipeline project is expected to create a green belt through Matabeleland North Province and resolve the perennial water shortage faced by the City of Bulawayo. Due to climatic changes, Bulawayo is constantly experiencing a downward trend in rainfall each year.

According to Mbiba and Ndubiwa (2006) the issue of sustainable development in Bulawayo is fundamentally facing this constant challenge of droughts and water crisis. This shortage of water has affected the city's industry and manufacturing sector leading to a rapid deindustrialisation. As at the writing of this thesis the City of Bulawayo is currently facing one of its most challenging water crises. Women are spending hours in water supply ques and walking about looking for water in their communities. The Women's Coalition of Zimbabwe (WCOZ) an NGO organisation has implored the city's authorities to consider the impending disaster as women are likely to be exposed to dangerous situations while looking for water, and also run a risk of being exposed to the Coronavirus (CITE, 2020). Photo 1 shows the residents queuing in close proximity without paying heed to any social distancing required to control the spread of the Coronavirus.



**Photo 1:** Bulawayo Water Crisis  
Source: CITE

Some Bulawayo suburbs have been without water for more than three weeks risking the fears that residents are exposed to the Covid-19 virus as the social distancing rule is no longer

adhered to (Tshuma, 2020). Photo 2 depicts the worrying water crisis unfolding for residents from the high-density suburbs of Bulawayo.



**Photo 2:** Bulawayo Water Crisis  
**Source:** The Chronicle

This water crisis is a classic example of the “environmental collapse” alluded by Alberti and Susskind (1996). An environmental collapse basically entails the failure by the municipalities to deliver on their mandate. The crisis has spread out to all the high-density suburbs as shown on more photos below. Photo 3 shows the Lobengula suburb residents queuing for water, and photo 4 shows residents of the Magwegwe suburb scrambling for water as the water supply crisis continues to worsen.



**Photo 3:** Bulawayo Water Crisis  
**Source:** The Chronicle



**Photo 4:** Bulawayo Water Crisis  
**Source:** The Herald

### 3.4 Roads and infrastructure crisis.

According to the City of Bulawayo (2020b), the city has a total road network of 2388 km (Table 3)

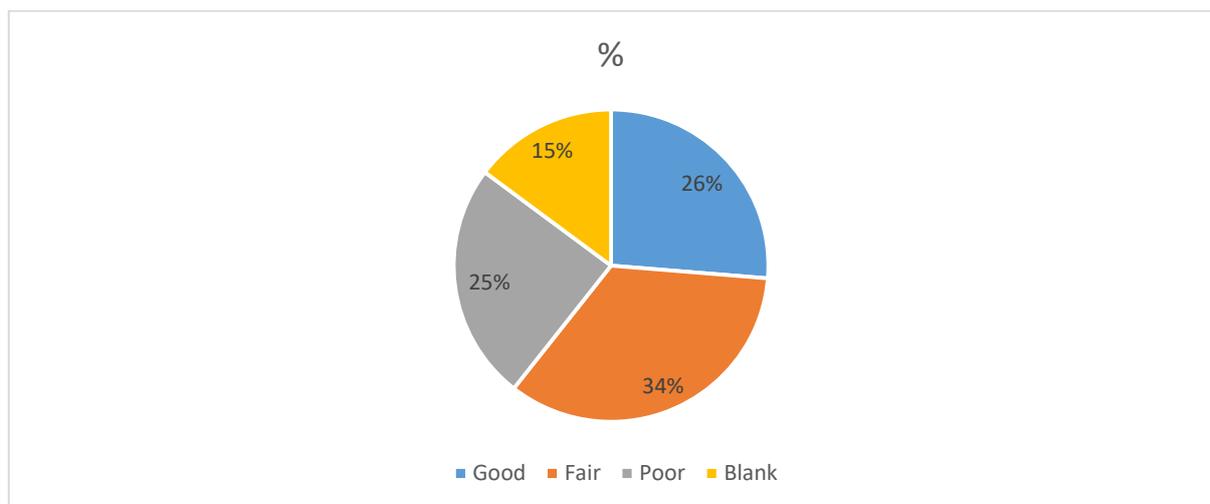
**Table 3:** City of Bulawayo total road length’s network

Type	Length, km
Sealed	1 509
Gravel & Sealed	75.5
Gravel	566
Earth	91.3
Blank	147
<b>Total</b>	<b>2 388</b>

**Source:** National Road Condition Survey 2016-2017.

Most of the city’s roads are in dire need of repair. Figure 2 shows that about 70% of the city’s roads are in need of reconstruction. The most affected roads are in the high-density residential areas, and are classified as in a very bad condition. The gravel roads are the most affected roads due to rains and lack of an adequate drainage system, making these sections of roads unrepairable and needing urgent reconstruction.

**Statistics of Bulawayo roads’ condition**



**Figure 2:** Riding Quality of the City of Bulawayo Road network.

**Source:** National Road Condition Survey. (Extracted from the study of report for the Master Plan 2019-2034).

The city is currently scouting for any means possible that will help it reconstruct its dilapidated roads. According to the Bulawayo24 (2020) news report most roads in Bulawayo are full of potholes which can make driving a deadly undertaking. Economic challenges compounded by the new breed of councillors have contributed to the malaise of the city's roads' dilapidations leading to what is referred as death traps on the roads. The roads are in extremely dilapidated state, with Photo 5 going viral on the internet media, this event happened when the truck fell into a huge ditch while attempting to navigate around the pothole (Bulawayo24, 2020).

**Photo 5**



**Photo 5:** Dilapidated Bulawayo road network crisis  
**Source:** Bulawayo24

A recent survey by Tshili and Zulu (2020) of The Chronicle newspaper revealed that Bulawayo roads are deteriorating at an alarming rate and this has been worsened by the current rains<sup>1</sup> leading to potholes everywhere (Photo 6).

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<sup>1</sup> Regardless of the current rainfalls, Bulawayo residents are still languishing from the water crisis largely due to the low water levels in the old dams built during the early 50s, and the failure by the council to pump the water from the reservoirs due to power shortages or damaged/stolen equipment.



**Photo 6:** Dilapidated Bulawayo road network crisis  
**Source:** The Chronicle

The extent of road dilapidations has invoked the attention of human rights groups, and they are lobbying for action from the city's authorities. The Matebeleland Institute for Human Rights (MIHR) has expressed concern over the state of the roads, and have labelled the potholes a "menace" (Photos 7 and 8) (NewsDay, 2020). According to the Bulawayo's mayor, approximately \$700 million is required for the task of restoring the roads to good condition (NewsDay, 2020). This entails the overhaul of about 70% of the entire city's road network, thus approximately 1672 kilometres of road reconstruction. According to the NewZimbabwe.com (2020) the city's mayor lamented on the lack of funding as the big challenge for the city.



**Photo 7:** Dilapidated Bulawayo road network crisis  
Source: NewZimbabwe.com (2020)



**Photo 8:** Dilapidated Bulawayo road network crisis  
Source: NewZimbabwe.com

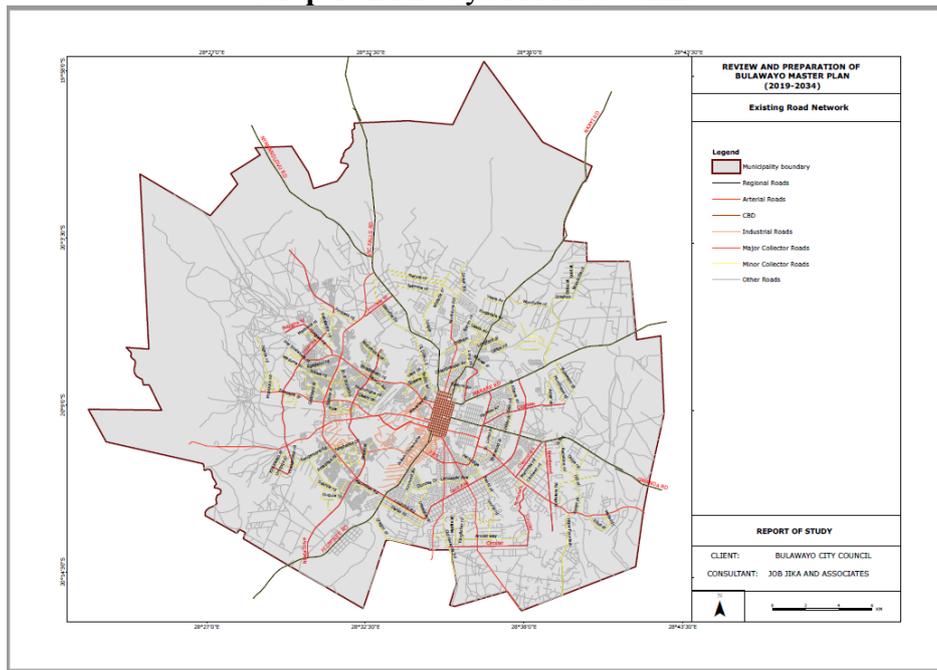
### 3.5 Potential Light-Rail Transit (Trackless Trams)

According to the City of Bulawayo (2020b), the city's busiest roads with large volumes of traffic are:

1. Plumtree Road
2. Khami Road
3. Luveve Road
4. Victoria Falls Road
5. Burnside and Matopos Roads

These identified main roads/corridors will ideally suit the City of Bulawayo's Trackless Trams initiative that is currently under discussion (Kazunga, 2019, May 09). Map 1 shows Bulawayo's major road networks. The introduction of the Trackless Trams on Bulawayo's wide roads could be the catalyst that the city needs to overhaul its dilapidated roads and corridors through a TOD approach alluded by Chakwizira (2013) and further discussed by Newman et al. (2019).

**Map 1: Bulawayo road networks.**

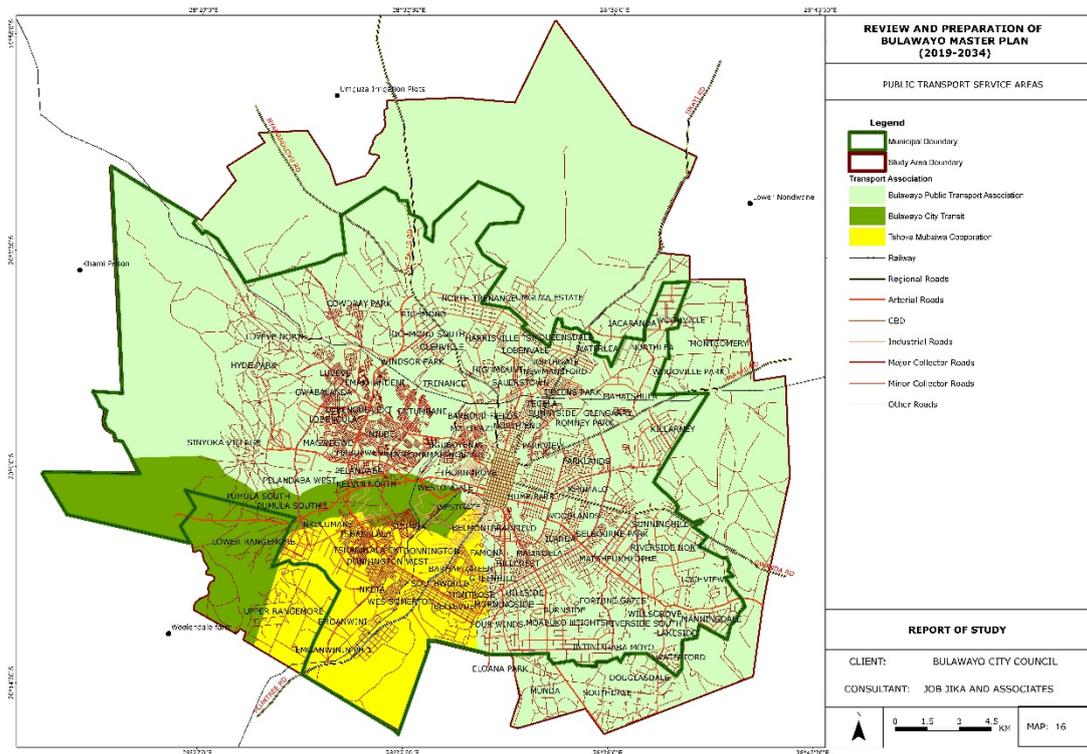


Source: City of Bulawayo Master Plan 2019-2034.

In an effort to improve the public transport system, the Bulawayo City Council facilitated the establishment of three public transport companies below with their allocated routes on Map 2.

1. Tshova Mubaiwa Transport Co-operative (TMC),
2. Bulawayo United Passenger Transport Association (BUPTA),
3. Bulawayo City Transit (BCT),

**Map 2: Bulawayo transport routes**



**Source:** City of Bulawayo Master Plan 2019-2034.

These three recognised public transport companies operate vans (combis) as a vehicle of transportation. The average occupancy of each van during peak hours is eighteen passengers. According to the city council, the plan was that eventually these three companies would merge into a single company and shift their mode of operational vehicles from vans to 25-seater minibuses or more ideally introduce normal buses. Due to their small sizes, the vans do random stop picks and drop points everywhere, they pull off the road into the road shoulders to drop and pick passengers. This kind of jitney, demand-based operation does damage the road shoulders and it compromises the safety of passengers as well as making travel time much longer than transit on fixed routes, especially if given priority (Vuchic, 2007).

Regardless of having the three registered public transport companies, there is still a significant number of pirate operators largely from small private cars. These small pirate operators have an exploitive reputation and are potentially dangerous so are a significant hazard to the safety of public commuters. A new transit system may be able to overcome this social issue as well as provide multiple economic and environmental outcomes such as a

catalyst needed to enable the rehabilitation of roads. Litman (2004) has documented the expected benefits of the light-rail transit similar to the trackless-trams transit (Table 4).

**Table 4:** Light-Rail Transit benefits

<b>Benefits</b>	<b>Description</b>
Congestion reduction	Reduced traffic congestion
Facility cost savings	Reduced road and parking facility costs
Consumer savings	Reduced consumer transportation costs
Transport diversity	Improved transportation options, particularly for non-drivers
Road safety	Reduced per capita traffic crash rates
Environmental quality	Reduced pollution emissions and habitat degradation
Efficient land use	More compact development, reduced sprawl
Economic development	Efficiencies of agglomeration, increases productivity and wealth
Community cohesion	Positive interactions among people in a community
Public health	More physical activity (particularly walking) increases fitness and health

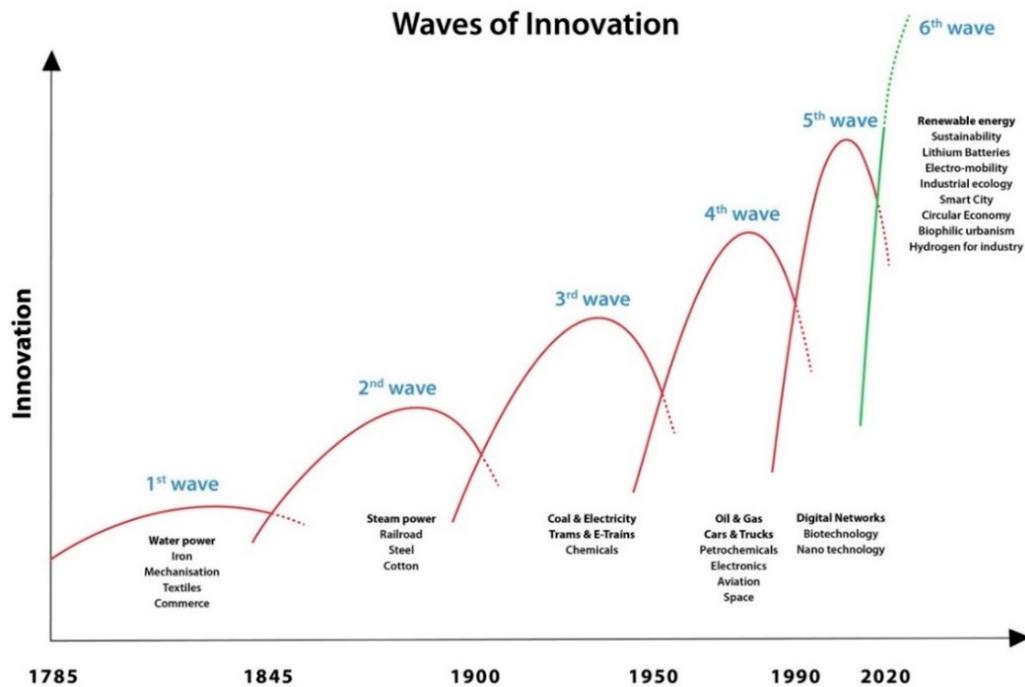
**Source:** (Litman, 2007)

Bulawayo is in a current state of crisis and basically all its infrastructure has collapsed as outlined above. All the benefits alluded to by Litman (2007) on Table 4 are certainly what the City of Bulawayo needs. Unfortunately the extent of Bulawayo’s infrastructure collapse makes it impossible to pick a single benefit on the table above and rank it as more important than others. All those benefits are critically needed by Bulawayo.

### **3.6 The future for the City of Bulawayo**

How does the future look for the City of Bulawayo post COVID 19? Figure 3 depicts innovation waves that rose up after each economic recession during the past centuries. According to Newman (2020a) the sixth wave of innovation depicted on figure 4 is likely to rise after the Covid-driven economic collapse. Could this be the opportunity for emerging economy cities and the City of Bulawayo to ride on this wave and rise out of the ashes of their previous economic malaises? Could Bulawayo become the model city of the 21<sup>st</sup> century through the embrace of the “Global Localisation” business model envisaged by Newman (2020a)? Could it be that the COVID 19 pandemic has brought about the creative destruction of the businesses and we should expect to see the emergence of new technologies that will arise after the pandemic and foster in the new business models? Are we going to see

the emergence of new transformative technologies that will lead to more intelligent transport solutions envisaged by Chakwizira (2013)?

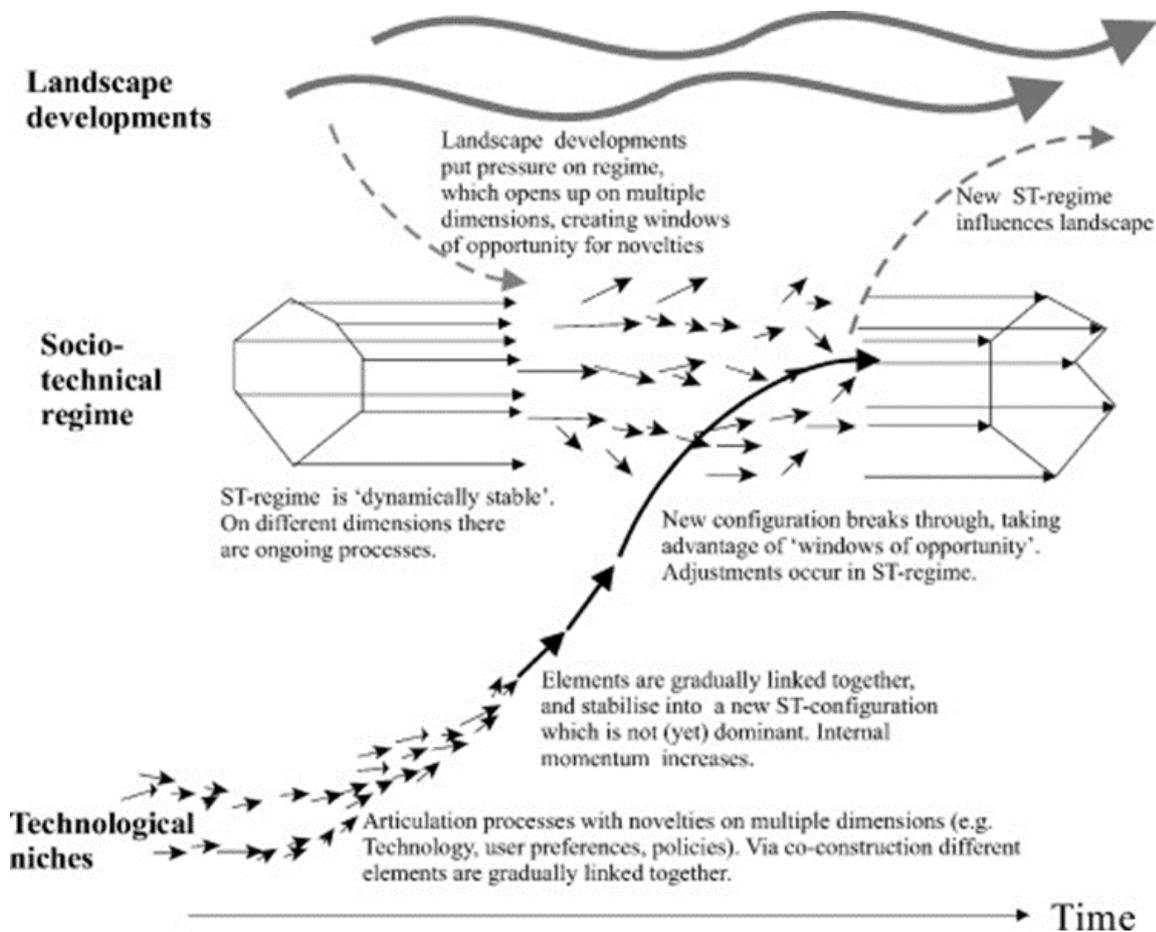


**Figure 3:** Waves of innovation through industrial history and into the future.

**Source:** Newman (2020a) - Adapted from Hargroves and Smith (2005).

According to Hargroves and Smith (2005) the expected next wave of innovation would be related to sustainability innovations. Newman (2020a) is of the opinion that green energy, smart cities and electro mobility are on the brink of breaking into the main socio-technical regime alluded in Geels (2011)'s multi-level perspectives (MLP) framework depicted on figure 4. Utilising the MLP concept, it is apparent clear that the landscape developments are putting pressure on the current socio-technical regime, thus there are growing calls for clean, sustainable, creative and innovative economic developments. There is pressure to promote sustainability innovations that will lead to the attainment of the SDG's targets. The current public transport socio-technical regimes in most emerging economies cities are outdated, uneconomical, environmentally unfriendly and utterly dysfunctional as demonstrated by the current decaying infrastructure networks for the city of Bulawayo. The anticipated next wave of innovation envisaged by Hargroves and Smith (2005) could be what the cities of the emerging economies need, doubly so the City of Bulawayo.. Its public transport and roads network are in dire need of total overhaul, electro mobility and leapfrog technologies (niches) such as the Trackless Trams (TTs) are now mature enough to break through into the

mainstream socio-technical regime referred to on the multi-level perspectives' framework (Geels, 2002; Geels & Schot, 2007, 2010). The city is also experiencing constant power shedding due to insufficient electricity power to meet the demand of the city. This provides an opportunity for the distributed energy resources (DER) and infrastructure such as solar power to be used as the main way of rebuilding the city. Could this be an opportunity for the City of Bulawayo to embrace the combination of light rail (trackless trams) transit together with solar power at stations for recharge and as the basis for powering all the buildings in the station precincts? As already alluded, this will entail the need to seek infrastructure synergies of renewable energy, water, land and transport development to promote sustainable and regenerative developments through the TOD approach.



**Figure 4:** A dynamic multi-level perspective on transitions.

**Source:** Geels (2005, p. 452)

According to Chakwizira et al. (2014) cities of the developing economies need to develop sustainable transport solutions to enable them to achieve their SDG's targets. Thus, it is

crucial that cities of the emerging economies understand that having sustainable transport solutions is an important prerequisite and an enabler for achieving future sustainable economic development. It is imperative that cities of the emerging economies realise that they are currently experiencing “a sustainable transport solutions crossroads” phenomenon described by Chakwizira et al. (2014), such a realisation could be an opportunity to break away from the traditional automobile-dependence urban planning centric.

Thus, Bulawayo has an opportunity to adopt innovative technologies that will enable it to leapfrog technologically and enable its developmental trajectory by riding this wave envisaged by Newman (2020a) and Batty (2007). According to Newman (2020a) cities of the emerging economies, doubly so Bulawayo, will need to embrace this opportunity as “their chance to leapfrog into the future through economic development based around solar-PV, batteries, electro-mobility, and smart city innovations”. This wave of innovation is likely to emerge from the “the ashes of the economy laid waste by the Covid pandemic” (Newman, 2020b). The adoption of the innovative and leapfrog technology will enable not only the economic recovery but also the economic transformation of developed and developing cities as deliberated in Ndwandwe and Gumbo (2017) and Ndwandwe (2017) studies.

This positive view of the future rising out of the global economic collapse from Covid, is not just dependent on these new technologies but needs a new approach to how cities are managed. Table 5 illustrates the urban responses that are expected from the sixth wave of innovation that could enable a developing city like Bulawayo to thrive into the future (Newman, 2020a).

**Table 5:** Features of the sixth wave in terms of urban responses.

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**Features of the Sixth Wave in Terms of Urban Responses**

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1. Relocalised centres with integrated local place infrastructure.
  2. Tailored innovations in each urban fabric.
  3. Less car dependence in most urban fabrics.
  4. Symbiotic partnerships to fund the new urban economy.
  5. Rewritten manuals for urban professionals.
- 

**Source:** Newman (2020a)

Regardless of all the current challenges it is experiencing, Bulawayo is endowed with an abundance of natural resources, thus, it has a potential to enhance its response capacity. According to Zaaijer (1998), a city's responses capacity "include the ability to develop new economic roles, new methods of financing and new partnerships involving public-private and non-governmental agencies, new forms of urban fabrics centric planning etc.". With its response capacity still intact, Bulawayo has a potential to rise from the ashes of its economic declines of the past four decades, and redefine its future and attain its sustainable development goals' targets. Bulawayo still enjoys the competitive advantage of its physical location, which has made it an important transport hub, through providing rail links between South Africa and the countries north of the Limpopo River. Now is its time to show that the kind of approaches outlined in this thesis can be grasped and acted on.

## **4 LITERATURE REVIEW**

### **4.1 The Sustainable Development Goals**

As the world's population increases, so is the need to develop the economies to cater for the needs of the ever-expanding population. The notion of sustainable development has become so critical and necessary as the world's population continues to grow. The Brundtland Commission (1987) defines sustainable development as the development that features environmental, social and economic development as one pact. The world is currently facing a rapid urbanisation and population growth. According to The World Bank (2020) urbanisation level has increased from 42.3% urban in 1987 to 55.7% in 2019; representing a doubling of the global urban population from 2.102 billion to 4.274 billion. During that same period urban population of Zimbabwe grow from 2.55 million to 4.72 million, thus almost doubled.

The rate of urbanisation indicate that a significant level of the world's population will be living in urban areas by the year 2050. This puts the onus on urban authorities to lead in the promotion of the sustainable development agenda. There is this constant concern that rapid urbanisation will lead to unsustainable development. However, the study by Grossman and Krueger (1995) and later by Newman (2017) has shown that the opposite can actually happen due to decoupling of wealth generation and environmental impacts such as greenhouse emissions. Grossman and Krueger (1995) documented a convex "U-shaped" relationship between environmental degradation and income growth. According to Grossman and Krueger (1995) it is possible to have a rapid urbanisation that does lead to a sustainable development. As nations become

wealthier, they develop the awareness and desire to protect the environment and call for a sustainable development approach to wealth creation.

As urbanisation accelerates, the urban authorities and local governments become the frontier of the economic development and the need for sustainable development becomes crucial in their developmental agenda. According to the UN’s SDGs, the SDG 11 directly relates to cities and urban authorities as highlighted on table 6.

**Table 6:** Sustainable Development Goal 11

<b>SDG</b>	<b>Indicator</b>	<b>Target</b>
11.1	Ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums.	2030
11.2	Provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.	2030
11.3	Enhance inclusive and sustainable urbanisation and capacities for participatory, integrated and sustainable human settlement planning and management in all countries.	2030
11.4	Strengthen efforts to protect and safeguard the world’s cultural and natural heritage.	2020
11.5	Significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.	2030
11.6	Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management.	2030
11.7	Provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities.	2030
11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.	2020
11.b	By 2020 substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement in line with the forthcoming Hyogo Framework holistic disaster risk management at all levels	2020 - 2030
11.c	Support least developed countries, including through financial and technical assistance, for sustainable and resilient buildings utilizing local materials	2020

**Source:** Ndlovu et al. (2020)

As the cities are the centres of the national economic developments and are at the helms of rapid urbanisation, it becomes imperative that they develop strategies to promote sustainable development as enshrined in the UN's SDG 11. This calls for strategies of localisation of the SDGs. Ideally, localisation entails making the intentions of the SDGs resonate with local contexts. Municipalities in developing countries are struggling with the provision of adequate basic infrastructure and Bulawayo is clearly the case. Strategies are therefore needed that will see to it that these struggling cities could be helped to develop sustainably. A clear grasp of SDGs and their operationalisation can help to propel sustainable urban development for the emerging economies cities such as the City of Bulawayo.

The idea that encourages cities to lead in the initiatives such as the sustainable development grew initially through initiatives such as the UN Habitat, Local Agenda 21, and ICLEI in the 1990's (Newman & Kenworthy, 1999). This was cemented with the UN's introduction of the Sustainable Development Goals (SDGs) with SDG 11 targeting cities (UNSDGs, 2015). This thesis will use the City of Bulawayo as a case study to evaluate how it is standing concerning achieving the SDG 11 with its clearly enunciated performance indicators. Newman and Kenworthy (1999) and Shaker and Sirodov (2016) advocate that sustainable development for cities needs to be created through a strategic plan designed to simultaneously improve the economic development, environmental quality, and social equity of the city, this is also advocated in the Bulawayo's strategic document (City of Bulawayo, 2020a). Such localised strategic planning is critical for delivering the SDG's.

The crucial evaluation and adoption of sustainable development strategies is now commonly being embedded in most strategic documents for the municipalities. Karatas and El-Rayes (2015) formulated a Sustainable Development Evaluation–Decision Support System (SDE-DSS) that could be utilised by cities to evaluate how they are achieving their SDGs targets. Their study was a continuous work based upon the initial studies by Fehr et al. (2004) who formulated a bottom-up management approach framework for managing cities' progress towards sustainable development. According to Alberti and Susskind (1996) failed sustainable development strategy manifests in environmental collapse. They posit that in its true sense, an environmental collapse is manifested by the municipalities' failure to discharge its critical responsibilities.

According to Mendes (2000) managing cities towards sustainable development is more than just possession of technical competencies. It is more driven by the ability to have a capacity building and application of 'soft skills' to the management of cities. This is further reiterated by Fehr et al. (2004) who formulated a model that puts emphasis on appropriate leadership and human capital management to avert environmental collapse. It is not to say that technical competencies are not needed, rather that they together with soft skills should be combined and harnessed strategically. Thus, Karatas and El-Rayes (2015) advocates for the importance of cities to think of sustainable development whenever they are setting out their plans for buildings. This is further reinforced and reiterated by Yang et al. (2017)'s advocating for sponge cities. Sponge cities are the cities that are designed to be capable of capturing rainwater for use during the dry or drought season.

## **4.2 The Trackless Tram Background**

Trackless Trams (TTs) are a mid-tier transit system, as opposed to the heavy rail metro (first tier) or bus systems (third tier). According to Newman et al. (2019) TTs can be categorised as a mid-tier transit system equivalent to a light rail. The Bus Rapid Transit (BRT), Light Rail Transit (LRT) and Trackless Tram Systems (TTS) form what we might refer as the mid-tier technologies. As elaborated by Newman, Mouritz, et al. (2018) TTS are much cheaper than heavy rail and light rail transit, but more expensive than buses.

Below are the physical attributes of Trackless Trams as deliberated by Newman et al. (2019):

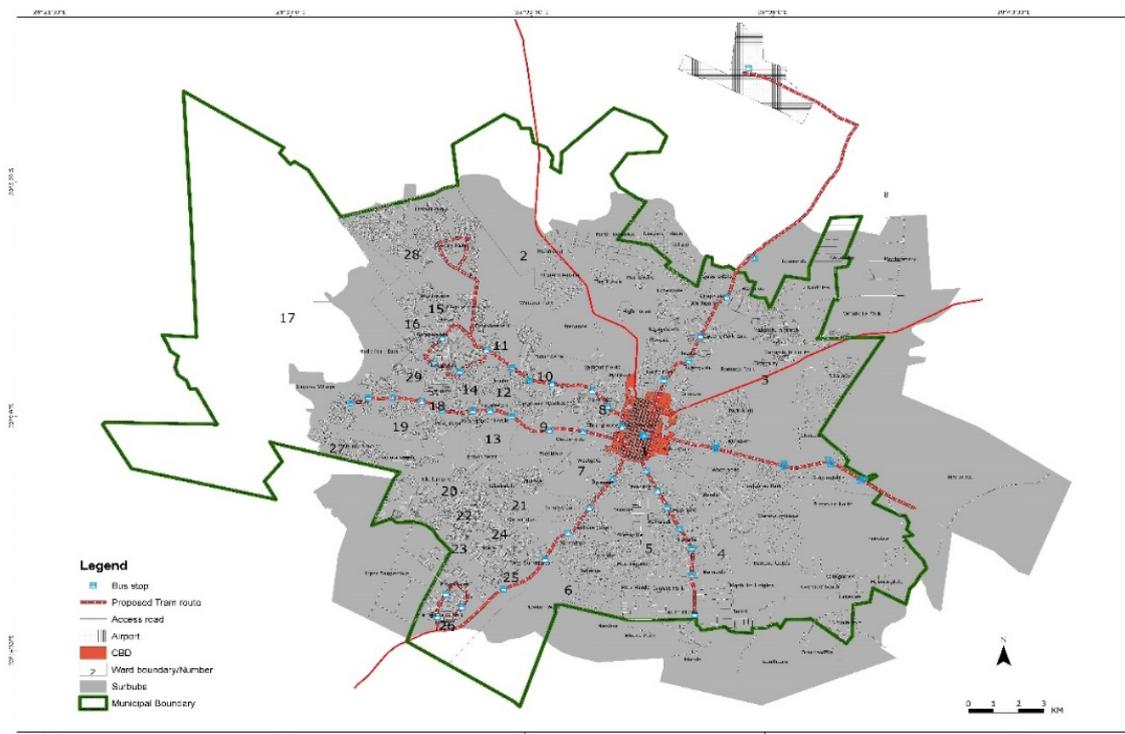
- Trackless Trams use an electric drive system that is power-driven by battery technology.
- Trackless Trams use tyres rather than steel rails.
- Trackless Trams can utilise up-to-date self-directed driverless technology.
- Trackless trams can use dedicated passages to improve its performance through more rapid transit and better use of its self-directed driverless technology (Daley, 2018).

The above characteristics enables the TTS to have a place when it comes to future city planning, they can be incorporated into the city's development plans. They represent an innovative public transit system that can enable economic development envisaged in the study by Gumbo and Moswane (2017), and in the urban transport development pathway advocated by Chakwizira (2013). The TTs station precincts can be constructed within the

dedicated corridors and be an enabler for partnership funding to attract private financing. It is also possible for the TTS' autonomous system to be overridden to enable the driver to drive around obstructions especially along the construction and accidents sites.

As alluded by Newman (2020b), 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 especially the emerging economies. The cities in the emerging economies can utilise this opportunity to adopt leapfrogging technologies such as the trackless trams to enable their economic and sustainable development and achieve their SDGs targets enshrined in the UNSDGs. Trackless Trams lends itself to leapfrog sustainable development, and stand ideal to provide opportunities for cities like Bulawayo to come out of their logjams and make something special with a true legacy from this difficult time as suggested by Newman (2020b). The City of Bulawayo has welcomed and now hopes such leapfrog technologies could be part of its future shown on map 3. 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).

**Map 3:** Bulawayo Proposed Tram routes.



**Source:** Ndlovu and Newman (2021a)

According to Newman et al. (2020), the novelty in a TTS is twofold:

1. It is electric with batteries on the roof (making it much cleaner and quieter for people thus enabling urban development around its stations) and
2. It is designed to travel very smoothly down a road with rubber wheels because it has special stabilization in its axles/bogies and sensors that have come from autonomous vehicle technology that guide it very precisely.

The above novelty makes TTS cheaper, easier to adopt and build compared to a light rail. It is therefore easier to integrate the TTS on the roads or corridors that have a potential to transition towards TOD. The ability to enable TOD and development around station precincts enables the TTS to have a potential to be delivered through partnerships arrangement. This is the arrangement whereby the private sector could build the station precincts and provide the Trackless Trams, and the public sector (local authorities and or central government) could fund the construction of the roads. Accordingly, TTS can enable the economic, social, community and environmental benefits if it is strategically adopted for the entire metro-wide network.

Below are the expected benefits that could be achieved when a systematic and strategic approach is adopted to deliver a TTS along the transit-activated corridors (TACs):

1. A local *Recharge Hub* for any electric vehicles (Newman et al., 2020).
2. *Affordable and Social Housing* in partnership between the developer and the city.
3. *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 associated with station precincts (Trubka et al., 2010).
4. *Climate change emissions reductions* from transport as the more urban/inner city quality of housing and transport is usually 33% less in greenhouse gases (Thomson et al., 2017).

The Bulawayo Trackless Trams project is an opportunity to provide a post recovery project after COVID-19 pandemic, and also to recover from the last two decades of the city's economic recession. The project has been received with great public excitement (Kazunga, 2019, May 09). 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.

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

- It can fit into its present system quite simply.
- 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 rooftop 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.

### **4.3 Transit-Oriented Development strategy**

Sustainable development is a process that needs planning and strategic undertakings.

Utilising the literature it is apparent clear that the use of the Trackless Trams to enable sustainable development for the emerging economies' cities will need some innovative undertakings. Trackless Trams can be delivered along the transit-activated corridors (TACs) and thus leading to transit-oriented development (TOD). The concept of TOD is appealing to the cities like Bulawayo that have wide roads to implement Trackless Trams easily.

As alluded by Cervero (2009) TOD is a concept that promotes development around transit stations and providing a liveable new town centre for the surrounding population. The concept of TOD was well implemented in Hong Kong by the Hong Kong's Mass Rapid Rail Corporation (MTRC). This concept was also adopted successfully by Singapore in the late 1970's. Bertolini et al. (2012) describes a true TOD as a holistic approach that goes beyond just development around transit stations, but a strategy that should aim at "the re-centring of entire urban regions around transport by rail and away from the car".

Litman (2007) posits that the rail or trackless tram transit does provide high quality transit service that will reduce travel time costs to people who shift modes; and it also reduces delays on parallel roadways; and the rail transit can stimulate transit oriented development (TODs). A market survey conducted by Reconnecting America (2004) revealed that TOD is

the preferred mode of development for the future, thus rail transit could be the future for most cities that are looking for new ways of redeveloping such as the City of Bulawayo. Numerous studies have shown that TOD encourages walking rather than driving. Therefore, TOD provides the opportunity for residents to achieve the recommended 30 minutes daily physical activity of walking (Besser & Dannenberg, 2005). According to Litman (2004):

“From a household’s perspective, rail transit provides a positive economic return on investment. Quality rail transit requires on average about \$100 annually per capita in additional tax funding but provides nearly \$450 annually per capita in direct consumer transport cost savings”.

This finding is reiterated by Nelson et al. (2007) who found that “Washington DC’s Metro rail transit service generates congestion-reduction benefits that exceed subsidies”. Thus, rail stations are ideal for creating TOD than bus stations, according to Litman (2004) “for these reasons, where ridership volumes are high and transit oriented development is a planning objective, rail may be justified despite higher initial costs”. As much as the City of Bulawayo has experienced some tumult times, by implementing TTs on its roads could present an opportunity for it to forge some new ways of development. This could be an opportunity for Bulawayo to break away from the universally applied modernist urban planning that promotes automobile urban fabric focus and embrace the transit and walking urban fabrics centric planning and enable its transition towards sustainable and regenerative development as envisaged by Thomson and Newman (2018). Thus, by adopting the transit and walking urban fabrics planning philosophy will enable Bulawayo to transition to TOD. Bulawayo could find itself rising from the ashes at an accelerated pace enhanced by the embracing of the leapfrog technology such as the Trackless Trams. This also could see Bulawayo achieving its SDG’s targets and at the same time find itself being a leader in terms of sustainable and regenerative development in Africa. According to Girardet (2014) regenerative development is about:

“.....a proactive relationship between humanity and the world’s ecosystems, and about nurturing nature’s dynamism and abundance whilst drawing on its income. Cities need to help regenerate soils, forests and watercourses that they depend on, rather than just accepting that they are ‘sustained’ in a degraded condition.”

TOD is ideal for the regeneration and rejuvenation of corridors. The City of Bulawayo has not experienced any significant development ever since the government of Mugabe assumed power. Bulawayo is a well-designed and laid out city, and its topology is well structured to adopt this concept of TOD to enable the regeneration and redevelopment of its corridors. The concept of Trackless Trams and sustainable development could be an opportunity for Bulawayo to technologically leapfrog and become a leader in innovation in the region. This calls for Bulawayo to look into the concept of introducing Trackless Trams on its wide roads and rapidly redevelop like Singapore and Bogota. According to Cervero (2009) when Bogota introduced its BRT it was immediately ranked as the most sustainable city. The concept of TOD was well implemented by Bogota to the extent that the city was instantaneously ranked as the most sustainably city with the most efficient and productive BRT system. Given the physical setup of Bulawayo, the introduction of Trackless Trams on its corridors will significantly improve its sustainability status.

The notion of achieving sustainable development by harnessing or combining the land development and transport management is very proper for developing cities that have not yet experienced any substantial sustainable development and are still relying on small vans and private cars for public transportation. Introducing Trams will likely reduce the number of vans and small cars that ply the Bulawayo routes as modes of public transport. The problems that Euralille in France had prior to its adoption of the TOD concept are so similar to the current problems that are being faced by the City of Bulawayo. When it adopted the concept of TOD, Euralille urban quarter was successful in turning around its economic ills and prospered significantly. In reiteration to Bertolini et al. (2012), the idea that TOD concept involves various partners to develop various structures makes it very ideal for financial stressed cities of the developing world such as the City of Bulawayo. The concept of utilising the land value capture (LVC) mechanism to enable financing of TOD projects is gaining traction and is appealing to the emerging economies' cities. The positive benefits of utilising the LVC is discussed in detail by Sharma and Newman (2017) in their study of the New York Subway and various Indian Metro Rail projects. The Hong Kong's MTRC is a classic example of how the TOD and LVC concepts could be adopted successfully.

According to Curtis and Mellor (2011) if TOD is efficiently and effectively implemented it optimises land use and transport integration leading to sustainable development and accessibility. This is ideally what the City of Bulawayo and other cities of the emerging economies need, rapid sustainable development that entails economic activities stimulation, corridors regeneration and the overhaul of the public transport network. Ideally, the TOD

concept should become the modern planning mechanism for the 21<sup>st</sup> century cities, and the City of Bulawayo should explore the possibility of adopting this concept and lead the region in terms of innovativeness and creativity. According to the “wave” urban transport improvement motion model developed by Chakwizira (2013), the TOD concept is important for promoting an integrated transport and land use development.

#### **4.4 Public-Private Partnership (PPP) concept**

Countries from the emerging economies are struggling to raise the required capital to deliver their public infrastructure and services. The public-private partnership concept seems ideal for the emerging economies to enable them to implement their public infrastructure projects. The PPP funding mechanism has been well utilised in the developed economies to deliver public infrastructure projects. The United Kingdom reintroduced the PPP concept in the early 1990s by introducing the Private Finance Initiative (PFI). The South American cities have also fully embraced this concept especially for their transport projects. According to Meidutė and Paliulis (2011) the benefits of using the PPP concept are:

- Financing advantage to resource constrained developing countries,
- Efficiency advantage brought about by the private partners to their public counterparts,
- Innovation advantage that are commonly associated with private sector,
- Growing need for infrastructure as most urban growth is outpacing the capacity of the public sector to provide the necessary infrastructure development,
- Quality improvement and reduction in public services costs.

The City of Bulawayo stands to benefit from such a funding concept. The Bulawayo Trackless Tram initiative seems to be a potential project that can utilise the PPP concept (Bhoroma, 2020; Kazunga, 2019, May 09). According to Mandri-Perrott and Menzies (2010) there has been an increase in the interest to use PPP to fund light rail transits which basically are in the same classification as the TTS. Rapid urbanisation is increasing the interest in the adoption of technologies such as the light rail transit (LRT) and trackless tram system (TTS) to improve the transport services and reduce the number of cars in the city. The government has traditionally been the major sole provider and funder of transportation projects and this culture has led to the slow deployment of the PPP concept for public transportation projects

(Newman & Kenworthy, 2015). However, there is a change in the attitude on this concept as most OECD countries are now utilising the PPP arrangement to deliver most of their LRT projects. There seem to be a strong case that supports that the PPP mechanism is likely to be successful if the potential projects are designed to integrate land development and transport solutions as proposed by Newman, Davies-Slate, et al. (2018).

According to Willoughby (2013) the factors below are necessary to enable the development, implementation and delivery of PPP urban transit projects:

- Robust civic consultation systems,
- Integrated land-use/transport planning system,
- Land/property market management,
- Monitoring systems,
- Progressive policies,
- Economic regulation, and
- Public institutional framework for urban transport PPP

Jurisdictions that have most of the above factors in place seem to have observed that PPPs are likely to lead to faster development and implementation of projects. However, according to Meidutė and Paliulis (2011) the four common barriers to the implementation of the PPP projects are:

- The absence of clear and expedient political will,
- Poor legal framework for PPPs,
- The absence of public authority to manage PPP initiatives, and
- No public campaign to champion the PPP initiatives.

There are various types of PPP arrangements that are utilised to deliver projects. According to Colin Buchanan and Partners (2002) the most common and appropriate PPPs for transport projects are the Build, Own and Operate (BOO) and the Build, Own and Transfer (BOT). This notion of improving the chances of delivering and managing of the transport infrastructure projects through various PPP financing arrangements is also suggested by Chakwizira et al. (2014).

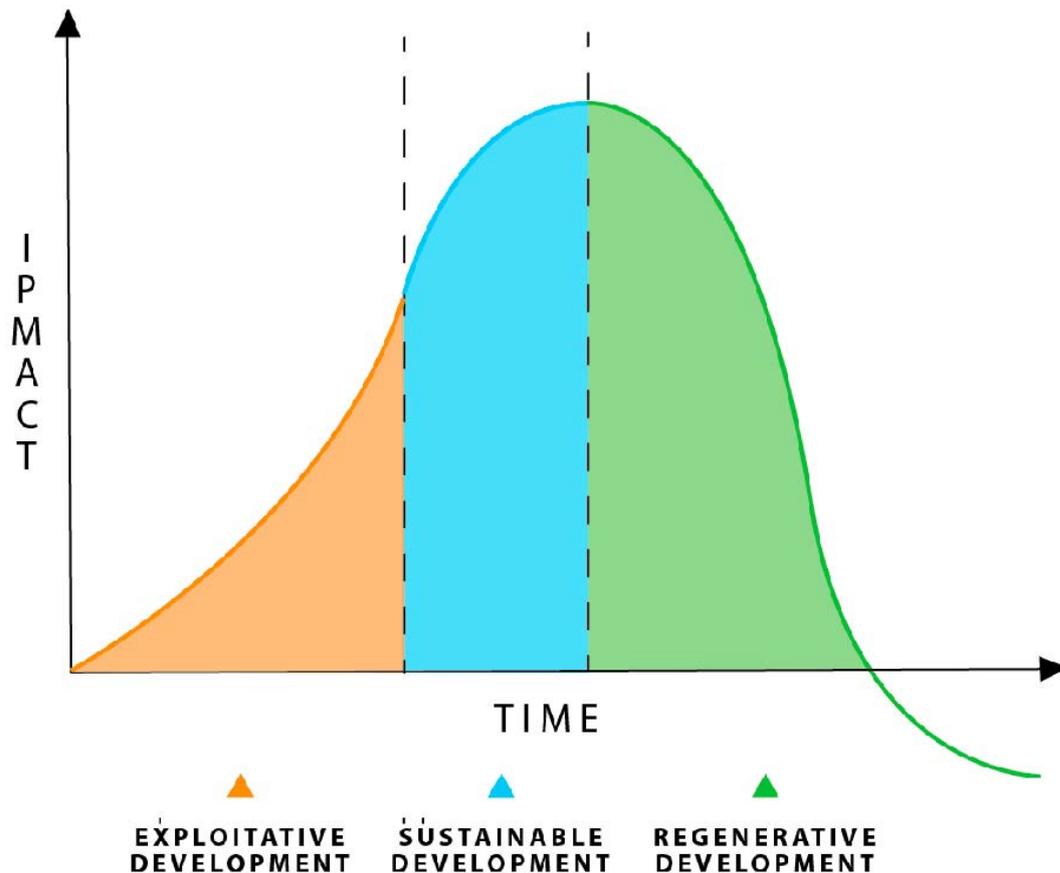
However, all projects are unique in their settings, hence each PPP arrangement should be structured to incorporate the specific local and environmental context of each project.

Bulawayo is well placed to be a “Solar City”. The TTS-PV project will make it possible to have a comprehensive solar electricity strategy that will enable buildings associated with the TTS station precincts and the surrounding residential properties to install solar PVs. Such an initiative will make a PPP concept delivered through partnership very much appealing for the City of Bulawayo. According to Dauskardt and Ganguly (2020), “PPPs can be an alternative source of finance for infrastructure investments in African countries, while potentially also delivering higher quality and efficiency in public assets and services”.

#### **4.5 Conclusion to Literature Review: Regenerative Development?**

The combination of SDG’s, TT’s, TOD’s and PPP’s could be integrated into a new kind of development agenda. Literature on how this could be understood is only just beginning but can be briefly summarised here as a conclusion to this overview as the 5 papers in the Appendix give the detail but not the overall way they could be brought together. The concept that most appears to represent this kind of new development is ‘regenerative development’.

The regenerative development agenda has been growing for the past 50 years (Newman, 2020a). Figure 5 shows the transition path starting from exploitative to sustainable to regenerative development. The world is experiencing a rapid urbanisation so is Zimbabwe, and Bulawayo is the second largest city in the country. As the world population is rapidly urbanising the onus is upon cities to develop sustainably and embrace a regenerative development approach by prioritizing such agendas as SDG’s, TT’s, TOD’s and PPP’s.



**Figure 5:** Transition from exploitive to sustainable to regenerative development.

**Source:** Newman (2020a).

Rather than dwelling on the current state of dismay for the City of Bulawayo, this study is looking into the future to display how a developing city such as Bulawayo can strategically rise from the ashes of its recent past and become a model of sustainable and regenerative development in Africa by adopting a leapfrog technology such as the trackless trams systems. According to Thomson and Newman (2018), “the opportunity for regenerative cities applies equally to new or retrofit urban areas but the greatest opportunities lie in the vast urban areas yet to be built”.

Hence, there is hope and opportunities for the cities of the emerging economies such as the City of Bulawayo to embrace some innovations of the sixth wave and turn them into leapfrog technology that can enable them to develop sustainably and embrace the regenerative development. Newman (2020b) postulates “with regenerative development both population and economic growth can be welcomed as they are driving lots of good”. He further elaborates that “with the sixth wave we could anticipate to build on the digital wave into a

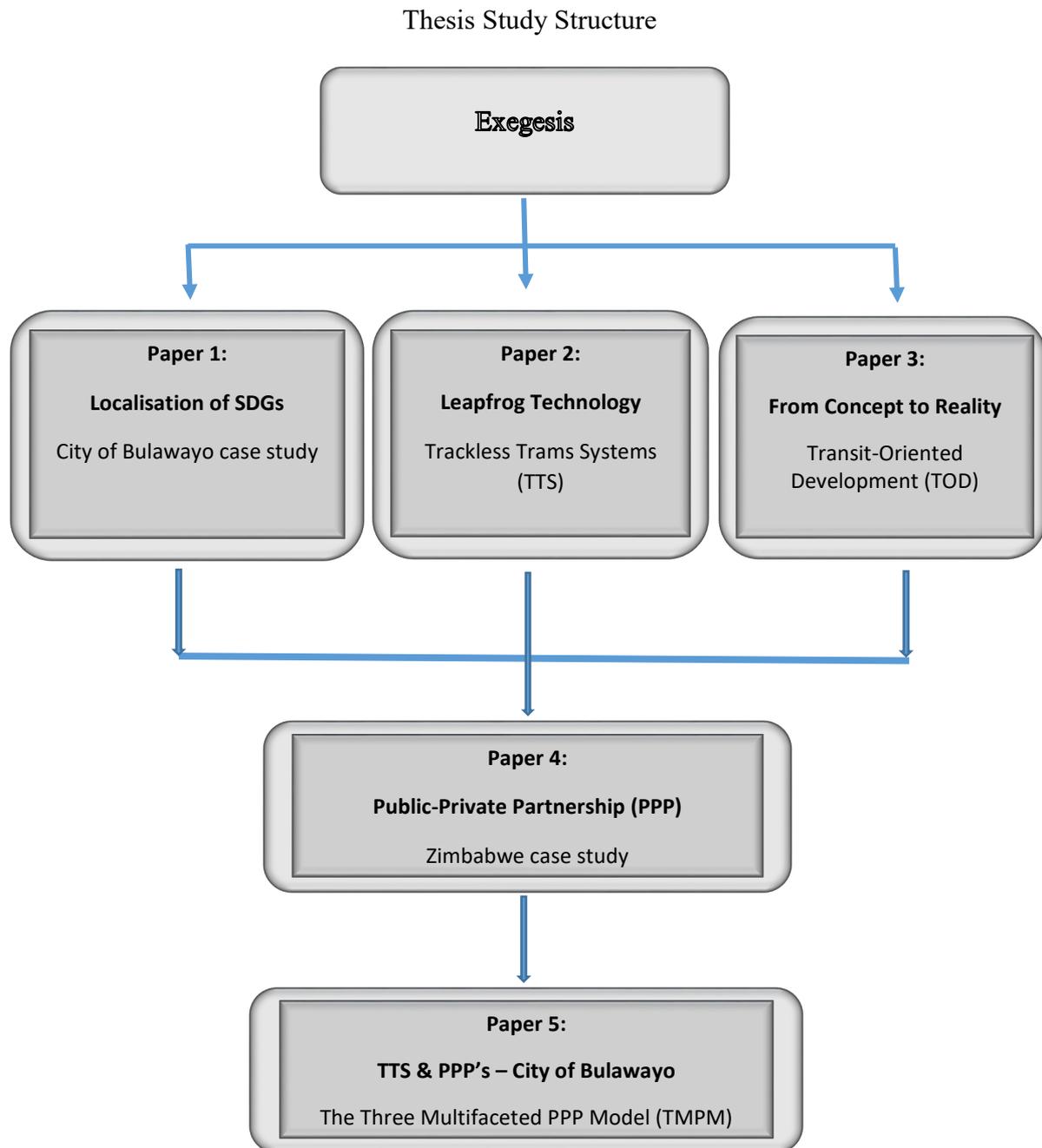
future based on sustainability-based technologies and systems”. These technologies are capable of going beyond simply promoting sustainable development to enhancing regenerative development. These technologies have the capability to enable the cities from the developing economies to leapfrog developmentally. Thus, this sixth wave is ideal for capital-constrained cities of the emerging economies like Bulawayo that need to rise out of the ashes of their economic recessions and declines. According to Gumbo and Moswane (2017) cities that have begun adopting the TOD concept in South Africa are beginning to show some signs of urban regenerations taking place.

Given their financial challenges, the cities of the emerging economies such as Bulawayo have few options for delivering such a future. It is critical that they are innovative and creative in their approach to resolving the required funding for their public infrastructural projects that are the fundamental building block of regenerative development. Bulawayo will need to explore and utilise the Public-Private Partnership (PPP) funding model to drive the redevelopment of its public infrastructure and hence this approach is given a precedence in how to deliver leapfrog technology. The City of Bulawayo needs to resolve the problem of its dilapidated roads and corridors in terms of urban development which has not been happening for decades. This is why the concept of adopting leapfrog technology that can resolve issues of transport, energy and urban development is appealing as a concept.

Emerging economy cities like Bulawayo have the potential and opportunity to develop sustainably, even regeneratively. Currently the City of Bulawayo is facing a crisis of power, water shortages and collapsed roads infrastructure with very few of the support services enjoyed by most people in the world’s cities. This calls for strategies that will seek infrastructure synergies of renewable energy, water and transport development to promote sustainable and regenerative developments. It is hoped that this thesis can help provide frameworks, direction and strategies to help set this in motion.

## 5 OVERVIEW OF THE RESEARCH

In order to address the thesis' main question, five sub questions have been devised. The papers of the thesis will be based upon addressing each of these sub questions. The systematic integration of these papers will fully address the main question of this thesis. The structure of this thesis is as depicted on figure 6.



**Figure 6:** The thesis structure - flow of the papers

Table 7 provides an overview of the papers that form the base of this thesis. The table displays the key themes, actions and methodologies adopted by each paper. The table also identifies the potential journals for each relevant paper. The papers will each address their various key themes and actions as outlined:

**a. Paper 1:**

The key theme for paper 1 is the localisation of the SDGs by urban municipalities. The paper will use the City of Bulawayo as the case study. This paper will conduct an investigative approach on the City of Bulawayo to understand if the city has any SDG agenda set for its developmental programmes. Utilising the literature on urban localisation of SDGs the paper's key contribution is to develop an evaluation framework that can be utilised by any cities of the emerging economies to evaluate their readiness and extent of the implementation of the SDGs.

**b. Paper 2:**

The key theme for the second paper is to conduct a literature review to understand the concept of leapfrog technologies. The study of leapfrog technology is conducted with a focus on Trackless Trams. A framework is created to assess the key qualities of a leapfrog technology and then this is used to assess the capability of the Trackless Trams to qualify as a leapfrog technology, and its ability to enable sustainable development for the emerging economy cities such as the City of the Bulawayo.

**c. Paper 3:**

The theme of this paper is to review and evaluate the literature on transit-oriented development (TOD). The TOD concept is then applied to the City of Bulawayo utilising the Trackless Tram leapfrog technology. The essence of the paper is to show how TOD design could enable emerging economy cities like the City of Bulawayo to technologically leapfrog through the implementation of TTS on the identified transit-activated corridors (TACs) which are a linear collection of TOD's along main roads.

**d. Paper 4:**

Given the financial hardships that are experienced by most cities in the emerging economies including the City of Bulawayo, this paper’s main theme is to evaluate the PPP funding mechanism’s potential to deliver these critically needed developmental projects. The key theme of the paper is to explore the potential of Zimbabwe to adopt the public-private partnership (PPP) concept in partnership with the City of Bulawayo and private sector investors. The reason why the paper evaluates the country as the main case study is due to the fact that most PPP legal frameworks that govern the implementation of PPPs are developed nationally. The paper evaluates the potential projects that could be implemented through a PPP in Zimbabwe and then shows how this could be applied to the proposed Trackless Tram project.

**e. Paper 5:**

Utilising the findings and evaluation of the papers above, this paper’s main theme is to design an ideal PPP model that could be utilised to deliver the Trackless Trams on Bulawayo’s TACs. The paper focuses on identifying the tasks of the potential partners in this arrangement and assigns the tasks/risks that suits each potential partner’s strength and ability. An assessment of each partners’ potential is conducted by applying a simple evaluation and assessment framework formulated in the paper.

**Table 7:** Outline of Thesis in Exegesis and Five Papers with Key Themes and Actions.

QUESTIONS	Publication (Chapter)	Key Themes	Key Actions
Exegesis	Exegesis  Completed:31/12/2020	Problem identification.  Background of the case study.  Background to the key concepts in the papers and their integration.  Structure of the thesis.	Introduction.  Research questions and objective.  Methodologies for papers.  Conclusions and recommendations for further research.

<p>Sub Question 1:</p> <p><b>How can the SDGs which are the globally accepted new approach to economic development, be implemented in a city like Bulawayo?</b></p>	<p><b>Paper 1</b></p> <p>Published in the Journal of Sustainable Development (<b>JSD</b>) on the 29<sup>th</sup> of September 2020.</p>	<p>Localisation of Sustainable Development Goals (SDGs).</p> <p>Bulawayo’s SDG agenda.</p>	<p>Literature review – Urban SDGs localisation</p> <p>Formulation of the “Multi-Criteria Framework” for SDGs planning &amp; implementation</p> <p>Application of the “Multi-Criteria Framework” – CoB case study</p> <p>Discussion and recommendation on the potential of the CoB SDGs model.</p>
<p>Sub Question 2:</p> <p><b>How can developing cities leapfrog into the future with a technology like Trackless Trams?</b></p>	<p><b>Paper 2</b></p> <p>Published in the Journal of Transportation Technologies (<b>JTTs</b>) on the 18<sup>th</sup> of May 2020.</p>	<p>Leapfrog Technology concept</p> <p>Trackless Trams Systems</p> <p>Evaluation of the Trackless Tram Systems for leapfrogging capabilities</p>	<p>Literature review - Leapfrogging Technology</p> <p>Assessment of leapfrogging through Trackless Trams technology</p> <p>Evaluation of the potential to attain SDGs through TTS adoption.</p>
<p>Sub Question 3:</p> <p><b>How would a Trackless Tram System be delivered or implemented in Bulawayo?</b></p>	<p><b>Paper 3</b></p> <p>Published in the Urban Studies and Public Administration (<b>USPA</b>) journal on the 17<sup>th</sup> of May 2021.</p>	<p>Practical applicability of the TTS from a conceptual framework to reality with the agenda to enable a transition to Transit Oriented Development (TOD) within the identified Transit Activated Corridors (TACs) in Bulawayo.</p>	<p>Literature review on TOD</p> <p>Formulation of the “Evaluation and Assessment framework” for TOD</p> <p>Application of the “Evaluation and Assessment framework” on Bulawayo’s potential TACs.</p>

			Discussion and recommendation on the potential strategy of TTS delivery in order to enable a transition to TOD and achieve the SDG's target.
<p>Sub Question 4:</p> <p><b>Would PPP financing and management of infrastructure like a Trackless Tram be the better option for the future in Zimbabwe – case study Bulawayo?</b></p>	<p><b>Paper 4</b></p> <p>Submitted to The World Bank Research Observer (WBRO) Journal.</p> <p>Submitted: 21/11/2020</p>	<p>Public-Private Partnership concept</p> <p>Zimbabwe's experience with PPP's and how this could be applied to a Trackless Tram project</p>	<p>Literature review – Public-Private Partnership concept</p> <p>Identification of Zimbabwe projects ideal for PPP concept – comparative analysis and discussion</p> <p>Evaluation of the deliverability of Trackless Trams initiative through a PPP arrangement</p>
<p>Sub Question 5:</p> <p><b>How would the Leapfrog innovation of a Trackless Tram System and PPP's apply to Bulawayo?</b></p>	<p><b>Paper 5</b></p> <p>Published in the Current Urban Studies (CUS) Journal on the 2<sup>nd</sup> of February 2021.</p>	<p>Evaluation of an ideal PPP arrangement to enable the delivery of the TTS project - case study City of Bulawayo.</p>	<p>Formulation of the PPP model referred as the “Three Multifaceted PPP Model” for the TTS initiative for the City of Bulawayo.</p>

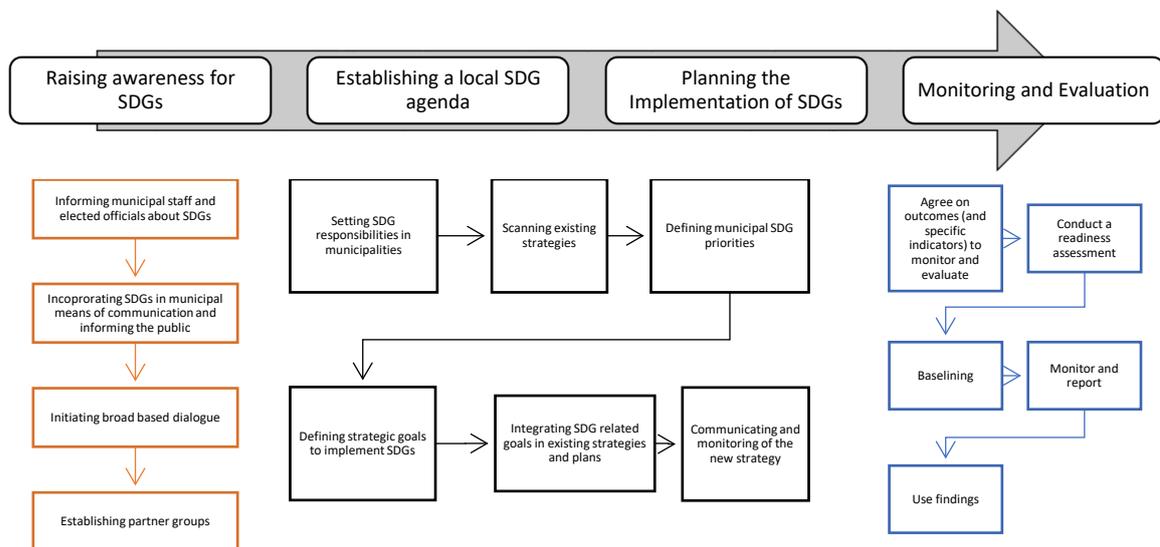
## 6 RESEARCH METHODOLOGY FOR THE PAPERS

The thesis utilises five papers to address the research’s main question. Each paper is structured with its own relevant methodology. Below are the summarised versions of each paper’s methodology.

### a. Paper 1:

The paper employed a literature review to determine the key approaches to help a city focus its development on the SDGs. A two-stage procedure (planning and implementation) of the literature review entailed four interlinked sub-phases: formulation of a study foundation, construction of theoretical and evaluation frameworks, assessment, and lastly the formulation of recommendations and drawing of conclusion as shown on Figure 7. The planning stage consisted of extensive review of literature. Key conclusions of each article were analysed; the results enabled the integration of sources as well as identification of divergence of premises, approaches and findings. The various governance and development management instruments were evaluated on the basis of the metrics informing the evaluation framework.

Framework Guiding Evaluation of SDG Localisation

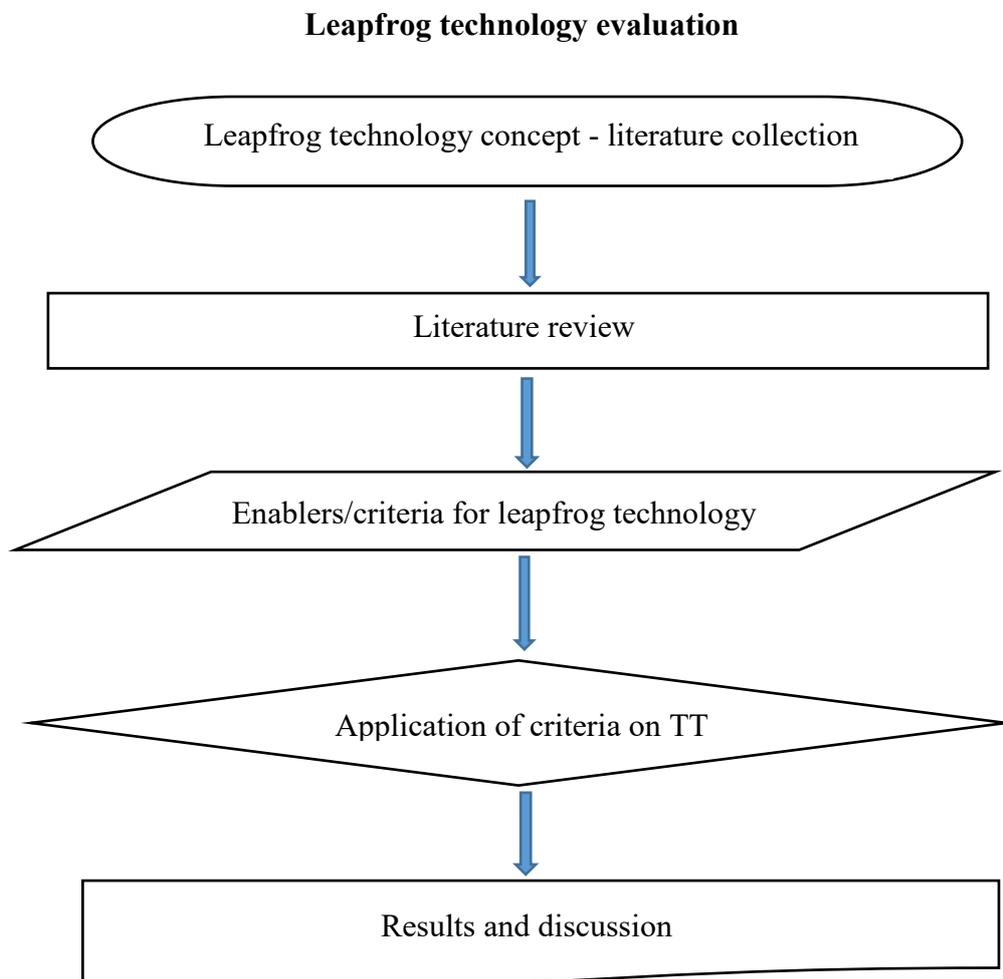


**Figure 7:** Framework for Evaluation of SDG Localisation

**Source:** Ndlovu et al. (2020)

**b. Paper 2:**

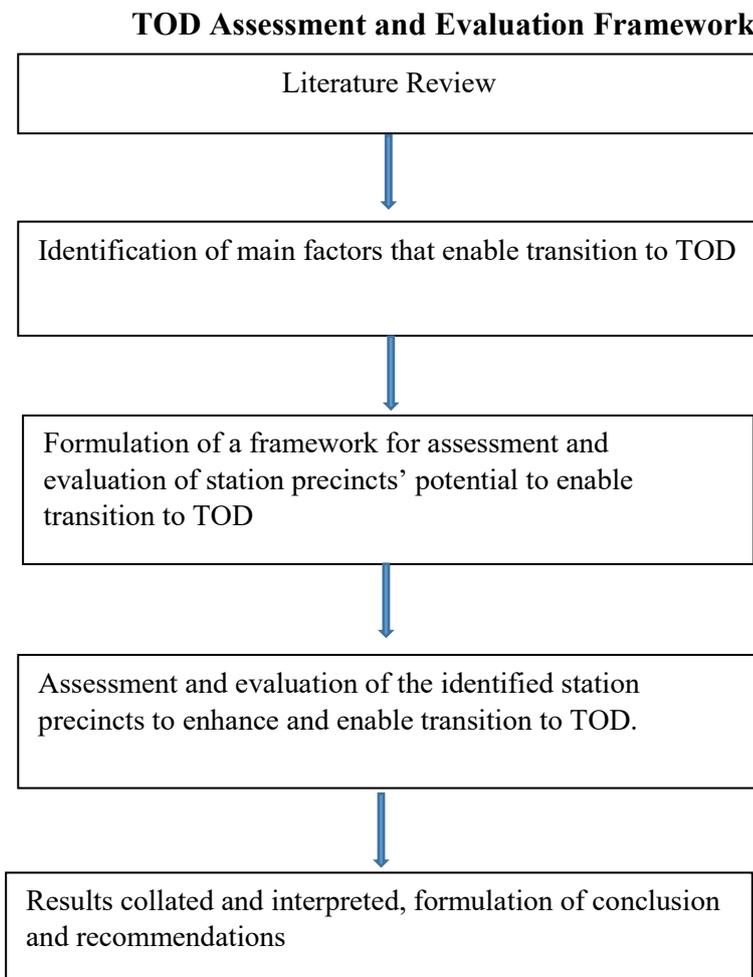
This paper assesses literature to show what technological leapfrogging is and the key criteria used to enable it to occur in developing countries. These include being “economical enough”, “less technical”, “lends itself to partnership”, “lends itself to community engagement”, “enables co-development” and “fulfils the sustainable development goals”. The paper then examines the Trackless Trams and applies the six criteria to it. Figure 8 demonstrates the steps taken to evaluate the potential and capability of the Trackless Trams to enable technological leapfrogging.



**Figure 8:** Steps to document the criteria that enable technological leapfrogging

### c. Paper 3:

This paper undertakes a literature review to determine the key factors that are necessary to enable a transition to transit-oriented development (TOD). Informed by literature, this paper identifies five factors that are important for enabling transition towards TOD. Using these factors, a framework for evaluating and assessing TOD is formulated. The paper applies the formulated framework to identified 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. Figure 9 demonstrates the steps taken to formulate the evaluation framework, and the overall structure of this study.



**Figure 9:** Formulation steps for TOD Assessment and Evaluation framework

**Source:** Ndlovu and Newman (2021a)

#### **d. Paper 4:**

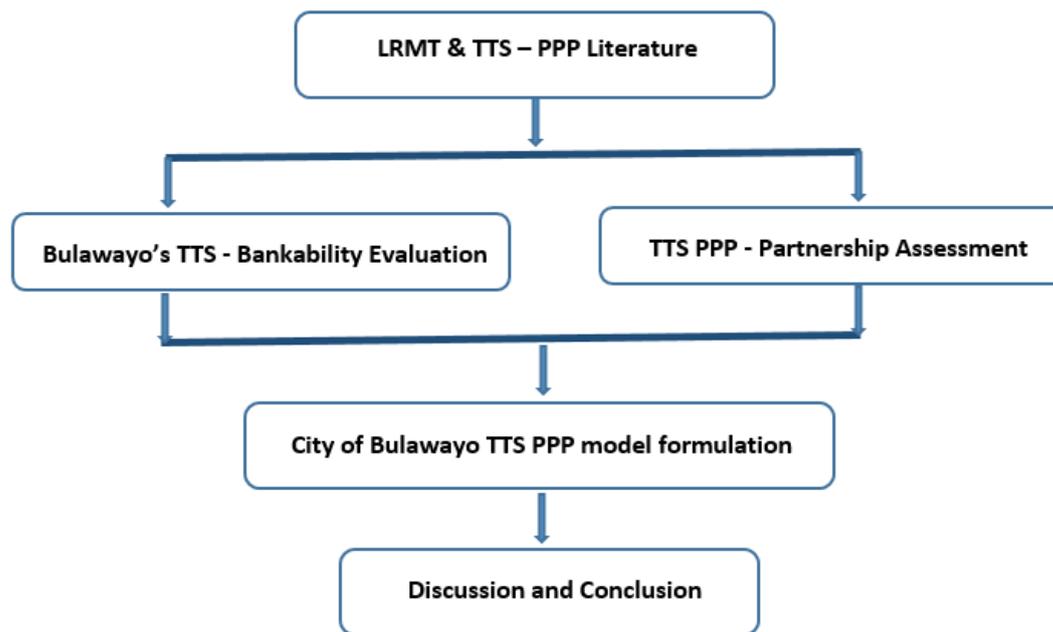
This study creates a potential PPP opportunity for a trackless tram/solar energy project in Bulawayo which has multiple advantages for SDG's. It identifies six other projects in Zimbabwe that can provide some guidance for developing an appropriate PPP that could assist procure such infrastructure. The projects are drawn from the three critical sectors of the economy, power generation, highways/transport, and water/sanitation. For this paper's scope and demonstration, it opted to identify the top two major projects within each of these sectors that have the potential of highest returns to attract private investors and highest economic impact factor to invoke the government's commitment and interest. Thus, projects identified had to have the qualities or criteria below:

- Have a potential significant impact to the society and economy,
- Have a higher rate of returns to attract private investors,
- Have undergone some feasibility studies.

Empirical investigations of these projects reveal the potential effectiveness of the PPP concept to deliver infrastructure for emerging economies. The same approach was briefly applied to the Trackless Tram suggesting that it could achieve all three of these criteria.

#### **e. Paper 5:**

The paper conducted a literature review to ascertain the fundamentals necessary for formulating an ideal PPP model for a TTS mid-tier transit technology, or as The World Bank calls it a 'light rail-light metro transit' (LRMT) (Mandri-Perrott & Menzies, 2010). The paper further formulated a bankability evaluation and capability assessment framework for Bulawayo's TTS project. With the understanding of the relevant fundamentals that are ideal for a potential TTS or LRMT PPP, the study formulated a "Three Multifaceted PPP Model" for the City of Bulawayo's TTS project. Figure 10 gives an overview of the paper's structure and methodology.



**Figure 10:** Structure of study for the Three Multifaceted PPP Model

**Source:** Ndlovu and Newman (2021b)

## 7 CONCLUSIONS TO PAPERS.

### a. Paper 1.

Through the application of the evaluation framework, the paper has indeed shown that Bulawayo has explicitly begun to demonstrate the pathway to sustainable development by developing a Master Plan that sets out how it wishes to achieve the SDG's. However, the city will need to avoid continuing the pre-occupation with issues from the previous era – such as corruption which is detrimental to addressing real development issues. Help is needed to update the planning system and to create an innovative management culture that can ensure SDGs outcomes and potential for using leapfrog technology are the priority. Nevertheless, the city has rapidly advanced through the localised planning process and is beginning to show it can begin to deliver the SDGs. Infrastructure projects could be developed in partnership with the private sector financing to enable major leapfrogging in technology to happen. There is ample room to apply the evaluation framework (developed in this paper) to other cities in the developing world.

**b. Paper 2.**

This paper examined the techno-physical and socio-economic attributes of leapfrog technology and then applied these to the trackless tram system (TTS). Based on the analysis of features that make a technology have the abilities to enable leapfrogging, the paper concludes that the trackless tram system certainly meets those requirements. Table 8 illustrates the evaluation criteria and the results.

**Table 8:** Evaluation of TTS for leapfrogging capabilities and traits

<b>Leapfrog Technology Requirements</b>	<b>Application to Trackless Tram Systems</b>	<b>Comments</b>
1. Economical enough	✓✓	Very cheap mass transit, not as cheap as separate buses or jitneys. See also 3.
2. Less Technical	✓	Requires some smart systems but only enough for mobile phone telephony
3. Lends itself to Partnership	✓✓✓	Ideal for working with developers who can help finance it through urban centres at stations.
4. Lends itself to Community Engagement	✓✓✓	Communities are very keen for better transit and if included will make TTS much more successful.
5. Enables Co-development	✓✓✓	Many overlaps with economic development as it creates agglomeration economies.
6. Fulfils Sustainable Development Goals	✓✓✓	Very strong on all SDG's due to equity, health and environmental improvements.

**Source:** Ndlovu and Newman (2020)

The paper also examined the social and economic benefits associated with trackless trams. The paper shows that TTS can improve and create significant social and economic benefits. It

can help minimize urban sprawl and increase urban density levels as well as reduce traffic congestion and provide a better public transport service. The paper therefore concludes by suggesting that strategies and plans should be developed that support technological leapfrog initiatives like the TTS. The paper also shows that the TTS lends itself to a partnership with urban development along proposed corridors. The adoption of a TTS is mostly feasible if delivered using an entrepreneurial approach and includes the private sector and all stakeholders from the onset. The paper suggests that the technology has most of the needed attributes to augment technological leapfrogging in transport.

**c. Paper 3.**

The findings of this paper show that the concept of adopting a transit-oriented development approach to delivering the TTS on the roads of Bulawayo should work well as it will enable the urban development necessary to finance the TTS. It will initially work best 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. These are identified and prioritised. In addition, the introduction of the TTS will drastically reduce the cars and vans that clog the roads within the city centre. This paper finds that the City of Bulawayo could significantly improve its ability to achieve its sustainable development goals and contribute towards the Paris Agreement as well as becoming a model for emerging cities in the 21<sup>st</sup> century. The project is likely to attract climate-related funding and financing.

**d. Paper 4.**

The paper reveals that the adoption of a PPP business model does allow projects to be built quicker and efficiently without having to wait for overstretched government resources or external debt sources which are being impacted by credit risk. The Trackless Tram-Solar project being assessed in this paper has been found to fit a PPP structure of a Build Own Operate (BOO) system that sets out how to deliver it in three levels. These three levels are set up to ensure that there is strong government involvement where steps are needed that involve public infrastructure and needs while other levels involve strong private investment leadership where their strengths are needed. This model is based on a review of six large infrastructure projects in Zimbabwe in energy, water and transport sectors. The assessment based on the review of six case study projects showed that both a high internal rate of return (IRR) and a high economic impact on the broad economy and SDG's, can be achieved. A key

insight was the need for local involvement in not only the local government but also in understanding the local socio-economic dynamics that are needed for the achievement of a PPP to deliver benefit to both private investment outcomes and public common good outcomes.

#### **e. Paper 5.**

The TPM model developed in this paper is pragmatic and more realistic to enable the adoption of the TTS by the City of Bulawayo. The model factored in some lessons learnt from observed PPPs that have been successfully implemented in public transport sectors around the globe especially in South American countries. The study also utilised the Polish experience of reducing the capital risk exposure to the players by segmenting the project into three small manageable segments or layers. Poland utilised the strategy of segmenting the construction of its A2 Toll Motorway project into smaller construction phases or sizes. In a little deviation from the Polish approach, the TPM model does split the “vertical” size of the project into smaller sizes thus lowering the capital risk exposure by distributing it to many players while still implementing the whole project. The TPM structure is ideal for the City of Bulawayo on many fronts, and it can also be easily adopted by other cities that are facing some financial difficulties funding their public infrastructure projects that seek multiple benefits as in this project.

## **8 FURTHER RESEARCH**

Four areas are considered to be necessary for further research in the area of this thesis.

- 1. Trackless Tram Evaluation Studies.** TTS projects are being set up in cities across the developed and developing world. They should be evaluated along with the planned project in Bulawayo. These evaluations should be able to determine if the predicted benefits and costs associated with building TTS are close to those outlined in the literature that is in this thesis. Such studies should involve interviews in the places where they have been built to determine how well they perform and how easy was the process of delivering them.
- 2. SDG Evaluation Studies.** Further study is needed in the area of developing theoretical frameworks and strategies to promote the domestication and localisation of SDGs especially at the urban level. This further research should focus mostly on the

monitoring of the progress. Monitoring of progress of localisation and domestication of SDGs will require observation over a period of time. There is also a need for further research on the formulation of frameworks that could be utilised to assess and promote sustainable development through a three multifaceted approach that incorporates transport (TTS), land development and renewable energy adoption (DER) as a one package strategy that will enhance the achievement of SDGs targets for the emerging economy cities.

3. **PPP Evaluation Studies.** The PPP legal framework enhances the chances for potential PPP projects to succeed compared to a scenario where no legal framework is available. This is assumed to be the fact, however further research on that notion is needed based on an evaluation of PPP's in practice. This study will be crucial to guide and conscientise the national governments to think of enacting the ideal PPP legal framework to promote this kind of procurement mechanism especially for emerging economies' cities. Further research is required to formulate the frameworks that are necessary to conduct a quick bankability and partnership assessment of potential PPP projects. That research will be crucial in identifying potential projects that could be implemented through a PPP approach, thus allowing the government to use its limited resources to undertake other public projects and leaving the private sector to develop and undertake those projects identified to suit the PPP mechanism. Assessments are needed on how well PPP's like the one proposed here can provide the basis of economic development as well as achieving key public goals in social and environmental outcomes.
4. **TOD Evaluation Studies.** There is a need for further research on the statistically significant variables (factors) that are relevant to enhance or influence transition to TOD. This is particularly important when the new idea of using a whole corridor of TOD's in a Transit Activated Corridor (TAC) has been attempted. By utilising the regression analysis methods, potential variables could be identified and used to enhance the frameworks that were formulated in this paper and other previous studies. This should be done as an evaluation of TTS projects as they are rolled out in developed and developing cities.

## **9 APPENDIX OF PUBLICATIONS**

- a. Publication 1**
- b. Publication 2**
- c. Publication 3**
- d. Publication 4**
- e. Publication 5**

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**Publication 1: Co-Author Statements**

**To whom it may concern**

I, Vinnnet Ndlovu, contribute **70%** of the paper/publication entitled

**Ndlovu, V.**, Newman, P., & Sidambe, M. (2020). Prioritisation and Localisation of Sustainable Development Goals (SDGs): Challenges and Opportunities for Bulawayo. *Journal of Sustainable Development*, 13(5), 104-118.  
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# Prioritisation and Localisation of Sustainable Development Goals (SDGs): Challenges and Opportunities for Bulawayo

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## Abstract

Cities are engines of socio-economic development. This article examines and provides insight into the extent of localisation of the UN's Sustainable Development Goals (SDGs) using the City of Bulawayo (CoB), in Zimbabwe, as the case study. The key question posited is 'Does Bulawayo demonstrate potential for sustainable development?'. Bulawayo is a strange case study as in the period of the Millennium Development Goals Zimbabwe had a massive increase in death rates from 2000 to 2010 due to the HIV pandemic, political chaos and economic disintegration of that period. Coming out of that period there was little to help cities like Bulawayo grasp the opportunity for an SDG-based development focus. However, after the paper creates a multi-criteria framework from a Systematic Literature Review on the localisation of the SDG agenda, the application to Bulawayo now generates hope. The city is emerging from the collapse of the city's public transport and water distribution systems, once the envy of and benchmark for many local authorities in the country, and has detailed SDG plans for the future. Bulawayo now serves as a planning model for localisation of sustainable development goals.

**Keywords:** localisation, operationalisation, urbanisation, Covid-19, leapfrogging, sustainability

## 1. Introduction

Since the adoption of the UN's Sustainable Development Goals (SDGs) in 2015, there is a strong need for localisation of the global development agenda (UN, 2015). Given the plethora of challenges facing cities in developing countries, including the ongoing pressure from COVID-19, no city can afford to ignore or delay aligning its development trajectory to the SDGs. This paper provides an overview of SDGs and how they apply to cities and creates a framework for evaluating how a city can localise the SDGs. The framework is then applied to the context of Bulawayo to evaluate the potential of the City to develop sustainably. Furthermore, it seeks to understand some of the key challenges and opportunities towards the transition to a sustainable city.

### 1.1 Cities in the Context of Sustainable Development Goals (SDGs)

SDGs articulate a post 2015 global development agenda; they superseded the Millennium Development Goals (MDGs). The global development agenda is encapsulated in 17 goals emanating from consensus of 193 UN member states. Municipalities, through entities with specific focus on local government (e.g. the United Cities and Local Governments [UCLD]) participated in the formulation of the SDGs. SDG 11: 'Make cities and human settlements inclusive, safe, resilient and sustainable', specifically relates to and places cities as the footstool for sustainable human development and progress (**Table 1**). The centrality of cities towards the future that humanity is thriving for in the context of SDGs is summed up in the statement "*The future we want includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more*", (United Nations, 2015).

Table 1. Sustainable development goal 11

SDG	Indicator	Target
11.1	Ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums.	2030
11.2	Provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.	2030
11.3	Enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries.	2030
11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage.	2020
11.5	Significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.	2030
11.6	Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management.	2030
11.7	Provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities.	2030
11.a	Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.	2020
11.b	By 2020 substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement in line with the forthcoming Hyogo Framework holistic disaster risk management at all levels	2020 - 2030
11.c	Support least developed countries, including through financial and technical assistance, for sustainable and resilient buildings utilizing local materials	2020

Notwithstanding the direct relevance of SDG 11, other SDGs are critical towards the development and prosperity of cities. Table 1 highlights the SDG 11 targets that are most directly related to cities. These targets might not explicitly mention cities, but urban policy, strategy and development actions are implied. At the least, cities are instrumental towards the realisation of the targets.

Localisation entails making the intentions of the SDGs resonate with local contexts. Countries and key role players are expected and encouraged to ensure local specific prioritisation of SDGs, and even support local authorities to adapt global targets to local conditions. Localisation of SDGs are crucial due to different contexts, some come from extreme poverty and some are wealthy so there will be a big difference in how they need to prioritise their approaches. Most municipalities in developing countries are still struggling with the provision of basic infrastructure and in this case study on Bulawayo that is clearly the case as will be outlined below. Failure to operationalise SDGs through clear planning directives, as happened during the advent of the MDGs, will lead to perpetuation of poverty and vulnerabilities of most cities in developing countries. In essence, urbanisation is a major tool in achieving the SDG's but without good planning cities will gradually have their urbanisation reversed due to the collapse of services. This will be demonstrated below in Zimbabwe where semi-rural societies within an urban context were starting to dominate Zimbabwe's landscape as development failed and cities began to depopulate (Kamete, Sidambe, & Ndubiwa, 2000). Only a clear grasp of SDGs, and their localisation (a process to be championed by both political leaders and planning staff) and their operationalisation (which includes sustainable funding models) can help to propel sustainable urban development.

This article attempts to provide answers or shed light to the following key questions and issues:

- 1) Can Bulawayo develop sustainably, as per the Sustainable Development Agenda? If so, what progress has been made by the City of Bulawayo (CoB) towards localisation of such an approach to development (articulated through the Sustainable Development Goal 11)?

- 2) What constraints, if any, impede the operationalisation of the SDGs by the municipality?
- 3) Can Bulawayo demonstrate the reversal of urbanisation through localised planning for the SDGs?

The main benefits to be derived from the case study are to identify the factors/elements that municipalities can leverage on for effective operationalisation of the SDGs and thus make sustainable development a reality, especially in a developing city context.

## 2. Background and Contextual Analysis

There has been an intense focus on sustainable development since the work by the UN Commission on Environment and Development and their ground-breaking publication “Our Common Future”, also commonly referred to as the Brundtland Report (1987). The notion of sustainable development was not immediately applied to cities but it soon grew through activities such as UN Habitat, Local Agenda 21, and ICLEI in the 1990’s (Peter Newman & Kenworthy, 1999). It then followed in the 21<sup>st</sup> century into The New Urban Agenda (UN-Habitat, 2016) and the Sustainable Development Goals (SDGs) with SDG 11 on cities (UNSDGs, 2015). This paper seeks to look at how the sustainable development concept and especially how the SDG 11 with its clearly enunciated performance indicators, can be taken up in developing cities, with a case study of Bulawayo, Zimbabwe.

Bulawayo inherits its name from the roots of the Ngunis who formed the Mthwakazi Kingdom in the early 19<sup>th</sup> century. The city became the capital of the Mthwakazi Kingdom and was the main industrial city of Southern Rhodesia in the colonial era. Bulawayo (**Map 1**) is located on the main train line built to link Cape Town to Cairo. It has a strong history in urban planning as a city that was designed to be a model for development in Africa (Mbiba Beacon & Ndubiwa Michael, 2008).



Map 1. Location of Bulawayo, Zimbabwe

Source: Google Maps

Bulawayo has a population of 738,600 and is struggling to find a new future after the devastating loss of life as shown in Figure 1 as well as the collapsing infrastructure and identity during the Mugabe period in the first decade of the 21<sup>st</sup> century. Figure 1 shows that the death rate in Zimbabwe increased dramatically in the period from 1990 to 2010. In 1986 the death rate was 8.16 per 1000 population which was low by developing country standards. However, the death rate began the remarkably rapid increase as shown in Figure 1 and peaked in 2004 at 17.95 per 1000 population, one of the worst death rates in the developing world. It then began to improve and reached back to where it had been around 2017 and the latest data from 2019 shows it has reached 7.88 per 1000 population.

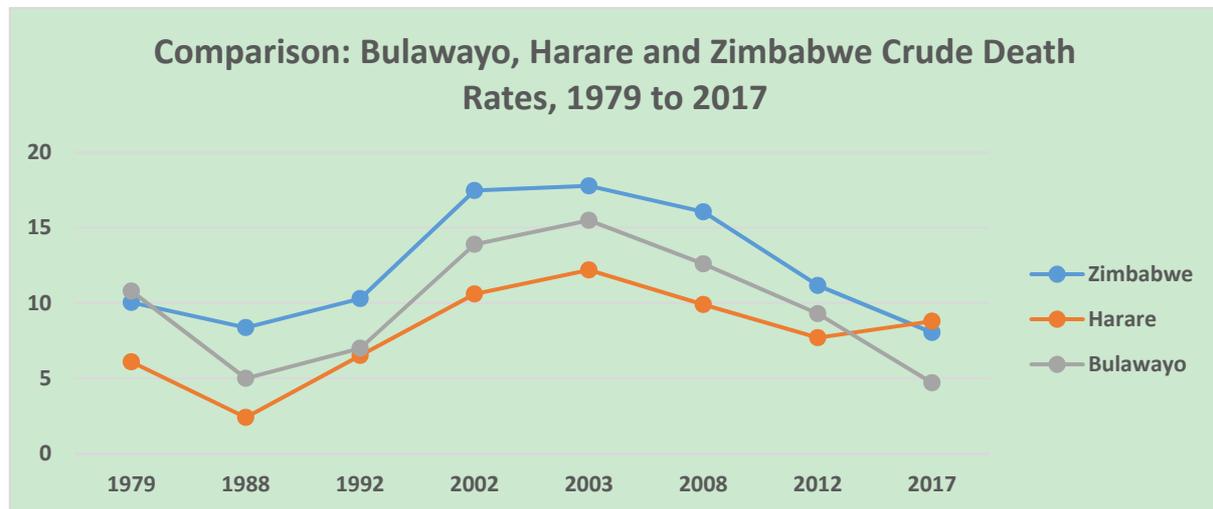


Figure 1. Death rate in Zimbabwe 1979 to 2017

Source: ICDS 2017 – Harare & Bulawayo (data) & Source: World Bank – Zimbabwe (data)

What this means for the SDGs is that there has been little chance of sustainable development in Zimbabwe in the period that the world has been working on this approach to economic development. No city or region can achieve anything when such political chaos and economic devastation was causing such high loss of life as depicted on figure 1. This paper is therefore not going to try and seek any other data from that period but instead seek what could be the best way forward for a place like Bulawayo to now try and pursue a programme of development that can start to achieve some localised sustainable development goals. We are focussing on Bulawayo as cities are the focus of ‘localization’ (Reddy, 2016) and can be expected to take up the SDG 11 project as a matter of priority.

Zimbabwe’s post-independence politics of ethnicity has been engineered to destabilise and even derail Bulawayo’s development but Bulawayo has a resilience which is now emerging as a way of overcoming such tribal politics with its divisions causing serious economic decline, as evidenced by the death rates shown in Figure 1. Despite the tribal-rooted politics of the ZANU-PF government, Bulawayo has emerged, in the last decades, as one of the best-managed municipalities in Zimbabwe (Bhebe, Bhala, Kadodo, & Sithole, 2010). However, it has much to do. The city suffers from avoidable water shortages as the national government reneged on development of the Zambezi water project, which could have provided a permanent solution to Bulawayo water challenges. Once the industrial capital of Zimbabwe, water shortages and deliberately skewed regional economic policy has led to the city’s de-industrialisation, culminating in high unemployment and ejection of the people of Bulawayo to the diaspora, leaving a city with little hope and a terrible death rate. Informal entrepreneurship now forms the backbone of the city’s economy and Bulawayo now seems ready to recreate its future.

The Brundtland Report in 1987 created the term sustainable development to highlight how economic development must include social and environmental goals from concept to reality. Since that time, the world has continued to experience rapid urbanisation. The World Bank shows that urbanization level has increased from 42.3% urban in 1987 to 55.7% in 2019; this represents a doubling of the global urban population from 2.102 billion to 4.274 billion (World Bank, 2020). The urban population of Zimbabwe had a similar growth during that period from 2.55 million to 4.72 million, however it slowed to almost zero during the first decade of the 21<sup>st</sup> century due to substantial economic decline in the last years of the Mugabe Government; it then grew again in the second decade of this century (World Bank, 2020). The paper will see what this period has demonstrated in terms of the SDGs as the economy fluctuated considerably during this period.

The relationship between urban growth, the economy and the SDGs is very complex. The fear is that rapid urbanisation will bring an unsustainable resource exploitation, for example, it is assumed that as rapid urbanisation takes place so the levels of energy use and greenhouse emissions also grow and place pressure on resources and environmental issues increase. However the study by Grossman and Krueger (1995) and later by Peter Newman (2017) has shown that the opposite relationship can actually happen due to decoupling of wealth generation and environmental impacts such as greenhouse emissions. Grossman and Krueger (1995) documented a convex “U-shaped” relationship between environmental degradation and income growth. They suggested that societies do

show remarkable ingenuity in harnessing new technologies to conserve scarce resources. Accordingly, we can expect that environmental quality might improve if countries develop through substituting cleaner technologies for dirtier ones. It is observed that when countries experience greater prosperity, their citizens become environmentally conscious. This is the goal of sustainable development and hence it has become a non-negotiable and central part of human development. However, when a decade is characterised by a plateau in urbanization the prospects for sustainable development become mixed.

Local government is at the coalface of service delivery and efforts to achieve sustainable development. The SDGs, adopted in September 2015 by 193 United Nations member states, constitute and articulate the global agenda for human development. The operationalisation of SDGs has been fraught with several challenges in developing countries. There is no evidence of any effort of localisation of SDGs by local authorities in Zimbabwe and this is to be expected as shown above.

Zimbabwe is a signatory of most global compacts, however, the country has been 'excommunicated' from the global development institutional framework primarily due to gross and endemic human rights abuses and corruption covering most of the late 20<sup>th</sup> and early 21<sup>st</sup> century. Municipalities have not been spared the impact of the collapse of the country's economy. In 2002, the West, mainly led by America and the European Union imposed economic sanctions on the country's kleptocracy to force constitutional and political reforms. Miniscule reforms have taken place. Bulawayo, the country's second largest city is the epitome of the intersection of the politics of ethnicity and economic malaise within this difficult environment. The research project is therefore setup to try and show how Bulawayo could move out of such a framework of despair and create a future based around the SDGs. The fundamental question is how should a city in a developing country structure and complete localised planning for an SDG-based development strategy?

### **3. Methodology**

#### *3.1 Approach*

The research employed a systematic literature review to determine the key approaches to help a city focus its development on the SDGs. A two-stage procedure (planning and implementation) of the systematic literature review entailed four interlinked sub-phases, that is formulation of a study foundation, construction of theoretical and evaluation frameworks, assessment, and lastly the formulation of recommendations and drawing of conclusion as shown in **Figure 3**. The planning stage consisted of extensive review of literature. Key conclusions of each article were analysed; the results enabled the integration of sources as well as identification of divergence of premises, approaches and findings. The various governance and development management instruments were evaluated on the basis of the metrics informing the evaluation framework. The methodology, like any other, is fraught with challenges, hence, it was critical to identify and mitigate inherent shortcomings.

#### *3.2 Limitations*

The first apparent shortcoming is related to the delineation of the scope of the research. To manage the huge body of literature, the scope of paper has to be delineated. One of the emerging and most popular area of focus relates to domestication of the global development agenda. Difficult as it is, the study had to make a distinction between domestication and localisation. Apart from the conceptual delineation, there were practical constraints attendant to the methodology.

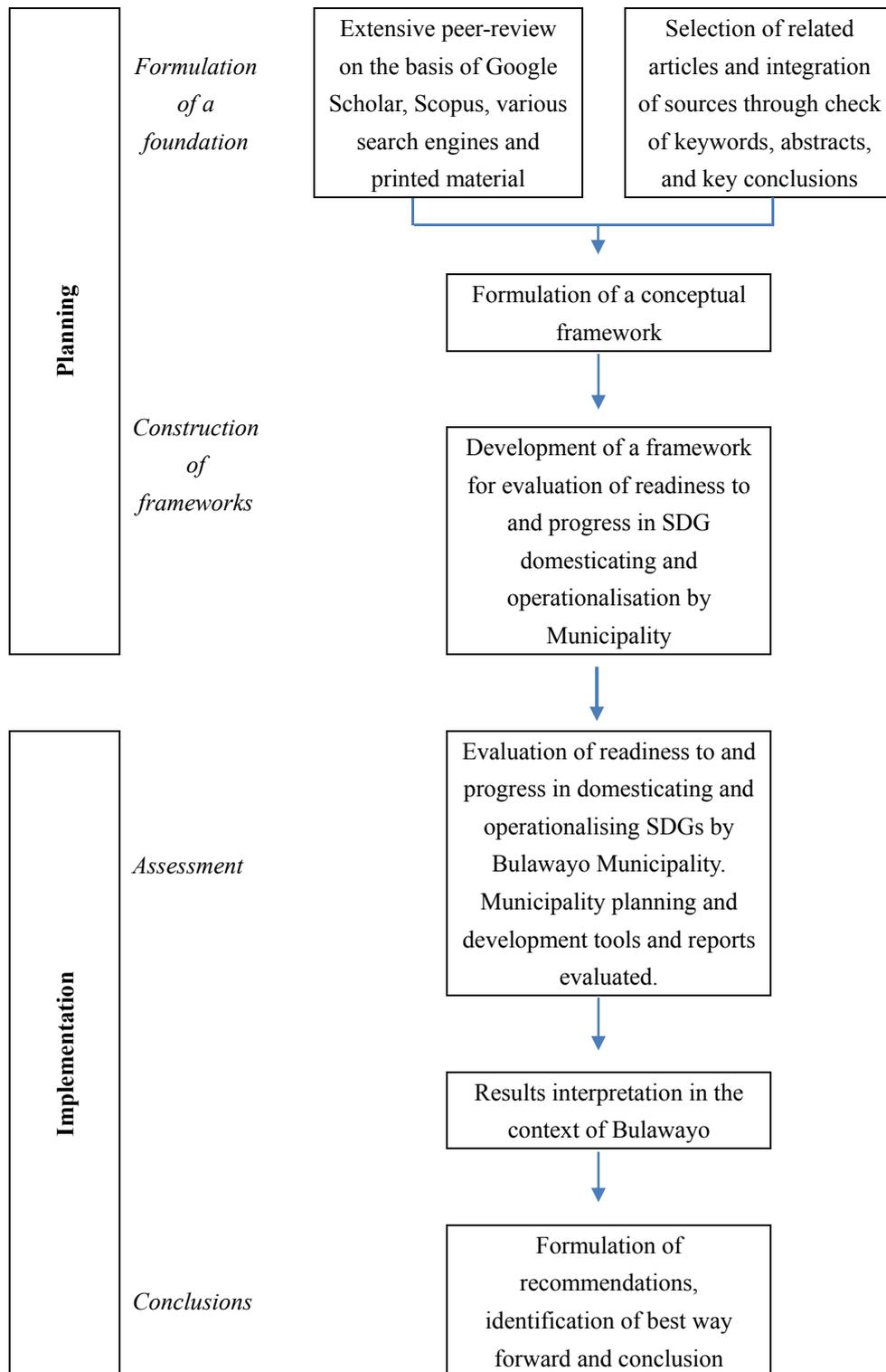


Figure 3. Systematic literature review procedure

One of the key constraints relates to the fact that literature review was mainly limited to journals and other published material that is readily available on public platforms. There is thus a realisation that they might be other written material that are not necessarily published or available on the public domain. Furthermore, the paper has a narrow and well-defined geographic focus that is Bulawayo. Experiences in other municipalities in Zimbabwe and other countries might reveal different results. An additional constraint pertains to the approach of selection of what

is then deemed relevant literature for review. Despite the limitations of our methodology, we expect that the selected published and official material provides important insights into the subject matter and that the study is representative of the state of domestication and operationalisation of SDGs in Bulawayo. To reduce bias, a wider body of literature was reviewed, and insight reflected on in the context of the study area, Bulawayo.

#### **4. Systematic Literature Review**

##### *4.1 Sustainable Development and Cities*

Sustainable development has come to mean many things but has primarily come from the need to modify economic development so that it more fully integrates social and environmental outcomes. There is a realisation that development is a multifaceted and complex phenomenon (Yang, Xu, and Shi (2017).

According to Newman and Kenworthy (1999) and Shaker and Sirodov (2016) sustainable development for cities needs to be created through the a strategic plan for the city designed to simultaneously improve the economic development, environmental quality, and social equity of the city. In terms of the SDGs, there are five pillars to sustainable development, viz. society, economy, environment, peace, and partnerships. The SDG paradigm has expanded on the traditional tripartite basis of sustainable development, by including the last two that is peace and partnerships as explained by Regan (2002). Cities are thus increasingly adapting governance and development management instruments and practices to guide planning and management of multi-sectoral activities within their jurisdictions. Such localised strategic planning is critical for delivering SDG's.

Equally important to promoting the sustainable development for cities is the evaluation of sustainable development progress as well. Several studies on this task have been conducted. Karatas and El-Rayes (2015) point out that most studies on the evaluation of SD have focussed on analysing (a) the sustainability of construction projects, and (b) the level of service and quality of neighbourhood infrastructure systems such as urban roads. To simplify the evaluation approach, Karatas and El-Rayes (2015) developed the Sustainable Development Evaluation–Decision Support System (SDE-DSS). Ironically, their model became overly complicated and thus impractical to operationalise. In response to this, other models were developed. Fehr, Sousa, Pereira, and Pelizer (2004) formulated a bottom-up management approach to managing cities towards sustainable development. The model is grounded on the focusing of sustainability as a process rather than an outcome though it is hard to imagine this being politically successful in a local area unless the outcomes are also achieved.

Alberti and Susskind (1996) posit that a failed sustainable development strategy manifests in environmental collapse. In essence, environmental collapse, equates to failure by municipalities to discharge their mandates. Service delivery failure will be characterised by pollution, non-collection of refuse or poor refuse management, potholes on roads, sewerage spillages, water bursts and power cuts, amongst other obvious failures that are easily seen by the local population. Unless preventing these 'outcomes' becomes part of an SDG strategy it is unlikely that the city will progress towards a better future in other aspects of SDGs.

Mendes (2000) argued that managing cities towards sustainable development is more than just possession of technical competencies. In that sense, the realisation of sustainable development is primarily dependent on the capacity building with and application of 'soft skills' to the management of cities. Fehr et al. (2004) constructed a model that puts emphasis on appropriate leadership and human capital management to avert environmental collapse.

Technical competence and management skill obviously needs to be combined. A key way to do this is by certifying standards that are both appropriate and yet can enable sustainable development outcomes. Karatas and El-Rayes (2015) reflected on the importance for cities to think of sustainable development when they are setting out their planning for buildings; they suggest that by building cities that have the capability to install renewable energy technologies with energy storage capabilities then all the economic, environmental and social goals can be reached. These buildings should be energy efficiency certified and the same approach needs to facilitate the economic and sustainable use of water. The cities' buildings should not only be energy efficient certified, but also the cities themselves should be designed to qualify as sponge cities. According to Yang et al. (2017) they defined sponge cities as the cities that act like sponges, can absorb, purify, and retain rainwater. These approaches that integrate resource consumption into planning can be applied across the whole of the planning system.

##### *4.2 Leapfrogging Towards Sustainable Development in the Next Economy*

The first era of the sustainable development paradigm has been very slow, however it is possible that it may accelerate in the coming era. The next global economy has been called the Third Industrial Revolution by Rifkin (2013), the Fourth Industrial Revolution by Klaus (2016) and the Sixth Economic Wave by a range of academics (Peter. Newman, 2020) building on the economic wave theory of Schumpeter (1939) and Kondratief (1984). The

key idea in all of these is that technological change can enable a new economy once the other one before it collapses. This is certainly the global situation and certainly is doubly the case with Bulawayo as it saw the collapse of its industrial base in the first decade of the 21<sup>st</sup> century not the 2020's as is happening now across the world.

For the developing world there are possibilities that they can leap-frog into the next economy (Ndlovu & Newman, 2020). They are not confronting the problems of the previous economy in terms of massive institutional inertia and lobbying from those who have the most to lose, like fossil fuel companies. The literature on leap-frogging suggests that this is possible if the cities and nations involved are able to create the kind of supportive governance base that can welcome and enable demonstrations (Conroy & Berke, 2004; Ndlovu & Newman, 2020). The literature review therefore begins to focus on what are the detailed outcomes being sought by cities.

#### *4.3 Evaluation of Progress by Cities Towards Sustainable Development*

Zinkernagel, R, Evans, J, and Neij (2018) postulate that “although cities have been using indicators for a long time it is only in the last decades that attempts have been made to collate indicators into sets that reflect the many different aspects required to assess the sustainability of a city”. The UN Global Compact, the Global Reporting Initiative and the World Council for Business and Sustainable Development (2020) have produced an SDG Compass that sets out ten pages of tools to assist nations in delivering the SDGs. According to Wilson, Tyedmers, and Pelot (2007) some key commonalities exist in a number of the various cited evaluation frameworks. These are mostly in the form of indicators relating to economic productivity and progression, ecological footprint, biocapacity, (citizen) wellbeing, and human development. The politics of or affecting the city is an area that some of the frameworks shy away from or rather peripheralize. This proves that measuring progress towards sustainable development of a city is more than a straightforward technical process. Fehr et al. (2004) used the indicators below to test the environmental sustainability of Toribate city:

- Demographic density and evolution
- Public transportation
- Solid waste handling
- Liquid effluent handling
- Air monitoring
- Fresh water supply
- Public education
- Public health care
- Cultural manifestations
- Energy supply
- Park maintenance
- Land use and resource preservation

Fehr et al. (2004) concluded that a city that is developing sustainably is one that is in control of the cited indicators.

#### *4.4 Public Participation and SDG Outcomes*

Fehr et al. (2004) posit that sustainability cannot be bought, that it is a philosophy of life that must be conquered and acquired. They posit that the challenge to get the sustainability plans successfully implemented or the adoption of this new “philosophy” lies purely on making the citizens accept these SD indicators and be involved in their achievements. Hence, their view that this task requires very competent and innovative managers who will be able to manage people with creative methods. They concluded that this management challenge has become an educational task. Competent managers should know to involve all relevant stakeholders at the beginning of developing the SD plans for the cities. A collaborative planning process minimises disputes by getting issues and concerns onto the discussion agenda for resolution. Conroy and Berke (2004) reaffirm this when they suggest that “when people are involved in the decision-making process, they are more likely to be supportive of the implementation of the initiative”. Potapchuk, Crocker Jr, and Schechter (1999) echoed this notion by inferring that “participation helps to build social capital in a community, which in turn strengthens the community”.

Given that sustainable behaviour is a day by day undertaking, local participation becomes very crucial to support this philosophy of lifestyle. It is the communities themselves that will have to live sustainably and responsibly hence public involvement at the onset of the plan is crucial. Innes (1996) refers to this as participatory democracy as a means for democratic discourse. Numerous studies have also shown that local capacity and participation plays an important role in promoting successful introduction and implementation of various community-based plans. Possibly the most significant is the political and community support to the planning process. Political support helps to increase community interest. Local participation that involves local resource commitment is documented to be crucial for the adoption and implementation of community-based initiatives such as SD programmes. Conroy and Berke (2004) tested the significance of the three dimensions of the plan-making process:

- Political support for sustainable development within communities,

- Efforts designed to support public participation,
- Resources committed to plan preparation.

The tests proved that the presence of the state in the promotion of such initiatives is extremely important and significant. The tests also indicated that the participation breadth was important and statistically significant. An involvement of the community in the initial stage of formulating the plans is a good undertaking, for it builds harmony and minimises the resistance downstream. According to Conroy and Berke (2004) “Increased participation breadth means an increase in the variety of opinions, concerns, and expertise that will be represented in the participation process”. The importance of public involvement in the planning process is also well documented in various studies of planning. The involvement of the government and the public in the sustainable development planning process promotes both the top-down and bottom-up participation. Hence, a key conclusion from this background literature is that state mandates and public participation are key to integrate in promotion of the sustainable development agenda.

#### 4.5 Framework for Assessment for City’s Potential to Localise and Achieve SDGs

The systematic review of literature has provided a conceptual assessment framework that can be used to assist with localisation of SDG’s in a city (Figure 2). The framework provides both a process path as well as articulates the substantive domains of focus with respect to assessing/evaluating a municipality’s readiness in localisation and progress in operationalisation of SDGs.

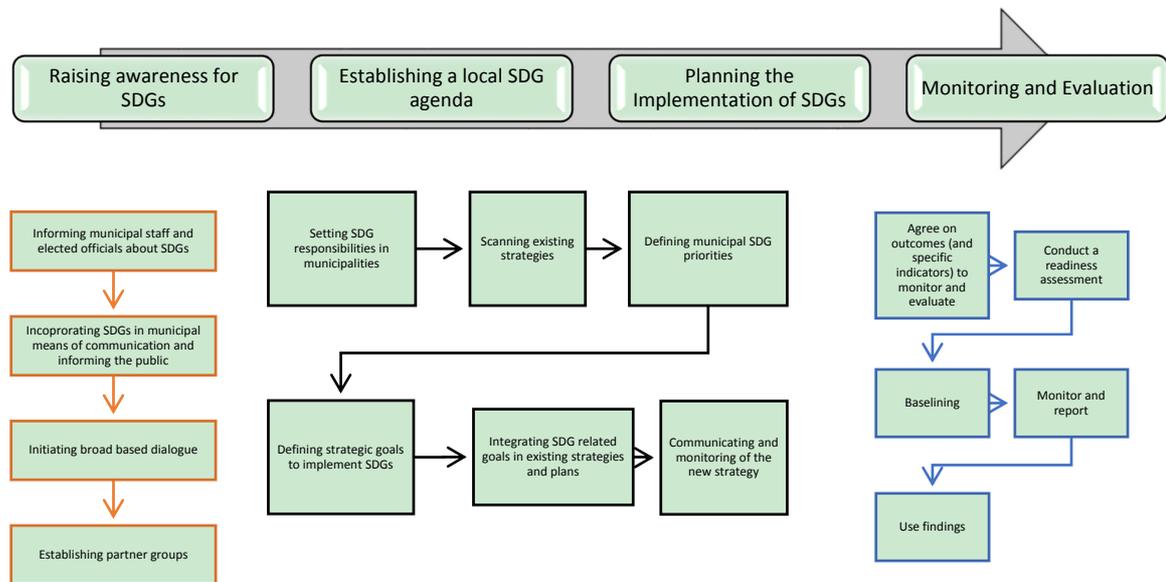


Figure 2. Framework Guiding Evaluation of SDG Localisation

Source: Top part adapted from UN; M&E component, Own

Awareness raising forms the cornerstone for localisation of SDGs. Building awareness focuses on the broad array of stakeholders, interest groups and the affected groups. As highlighted in the bottom part of Figure 2, dialoguing amongst the stakeholders is critical and should, if effectively facilitated, culminate in establishment of partnerships for the purposes of localisation of SDGs. Agenda setting heralds the start of tangible work by the various partners towards identifying key development priorities against the backdrop of the global development agenda, as enunciated by the SDGs. Role clarification is therefore a pre-requisite. The conceptual framework accentuates the need to undertake thorough planning, and to avoid a cosmetic process of simply reworking development instruments to reflect the language associated with SDGs. The planning is akin to but not necessarily the same as the technical process associated with the corporate strategic planning phase of PESTLE analysis which is conventional strategic planning, i.e. political, economic, social, technological, legal and environmental domains. A key difference is the need for community engagement to enable it to go forward with broad acceptance. SDG planning in cities provides the foundation for identification and prioritisation of a municipality’s SDG priorities, and formulation of strategic goals and targets along with a process to deliver the plan for the local context.

The backbone of the framework emphasises the need to align the process outcomes to the key themes addressed

by SDG 11:

- Planning and managing for sustainability, that is ensuring mutually conducive and beneficial interface between social, economic and environmental subsystem
- Appropriately planned and managed human settlements
- Access to affordable housing
- Infrastructure investments
- Sustainable transportation
- Access to services
- Culture, natural heritage, and public places
- Sustainable buildings
- Disaster prevention, risk reduction and disaster recovery
- Inclusivity (that is age, gender, and disability) and community resilience

Once the canvas of strategic goals and targets is knit together, a process of ensuring alignment and integration of SDGs into governance and development management instruments follows. Communication is key and should permeate the entire process, that is from awareness building to operationalisation of governance and development management instruments which encapsulate the localised (global) development agenda. Communication with the community and all stakeholders will be critical.

The framework utilises and emphasizes the need for results-based leadership and management. Instead of the conventional monitoring and evaluation approach, which is oriented towards technical reporting, a developmental approach, that is Results-based Monitoring, Evaluation, Accounting and Learning (MEAL) approach – is followed as envisaged by Macclune, McGinn, Asif, and Venkateswaran (2017). Baselineing, that is establishing the conditions prior to operationalisation of localised SDGs, is critical. It provides the departure point for measurement of progress or lack of, throughout the processes of implementation of the localised SDGs' frameworks. The benefits of the MEAL approach in the implementation of localised SDGs is that it:

- Informs resource allocation decisions
- Provides informed perspective in problem diagnosis, including identification of emerging challenges and externalities
- Informs decision making on competing alternatives and thus identification of the best alternatives
- Encourages and supports innovative thinking and actions, and
- Fosters consensus on the causes of problems, desired outcomes, and solutions to the same

The advantage of the MEAL approach is its ability to continuously provide the information on progress in the operationalisation of SDGs at any given time. The main focus is on outcomes that will demonstrate whether success has been achieved. This is undertaken with a dual intent, to learn and to improve. This enables continuous improvement which will be critical to any city, especially one trying to be a leader in a complex and difficult development environment.

With this framework, the paper will now examine how it has been applied to Bulawayo.

## **5. Results: How does the SDG Localisation Framework Apply to Bulawayo?**

This paper seeks to find how the SDG Localisation Framework can help provide an SDG-based future for the City of Bulawayo as shown in Figure 2. Most importantly it seeks to provide answers to the 4 key questions embedded in the framework, namely:

- 1) What is the extent of awareness for SDGs within the City?
- 2) Is there an established SDGs agenda in the City of Bulawayo?
- 3) What measures and steps have been taken, if any, to operationalise the SDG 11 by Bulawayo City Council?
- 4) Is there a system for the monitoring and evaluation of the operationalisation of SDGs in the City, and if so, what is its efficacy?

### *5.1 Staff Awareness*

City Council's planning staff have been exposed to and on a number of occasions had opportunity to engage on

the subject of sustainable development, more so within the current SDG context. To ensure that awareness and appreciation for SDGs permeates to the city at large, the following has been undertaken:

- A workshop on SDG was conducted for the Councillors and the civic community (Oosterom, 2019);
- Female councillors have received training on SDGs in order to capacitate them as women in leadership roles;
- Gender equity and social inclusion awareness campaigns on gender based violence, Sexual and Reproductive Health Rights (SRHR ) and service delivery campaigns; and
- Gender Mainstreaming initiatives by organisations such as Gender Links, ZWR CN, WILD and Women Coalition of Zimbabwe and CSO WASH incorporate SDGs.

One of the expected main outcomes of the workshop was that the Councillors would further engage their different constituencies on the subject, that is SDGs, and their implications for the city's current and future development. Thus the SDG planning process has been linked into the service delivery process heightening awareness across the municipality. It would appear therefore that there is a high level of awareness of the SDGs within Bulawayo City Council.

### 5.2 SDG Agenda

It is evident that the City of Bulawayo has made SDGs central to its developmental agenda. The City of Bulawayo is not only driving the SDG agenda through its service delivery programmes but has established how the SDGs relate to all the main legislative tools guiding development in the city. Table 2 summarises the key instruments informing the City of Bulawayo's Master Plan 2019-2034. The City of Bulawayo's Master Plan – its key strategy document - has thus been developed to embrace and promote the SDGs' agenda as evidenced in **Table 2**. The Report of Study that will inform the production of the Master Plan's written statement explicitly states that the City's new Master Plan is being aligned to the SDGs. As a result, during the preparation of the written statement due cognisance will be given to the SDGs. The SDG agenda appears therefore to be incorporated into the localised planning of future development in the city (City of Bulawayo, 2020a, 2020b).

Table 2. Development, policy and legislative frameworks guiding the development of the City of Bulawayo Master Plan 2019 – 2034

Urban Councils Act (Chapter 29:15) National Housing Policy 2012 Sustainable Development Goals Regional Town and Country Planning Act, Chapter 29:12 of 1976 (Revised 1996) Urban Councils Act, 1995, No. 24 of 1995 Environmental Management Act, Chapter 20:27 of 2002 Environmental Impact Assessment and Ecosystems Protection Act, No I 7 of 2007 Environment Management Act (Environmental Impact Assessment & AMP; Ecosystems Protection) Regulations, Chapter 20:27 of 2007 Regional Town and Country Planning Act, Statutory Instrument 216 (Use Group Regulations) of 1994 Mines and Minerals Act, Chapter 21:05 of 1961 Zimbabwe Interim Poverty Reduction Strategy Paper (I-PRSP) 2016-2018 Forest Act, Chapter 19:05 of 1949 Education Act, Chapter 25:04 of 1987
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Source: City of Bulawayo (2020b, p. 11)

### 5.3 Steps to Operationalise

Below is a summary of some of the strategic priorities and processes reflected in the draft Master Plan, Corporate Strategy and other policy documents showing how steps are being taken to deliver the SDG's outlined in these plans. These are very early days as the municipality begins to set up programs across its service delivery and

planning system. Bulawayo used to be the industrial hub of Zimbabwe but since the 1980s it has experienced some massive de-industrialisation. Like the rest of the country, the informal sector has become the backbone of the economy. Efforts at providing an enabling environment for informal sector operations have been done through the establishment of industrial incubators, designation of sites for informal sector operators to operate from as elaborated by the City of Bulawayo (2020b, p. 59). These efforts are meant to ensure that people can make a living by indirectly addressing Goal 1 (City of Bulawayo, 2000). With respect to SDG 2, the City has developed an Urban Agricultural Policy to promote and guide urban agriculture and contribute to food security (City of Bulawayo, 2010), (City of Bulawayo, 2020b, pp. 60-62).

The City has for the past two decades allocated sites for garden allotments to assist the elderly and destitute. Health issues are also at the centre of the City's strategic priorities in line with SDG 3. As demonstrated by the City of Bulawayo (2020b, p. 175) the provision of health facilities in all the neighbourhoods is meant to improve the health and wellbeing of the community. In addition, the City of Bulawayo (2020a, p. 24) shows there have been an increase in private hospitals and surgeries, approved by the Bulawayo City Council in the residential areas in line with its corporate strategy of promoting the private sector to lead in the building of public infrastructure. Outreach services are being provided to supplement inadequate health service delivery in areas such as St Peters, Aisleby Farm, Emganwini, Nketa and Cowdray Park on a monthly basis. According to the City of Bulawayo (2020b, pp. 171-191) all these are being undertaken as part of the core function of the Municipality of providing primary health care.

The undertakings by the City of Bulawayo (2020b, p. 40) do indicate that the Municipality has paid a lot of attention to issues of preserving and protecting the natural environment and climate change, as per the provisions of SDG 13 and 15. The City is working closely with the Environmental Management Agency (EMA). Major projects (housing, commercial and industrial developments) in the city are being undertaken subject to the preparation of a prospectus and detailed EIA report. In addition, environmental audits are being undertaken as indicated by the City of Bulawayo (2020b, p. 282). For example the dumpsite in the city was developed in 1994 without the benefit of an EIA. In an effort to ensure that good environmental management practices are in place, monitoring boreholes have been sunk and leachate from the ponds is being collected to ensure that there is little/no pollution (City of Bulawayo, 2020b, p. 199).

Education is crucial in the drive towards a sustainable city, as per SDG 4. The provision of primary educational facilities constitutes a major function of the city. In the new residential neighbourhoods the city provides primary educational facilities as revealed by the City of Bulawayo (2020b, p. 141). According to the City of Bulawayo (2020b, pp. 131-140) additional Early Childhood Development facilities have been established to improve education outcomes. Furthermore, the city has made provision of land for private school development which has assisted in the provision of additional educational facilities (City of Bulawayo, 2020b, p. 151). Partnerships with the private sector to supplement the council's effort to provide public services forms part of the city's future corporate strategy focus as documented by the City of Bulawayo (2020a, p. 16 & 20).

Gender-sensitive development is also within the purview of the Municipality, as per SDG 5, hence the formulation of a gender policy. One of the main intervention speaking to SDG 5 is the 365 days of activism against Gender Based Violence (GBV) which is led by the Gender Desk within the Municipality (City of Bulawayo, 2017). A critical issue linked to gender has been the historic challenge of resolving the water shortage. The Municipality has taken on-board SDG 6 to plan for clean water and sanitation in a sustainable manner. Major rehabilitations works of the water works for the city from the dams have been undertaken as explained by the City of Bulawayo (2020b, p. 256). In addition, the Bulawayo Water and Sewerage Services improvement project (BWSSIP) is underway.

These cited examples above are part of initiatives meant to contribute towards the attainment of SDGs. This includes the streamlining of the City's planning and budgeting processes to align to and give prominence to each of the 17 SDGs. It is clear that the City is premising its work on sustainable service delivery and resource management. This is clear considering that departmental plans now encapsulate the SDGs as revealed by the City of Bulawayo (2020b, p. 11). All departmental plans must demonstrate alignment to and how they contribute to specific SDGs. This includes localisation of strategic objectives and targets, within the framework of the SDGs.

The city is involved in various public relation activities in an effort to enhance the relationship between the Local Authority and the community. It is hoped that the City will leverage on its twinning relations with Aberdeen (United Kingdom) and Durban – Ethekewini (South Africa) to learn and exchange its experiences and thus improve on its efforts towards urban sustainability. Sustainable development is at the heart of the City's development efforts.

#### 5.4 Monitoring and Evaluation (M&E)

The SDG's form part of reporting across different forums of accountability and at different intervals in the municipality. However, the City's M&E system identifies funding of development programmes and projects as a major challenge. However, the City identifies research and investing in innovative ways of doing things as key enablers towards meaningful work towards SDGs. In this regard, the City has moved to enhance its operations through eGovernance.

### 6. Conclusion

Notwithstanding the exponential growth of literature on SDGs, there is little focus on the readiness of and progress by local government in the localisation of SDGs. The paper has used a systematic literature review of research on municipalities in relation to implementation of SDGs. A multi-criteria framework for planning and managing towards the achievement of SDGs has been developed using a four-step process: raising awareness of SDGs; establishing a local SDG agenda; planning implementation of the SDG agenda; and, monitoring and evaluation.

The SDGs are a call to end poverty, protect the planet and ensure that people enjoy peace and prosperity by 2030. The City's mandate is to ensure good governance, provide services as well as social and physical infrastructure. It is important to see that the collapse of Bulawayo's public transport and water distribution systems, once the envy of and benchmark for many local authorities in the country, provides a poignant reminder that past glory is meaningless in addressing present challenges. There is therefore a need for continued awareness building and capacity building of planning staff, elected officials and interest groups within the City. In this regard, there is need for forums involving Council management and Councillors to discuss SDGs – what the city is doing or can do towards the attainment of these universally agreed goals. People could be having knowledge from other forums – funds could be sourced from UNDP – the lead UN development agency for awareness workshops to council management, councillors and the community. There is a need to invest a lot of effort in building community level awareness and involvement in the work towards SDGs. This could be facilitated through grassroots workshops and meetings at the ward level.

Infrastructure projects can be developed in partnership with private sector financing to enable major leap-frogging in technology to happen.

The massive increase in death rates from 2000 to 2010 due to the HIV pandemic, political chaos and economic disintegration of that period has made the work on SDGs very difficult for the City of Bulawayo. To come out of that period of economic and social collapse there was little to help cities like Bulawayo to grasp the opportunity for an SDG-based development focus. Nevertheless the city has rapidly advanced through the localised planning process and are beginning to show they can begin to deliver the SDGs.

Through the application of the evaluation framework, the article has indeed shown that Bulawayo explicitly demonstrates the pathway to sustainable development. However, the city will need to avoid continuing the pre-occupation with issues from the previous era - corruption, nepotism and even trivia (e.g. changing street names) - to the detriment of addressing real development issues. Help is needed to update the planning system and to create an innovative management culture that can ensure SDG outcomes and potentials for using leap-frog technology are the priority.

There is ample room to apply the evaluation framework (developed for this case study) to other cities in the developing world.

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**To whom it may concern**

I, Vinnnet Ndlovu, contribute **80%** of the paper/publication entitled

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# Leapfrog Technology and How It Applies to Trackless Tram

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## Abstract

Rapid innovation and development of modern technology has brought about the opportunity for developing economies to technologically leapfrog. The smart phone is the most recent example. This paper assesses literature to show what technological leapfrogging is and the key criteria used to enable it to occur in developing countries. These include being “economical enough”, “less technical”, “lends itself to partnership”, “lends itself to community engagement”, “enables co-development” and “fulfills the sustainable development goals”. The paper then examines the new mid-tier transit technology called Trackless Trams and applies the six criteria to it. The paper suggests that there are five good fits with the criteria and the sixth, the “less technical”, can be accommodated in most developing cities through distributed solar energy systems and also smart technology systems through mobile phone-based communication infrastructure. The case for Trackless Trams to be part of the future in developing cities is therefore strong.

## Keywords

Technological Leapfrogging, Trackless Trams, Socio-Technological Regime

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## 1. Introduction

The surging urban explosion in emerging economies has overwhelmed their public infrastructure, which is already lagging in many aspects [1]. Addressing the problem would require concerted efforts from both the government and the private sector [2]. However, to skip the learning curve of the developed countries, there is an opportunity for emerging economies to explore the concept of technological leapfrogging by adopting emerging technologies [3]. This concept appears to be validated by the accomplishments that have been made in the telecommunication sector [4]. Telecommunication infrastructure is one of the critical

networks necessary for promoting economic growth in developing nations. A cost-efficient and effective transport network is equally vital and necessary when it comes to promoting the desired economic development of these countries [5].

This study will explore the use of Trackless Tram Systems (TTS) as a potential leap-frog technology in rapidly growing cities of the global south. Given that most emerging economies, especially in Africa, are still in the process of exploring their options when it comes to building their various infrastructure networks, they are likely to benefit from technological leapfrogging [6]. The study addresses the questions:

- How can leapfrog technology be defined?
- What are the key requirements for enabling leapfrog technology?
- What is a Trackless Tram System?
- How does TTS apply to leapfrog technology requirements?

## 2. How Can Leapfrog Technology be Defined?

Technology leapfrogging is a relatively new area of study [7] though Schumacher (1974) tried to show in his concept of “intermediate technology” that the gigantism and high capital expense of much technology from the industrial west could be scaled down to fit emerging economies. It is possible that newer technologies in renewable energy and smart systems are already much more modular and easier to scale into affordable and appropriate forms for developing economies [8]. Nevertheless, technology leapfrogging will still need to fit into the development process seen today as necessary to achieve the kind of “inclusive, safe, resilient and sustainable cities” suggested through the United Nations’ New Urban Agenda and SDGs.

According to Steinmueller [9], technological leapfrogging can be described as “bypassing stages in capability building or investment through which countries were previously required to pass during the process of economic development”. The leapfrogging concept can take different forms, phases or stages [3]. Kimble and Wang [10] for instance, identified leapfrogging phases that can contribute to industrial growth when looking at transistors and electric vehicles. They identified three paths: the standard path, catching-up, and technological leapfrogging. The standard path is the usual pathways of technological development that were followed in the past. It is not considered as an “actual” leapfrogging path but the typical expected path of growth [11]. While the catching-up type is a fast-tracked leap that leads to economic and technical development through technological transfer interventions [9]. In this case, an “actual” leapfrogging does not occur. Instead, there is a technology transfer that necessitates the need to follow all stages of development but at an accelerated rate [12]. However, the actual technological leapfrogging assumes that bypassing certain stages of development is necessary if its benefits are to be felt rapidly [11].

Kimble and Wang [10] also identify three forms of technology leapfrog. They include stages of “skipping leapfrog”, “path creating leapfrog”, and “paradigm-changing leapfrog”. Within the stage of “skipping leapfrog”, one or more

stages in the growth of the technology are omitted as demonstrated on **Figure 1** that illustrates stages A, B and D with a skip of stage C.

“Path creating leapfrog”, on the contrary, involves creating an alternate route for one or more stages instead of skipping a phase while adopting the technology [13]. Such a scenario is commonly seen in sectors where technological progress or improvements are continuously shifting, for instance, in the ICT software industry [10]. In contrast, paradigm-changing leapfrog occurs when the skipping uses new advanced expertise not available in the present socio-technological regime [10].

Based on the needs of the emerging economies, the paradigm-changing leapfrog stage appears to be the best form of leapfrogging that developing countries can attain, especially if it enables a new way of bringing in finance for development. However, the accomplishment of this phase does not automatically imply the redevelopment of the know-how itself. Instead, it could involve the implementation and use of expertise in a way that enables other matching technological capabilities. This happens through the ability to have smooth downstream integration capacities especially through communication systems [14] [15]. James [4] explains how the leap from fixed-line to mobile phone occurred and suggests ratio-focused approach that uses the idea and the effect of leapfrogging using mobile phones in developing economies.

Africa is recognized as the most prominent case of how the adoption of mobile phones eliminated the need to create resource-intensive fixed-line phone substructures [16]. However, a thorough assessment of the infiltration of the mobile phone in Africa showed that the region still lags [3]. Nonetheless, a comparative study of the proportion of mobile phones to fixed-line set-ups demonstrated that Africa was able to leapfrog by adopting mobile phones as their means of communication [16]. Another notable example of technological leapfrogging is when Papua New Guinea transitioned from traditional landline telecommunications systems to satellite-based communications in one leap [17]. Azerbaijan, a developing country in Asia, is also known to have reached a higher level of ICT connectivity in a short space of time [18]. In a bid to explain the transition taken by Azerbaijan to technologically leapfrog through its ICT system, Tan, Ng and Jiang [7] came up with the “Four Ps Framework Model”. The model helps to explain the phases executed by the Azerbaijan government to pass its industrial leapfrogging within its ICT sector fruitfully. Below is the “Four Ps Framework Model” of technological leapfrogging developed by Tan, Ng and Jiang [7]:

- Stage 1: Psyching;
- Stage 2: Planting;
- Stage 3: Propelling;
- Stage 4: Perpetuating.



**Figure 1.** Stage skipping leapfrog [10].

According to Tan, Ng and Jiang [7] stage 1 involved mostly building publicity around the project and designing the plan. While in stage 2, the project stakeholders established the resources that need to be used to make the project a success. This stage entailed understanding the existing capabilities. During the process, decisions on whether to procure new resources or adopt the “bricolage” strategy were made [18]. Bricolage can be less expensive and usually the only alternative for countries that have few resources. According to Tan, Ng and Jiang [7], the real ICT Development was implemented during stage 3. In other words, stage 3 mainly entailed launching the project through the development of the ICT infrastructure. Finally, during the perpetuating stage, there was an emphasis on maintaining the path of ICT development [18]. For Azerbaijan’s ICT development project, the buy-in attitude and commitment to supporting the plan were influenced by the sharing of the quick wins and benefits among the stakeholders. Also, it is essential to understand that technological leapfrogging in Azerbaijan, mainly the ICT Development project was directed by sound and policy-driven tactics, which were endorsed by the ruling government [18]. As such, it was handled as a national scheme and supported by several governmental departments and the vision was well articulated and made public for all stakeholders to understand [18].

### **3. What are the Key Requirements for Enabling Leapfrog Technology?**

Six requirements or criteria have been garnered from the literature on leapfrogging.

#### **3.1. Cost Effective: “Being Economical Enough”**

To get leapfrogging projects off the ground, capital investment is required. However, it is evident that inadequate financial resources, more so in developing countries, is a problem that could hinder any plan despite how ambitious it is [19]. Furthermore, even though aid could help in eliminating the challenge, there is a consensus that relying on aid agencies too much could be risky. According to the secretary general of the International Telecommunication Union (ITU), aid agencies can only be helpful if they act as intermediaries that bring together private sector players, network operators, and governments (ITU). The private sector can provide the needed capital for such projects [20]. This is not usually the case with transport projects that are more often than not left to governments to find the financial capital. Hence any technological leapfrog that can attract private capital to help with the upfront costs will be an important help.

#### **3.2. Capability and Capacity: “Being Less Technical”**

Leapfrogging is an appealing concept for developing countries. However, studies reveal that one of the main hindrances to implementing the concept is the lack of capability to produce such technologies in these emerging economies [21]. The developed countries contribute to the development of most of these technol-

ogies [3]. The challenge is that developing countries have to procure these technologies from advanced nations through arrangements that may prohibit them from developing the ability to produce the technology and hence may have issues with its management [22]. The leapfrog concept is thus best sustained if a country possesses the expertise to help manufacture and be able to manage the related technology [21]. Gallagher [23] alludes that “there is a danger that selecting technology on or very near the frontier” can be damaging. This is reiterated by Dahlman, Ross-Larson [24] by saying “In order to leapfrog, you have to be a frog, not a tadpole”. However, if a technology can build on other capacities which can be enabled through some training as it is “less technical”, then that would be the kind of characteristic that lends itself to technological leapfrogging.

### **3.3. Public Private Partnerships: “Lends Itself to Partnership”**

In other words, leapfrogging technology is not just a motivating conceptual occurrence, as it only works if it is executed as part of a more critical strategy, which is designed and reinforced by various policymakers [15]. To increase the chances of getting adopted, the technology should be viable enough to encourage partnerships and attract private investors who seek a stable return on their investment. The public-private partnership concept increases the likelihood of getting projects implemented quicker and efficiently [25].

### **3.4. Transparency: “Lends Itself to Community Engagement”**

Lack of stakeholder engagement is also considered a challenge to leapfrogging technology. In most cases, the success of specific leapfrogging projects has been attributed to the ability to have all stakeholders on board [3]. For instance, the importance of including the stakeholders at the start of the initiative is also evidently demonstrated in the Azerbaijan ICT Development technological leapfrog project. The initiative had a vibrant vision and implementation plan. According to Tan, Ng [7], it was a continuous event that needed resources, including numerous stakeholders’ input, to sustain its momentum.

### **3.5. Broad Economic Development: “Enables Co-Development”**

Co-development is where social and cultural considerations are built into the economic development process. Cargo cult mindset is another leapfrogging challenge that needs to be addressed. Cargo cult mentality is the belief that the gains observed from the utilization of a know-how or technology by developed countries will be realized by simply adopting the same know-how or technology in a given different context or domain. It is vital to look at the context as it might not be the same with where the technology was used successfully. In some cases, the social context of technology has been under-emphasized, despite being crucial in making the adoption successful. In most cases, it is the social setting that determines the recognition and successful implementation of the technology. As such, it highlights the importance of planning and policies in increasing the like-

likelihood of success. Azerbaijan and its ICT Development project stand out as an ideal example in this case. Planning and conducting an assessment of a fitting technology by taking into account the cultural and socio-economic settings and universal standard for interoperability is critical in avoiding costly errors and failure [17].

### 3.6. Wider Outcomes: “Fulfil Sustainable Development Goals”

Leapfrogging technology will not ultimately work in any society unless it is part of a set of wider outcomes [26]. These have been outlined by the UN and adopted by 193 countries as the SDGs [27]. Therefore, government policy that assesses leapfrog projects in terms of the SDG's, is essential for enhancing the ability to facilitate and support technological leapfrogging [21].

## 4. What is A Trackless Trams System (TTS)

According to Newman *et al.* [28] TTS can be categorized as a mid-tier transit system equivalent to a light rail. The main difference is that TTS run on rubber tyres and has batteries on the roof; this means no steel tracks and no overhead wires and hence it is likely to be much cheaper and quicker to implement. The TTS therefore appears to be a likely candidate to be a leapfrog technology. The paper will therefore move to examining this potential.

***Physical Attributes of Trackless Trams.*** Trackless trams use an electric drive system that is power-driven by battery technology [28]. Such an attribute eliminates the need to use overhead electrical cables and as its electric it can use renewable electricity rather than using non-renewable fuel [29]. Using rubber tyres instead of steel rails is also another feature of trackless trams technology that makes it have an advantage over light rail [28]. For instance, the rubber tyres eliminate the massive cost and the disruption associated with building steel rails through built-up cities and busy streets. Furthermore, trackless trams possess the same ability obtainable by high speed rail, which offers stabilization technologies through train-type bogeys with low set axles and hydraulic systems intended to avoid sways and bounce [28]. Lastly, trackless trams utilize up-to-date self-directed driverless technology using the ultra-modern optical guidance system that enables the tram to offer smoother trips and accurate docking at various locations, though the TTS always uses a driver to oversee its safety in mixed traffic [28].

Trackless trams can use dedicated passages to improve its performance through more rapid transit and better use of its self-directed driverless technology [30]. This can provide a high capacity service like a quality rail service. Having this capability gives TT an advantage when it comes to future city planning because it means they have the potential to be used for city redevelopment purposes. Fixed stations will be constructed within the dedicated corridors and can be a key way to enable partnership funding to be attracted to enable financing. A control center can be built that enables the service to be monitored and to suggest variations to the trams if there are problems that need to be avoided. This

can be done easily as the autonomous system can be overridden to enable the driver to operate the trams manually. This ability means that they could be driven around obstructions or obstacles in a scenario where it needs to pass through construction and accident sites. **Table 1** summarizes the main physical design of a three-car carriage trackless tram.

**Table 1.** Vehicle Specifications for a 3-Module Trackless Tram. Note: these are the characteristics of the CRRC Trackless Tram. Other TTS are being built in Europe.

Physical Attribute	Metric
Length	31.6 m
Wight	2.65 m
Weight (loaded)	51 tonnes (average 9 tonnes per axle)
Capacity	250 - 300 people
Max speed	70 km/hr
Gradient	13%
Turning Radius	15 m
Design Life	Over 30 years
Power supply	Rechargeable electric batteries
Operation	Automatic/manual
Car body construction	Space frame with bolted-on panels
Wheels driven	Rubber wheel
Bogies	Multi-axle steering system

Source: [28].

The other key features are outlined below emphasizing their potential to make TTS a leapfrog technology.

#### 4.1. Rubber Tyres

The most significant task associated with adopting a light rail system is the need to construct the steel rails in a way that generally means underground services in the road need to be moved [28]. This requirement is primarily considered a challenge because it is costly and disruptive to the environment, the local economy and the local community. On the contrary, a trackless tram runs on rubber wheels on the road, a feature that offers an opportunity to circumvent disruptive and capital-intensive construction works associated with building steel rail sub-structure required by the light rail trains [28].

This is one of the main reason cities in China and Europe are moving to a mid-tier transit system that does not disrupt their cities' economies. The potential is to deliver a TTS in a weekend (after some road preparations) instead of several years of building tracks in busy road systems. They can also be part of the city's activities in the road system instead of having to tunnel or to put the transit above the traffic-filled streets on gantries and overpasses which are all very

expensive and are not easy to integrate into land uses.

The rubber tyre systems are similar to buses in terms of their potential damage to roads and long-term tests may show more significant road-beds with greater concrete in them but tests so far are not indicating much damage.

#### 4.2. Self-Guiding

The latest guided routing technology utilized by trackless trams is also a feature that makes the technology better than most on-road buses and cars. In particular, the technology enables TT to pass along “virtual rails”, an ability that is also aided by up-to-date satellite navigation technology and the differential global positioning system (DGPS) [28]. At the same time, there is also a detection system that boosts the vehicle capability to distinguish road signs, and any intrusion that may be encountered. Finally, to aid the self-guidance ability, lines are marked on the road to offer optical control needed for virtual rails and enhance other road users’ visibility [28]. These technologies are rapidly being adopted in cities across the world however as will be explained below it is also possible to simply use mobile phone technology to enable the basic operations of the TTS along with a driver that can over-ride the system whenever needed.

#### 4.3. Electrification and Energy Storage

The vehicles utilize electric energy that is powered by lithium-ion phosphate batteries. The batteries used to power the TT can be recharged at a 10 kV platform-style overhead charging station during regular operation [28]. The 600 kW-Hr onboard batteries recharge faster compared to most cells. However, recharging can be done at the depot overnight. Battery technology is rapidly improving the range of vehicle distance so TT systems have moved from a range of approximately 15 to 25 km using a 10-minute charge and are considered likely to reach 50 to 60 km within a few years [28].

The highly projected move away from the consumption of fossil fuels makes the incorporation of Trackless Trams into road-based transit a suitable choice since it can utilize renewable energy and indeed this can be provided as roof-top solar panels at stations and depots. Storage can be supplemented for evening recharge by using batteries at stations and depots. The electrical drive system offers a smooth trip, which surpasses the ride-experience attained from fuel-based combustion engine automobiles and buses and is a major attraction for urban developers in building around stations.

Because of the potential to build a partnership-based TTS with private developers it is also possible to make a whole corridor of solar-based buildings integrated with electric transit as a demonstration of a new economy zero-carbon urban development. Such an option could be financed through Climate Funds. Depending on its location such a corridor could also include electric micromobility for last mile/first mile integration, especially with electric autorickshaws in developing cities.

#### 4.4. Cost Efficiency

The budget associated with building a light rail system is relatively higher in comparison to the investment in a TTS [31]. Specifically, a survey conducted by Bodhi Alliance and EDAB in 2017 reveals that constructing a Trackless Tram will be threefold cheaper as opposed to adopting a light rail system [31]. The significant differences in capital costs are associated with the fact that light rails are usually erected in high-density areas that have buried pipes and wires, which complicate the entire construction process [28]. As such, the cables and pipes have to be dug up and relocated, increasing the associated costs. Such complications and high costs were witnessed in the building of The Sydney Light rail. It is estimated that the system costed approximately 130 million US dollars per km, a figure that is tenfold more than the expenditure on a TTS [28].

#### 4.5. Interoperability

Trackless trams can be interconnected with heavy point mass rapid transportation stations considering their capacity to be utilized for the “first and last-mile service” [31]. For instance, trackless trams can be linked to central bus depots or inter-city rail stations [28]. In essence, the TTS is a mid-tier connector that can make a city function more effectively. It would mean that the trackless trams could transport passengers from central business districts (CBD) to the inner parts of the city as well as to major destinations in the suburbs, thereby decreasing the number of small vehicles or buses flooding congested central areas [31]. Similarly, the trackless trams can ferry passengers from the CBD to major rail stations or bus stations that take people out of the city.

Considering all the factors discussed above, it is seemingly apparent that this advanced technology has the ability and potential to offer the highest quality ride that one can experience from the light rail and bus rapid transit systems. The trackless trams can provide smooth rides and versatility, which is similar to what is experienced in light rail vehicles and buses, respectively. Furthermore, the cost associated with adopting the trackless trams is considerably lower, making it an attractive option.

### 5. How does TT Apply to Leapfrog Technology Requirements?

#### 5.1. Cost Effective: “Being Economical Enough”

As described above the TTS is perhaps a tenth of the cost of a light rail system. Because it can be part of a solar-electric system its operational costs are also significantly less than a bus system. The transition to an electric grid that is zero carbon requires a lot more systems that can balance the grid and the role of batteries in this is growing rapidly. Electric bus systems are increasing rapidly and finding that grid services can help pay for the costs of building such systems through using bus batteries at depots as part of grid services. This is an important consideration in using TTS as a first step in this transition. Climate funds are an obvious source for leapfrogging with a TTS.

## 5.2. Capability and Capacity: “Being Less Technical”

“Capability and capacity” implies that for leapfrogging to be accomplished, the technology must possess the following capabilities:

- *Develop an absorptive capacity to create or utilize the expertise:* concerning this requirement, Steinmueller [9] deliberates on the importance of the necessity to be capable of building the ability to come up with the same know-how in the local market and adopt the technology economically. Doing so will ensure that the technology can be easily domesticated to suit the needs of the locals. This can be done and the TTS can be fully built in any developing area. The TTS is also able to build on the technology and work practices of bus services thus using local know-how.
- *Ease of access and ability to make productive use of the technology:* such a prerequisite emphasizes the ability to obtain the technology as well as use it effectively to facilitate development [9]. The TTS is a promoter for desired economic growth and the restoration of cities’ corridors as further outlined below.
- *The technology should have corresponding technical abilities:* this requirement examines the complementary strength of the technology to enable it to work with matching but not necessarily the same know-how [5]. Trackless trams can lead other sectors to raise their standard. Introducing the TTS would mean that the roads must also be kept to a high standard. Mobile phone systems can be used to help manage the TTS and enable leapfrogging benefits to both the transit system and the mobile phone services. Ticketing systems and stations used by the trackless trams can also be utilized by buses and other vehicles as the technology has the ability to stimulate co-development projects such as battery recharging stations. TT stations could be made with amenities that can permit public recharging of other electric vehicles such as electric-tuktuks, scooters and bikes as well as motor vehicles. This can make the transition away from oil to be even more rapid with multiple advantages.
- *Realizing downstream incorporation capabilities:* this precondition highlights a vital need to create some degree of assimilation with other sectors downstream or upstream [9]. The technology being used in Trackless Trams has a higher likelihood of downstream connectivity through ITC systems like ticketing and observation of the services for management purposes. The technology can exchange and use data cohesively, an aspect that can enable it to be utilized as the primary and the last mile service for ticketing as well as for data management in the system.

TTS can thus offer a rapid transit service that is similar to that provided by the popular light rail systems being built in developed cities, and thus is offering a leapfrog technology that jumps from jitney style on-demand systems that cram into the streets of many developing cities unable to create a good bus service and where mass transit is way out of their financial and technical grasp. It leapfrogs into a mid-tier mass transit system.

### **5.3. Public Private Partnerships: “Lends Itself to Partnership”**

The partnerships needed for a TTS include: Land development with the private sector around station precincts to make the most out of the obvious TOD advantages that are created through increased land values; and Electric micromobility services such as e-tuktuks, e-scooters and e-bikes which can be provided by private operators of these systems and which can feed into each of the stations. Such partnership potential is inherent to the technology and should translate easily to any part of the developed or developing world.

### **5.4. Transparency: “Lends Itself to Community Engagement”**

Community engagement is likely to happen without much need for forced interventions as most communities are very involved in local transport issues. The key to a successful TTS that leapfrogs into a developing city, is that it must be inclusive of all people in the corridor including street businesses and small enterprises that are easily forgotten in such redevelopments. The need to conserve and create a range of housing options is also critical to the equity considerations of such transit systems.

### **5.5. Broad Economic Development: “Enables Co-Development”**

If strategically adopted, TTS have the potential to restructure the city and boost the revival of urban areas along identified passages in a co-development process with multiple economic development outcomes. The following benefits could be realized if trackless trams are implemented.

#### **5.5.1. Sprawl Relief**

High urban density levels are associated with many benefits, such as economic growth [32]. Strategic and practical adoption of trackless trams along transit corridors will increase urban density on those passages, consequently minimizing the impending urban sprawling [28] [33].

#### **5.5.2. Congestion Relief**

Traffic congestion is one of the leading urban problems experienced both in developing and developed countries [34]. Traffic congestion was estimated to cost the US roughly \$121 billion in 2012 [28]. The figure is equivalent to \$818 per commuter every year [28]. Moreover, according to Newman *et al.* [28], an additional 25 million tonnes of greenhouse gases are emitted annually due to urban development that is car dependent rather than transit-based. Strategic and practical adoption of trackless trams can considerably minimize the number of vehicles in a city, thereby reducing the emission of harmful gases.

#### **5.5.3. Reclaim Car Parking**

Most cities, more so those that are highly dependent on the automobile, have allocated vast portions of land to car parks. According to Newman *et al.* [28], urban areas that are dependent on vehicles around the globe usually allocate between 5 and 8 parking spaces for every single vehicle in the city. These pieces of

land can be redeveloped for productive and profitable use. There is no doubt that trackless trams can be a valuable addition to the reclaimed sites. Trackless trams can be integrated into the redevelopment programs to create value through Transit-Oriented Development schemes [28].

#### 5.5.4. Job Creation

Studies reveal that a high level of urban density is positively associated with an improved level of the knowledge-based economic activity, which is the fastest growing part of most economies [28]. Companies tend to agglomerate around denser parts of urban areas. For instance, studies have revealed that an increase in a country's level of density index was associated with the improvement of state-level productivity [28] [35]. A TTS can help enable these dense centers to work effectively without heavy traffic.

#### 5.5.5 Health Benefits

The most important health outcomes from a transport solution are associated with the level to which people walk less or more in their daily transport activity. Newman *et al.* [28] suggest that less car dependence can save as much in health costs as it costs to subsidize new suburbs with infrastructure. Furthermore, inhalation of vehicle fumes for long periods is associated with adverse health outcomes, especially from diesel fumes.

### 5.6. Wider Outcomes: “Fulfils Sustainable Development Goals”

As mentioned above, the technology associated with trackless trams will considerably reduce the emission of harmful gases with multiple health advantages [30]. Therefore, trackless trams should bring both social and environmental benefits. Adoption of trackless trams would lead to a decrease in cars on roads, thus minimizing the amount of CO<sub>2</sub> emissions [28]. Furthermore, as the urban density increases, the proportion of energy use per person lessens, resulting in a smaller amount of CO<sub>2</sub> emissions. Moreover, the adoption of trackless trams could potentially restore the corridors needing urban regeneration, consequently discouraging urban sprawl and saving agricultural land on the borders of the city [28].

As outlined above the TTS can attract development that creates jobs and hence enable social and economic development relevant to a number of the SDG's. The extent to which the city can create social advantages will depend on how well they do their community engagement and are inclusive of affordable social housing initiatives.

### 5.7. Conclusions to Leapfrog Assessment Based on Six Criteria

Trackless trams have the potential to aid emerging cities to technologically leapfrog while also contributing to the realization of SDGs and responding to the climate agenda. The low capital cost associated with trackless trams means that developing countries also have a chance to provide a modern infrastructure network that will increase their cities' ability to grow sustainably. As outlined by

Newman *et al.* [28], the technology is viable enough to encourage partnerships and attract private investors who seek a stable return on their investment.

**Table 2** below summarizes all the qualities and traits that make the TTS an ideal leapfrog technology.

**Table 2.** Summary of the TTS' leapfrog capabilities.

Leapfrog Technology Requirements	Application to Trackless Tram Systems	Comments
1. Economical enough	✓✓	Very cheap mass transit, not as cheap as separate buses or jitneys. See also 3.
2. Less Technical	✓	Requires some smart systems but only enough for mobile phone telephony
3. Lends itself to Partnership	✓✓✓	Ideal for working with developers who can help finance it through urban centres at stations.
4. Lends itself to Community Engagement	✓✓✓	Communities are very keen for better transit.
5. Enables Co-development	✓✓✓	Many overlaps with economic development as it creates agglomeration economies.
6. Fulfils Sustainable Development Goals	✓✓✓	Very strong on all SDG's due to equity, health and environmental improvements.

## 6. Conclusions

There is an expectation that a successful technological leapfrog will facilitate the adoption of a progressive socio-technical regime that will lead to socio-economic development. This paper has examined the techno-physical and socio-economic attributes of the trackless trams technology to see if this expectation can be realized. Based on the analysis of physical features that make a technology to be considered to have the abilities to enable leapfrogging, the paper concludes that the trackless tram system certainly meets those requirements. One of the main looked-for attributes of a technology needed to augment leapfrogging discussed in the paper is the ease of implementation and deployment. TTS can be easily deployed and integrated into other systems within society. Acquiring and utilizing TTS for commercial purposes is less challenging. A TTS can considerably minimize the current problem of having numerous cars and small buses or jitneys on the road. At the same time, a TTS has the interoperability and matching technological proficiencies and utilization to build on the know-how of most developing cities. They can be a major mid-tier connector across cities linked by first and last mile service through small buses and jitneys and connect to major centers like the CBD as well as bus or train stations.

The paper has also examined the social and economic benefits associated with trackless trams. Cities in developing countries are struggling to build the infrastructure needed for driving economic growth and development. From the discussion above, TTS can help to mitigate this challenge and improve and create social and economic benefits. The technology can also help minimize urban sprawl and increase urban density levels. Studies have revealed that there is a

correlation between population density index levels and the knowledge-based economy. For example, higher density index levels encourage the development of knowledge-economy jobs. At the same time, traffic congestion can significantly be reduced if TTS is effectively and strategically adopted. The paper has also deliberated on the possibility of financial gain should the vast parking land be reclaimed and be put into commercial use.

Leapfrogging technology has its challenges. Certain factors might make its implementation difficult. The paper has outlined some of the expected barriers to this idea. The impediments identified include lack of capability and capacity, government policy, cargo cult, and lack of stakeholder engagement and funding. The paper therefore concludes by suggesting that strategies and plans should be developed that support technological leapfrog initiatives. Azerbaijan is an ideal case of how government involvement is key to the success of such projects using ITC and the TTS in many ways could be seen as a similar kind of project as it will need to have a reasonable ITC system to support it.

Finally, a TTS will need to attract funding and financing and the paper has suggested that the TTS has considerable benefits in helping with this critical component of economic development. The TTS lends itself to a partnership with urban development along any proposed corridor. There is a need to promote a favorable environment that facilitates the adoption of such inventions to encourage investment from the private sector. The adoption of a TTS is mostly feasible if delivered using an entrepreneurial approach and includes the private sector and all stakeholders from the onset. Such partnerships are likely to create multiple benefits in co-design that can be realized once the trackless tram system is adopted. The paper suggests that the technology has most of the needed attributes to augment technological leapfrogging in transport.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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### **Publication 3: Co-Author Statements**

#### **To whom it may concern**

I, Vinnnet Ndlovu, contribute **80%** of the paper/publication entitled

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Vinnnet Ndlovu (**80% Contribution**)

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I, as co-author, endorse that this level of contribution by candidate indicated above is appropriate.

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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 be 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).

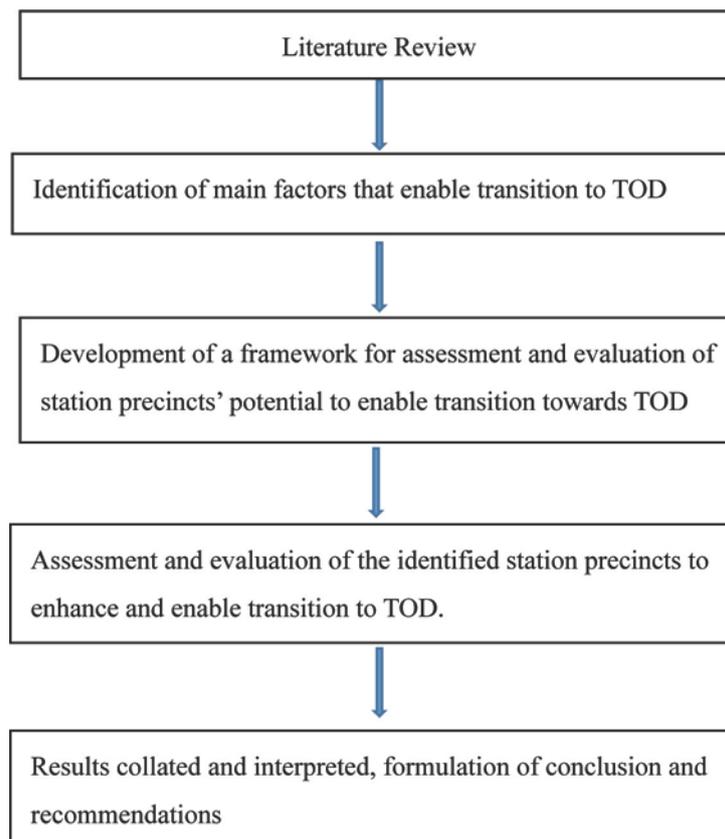
This study will assess and evaluate the suitability of the Transit Oriented Development approach for Bulawayo driven by the introduction of the trackless trams on its busiest corridors identified by the City of Bulawayo (2020). Guided by the knowledge acquired through literature this study will formulate 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.

Meidutė 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 minister 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 in Newman 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:

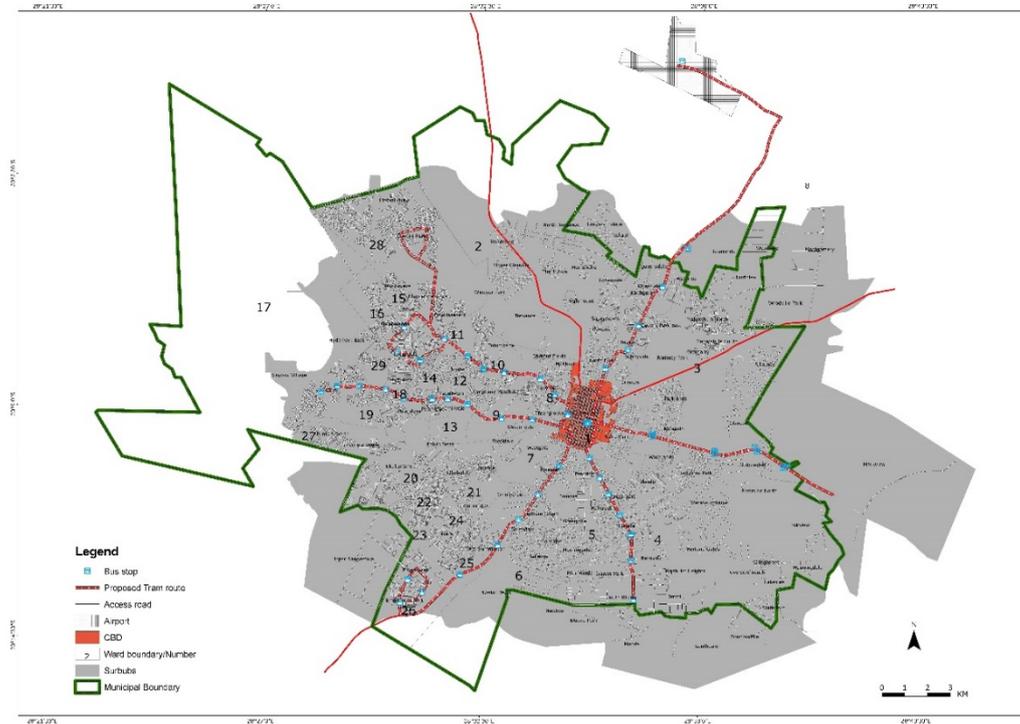
- 1) The TTS provides an alternative to Bus Rapid Transit and Light Rail as a major mid-tier form of transit that can help shape a city but is not expensive like a Metro.
- 2) The TTS is electric with batteries on the roof and has no need for steel tracks so it can be implemented over night instead over 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.



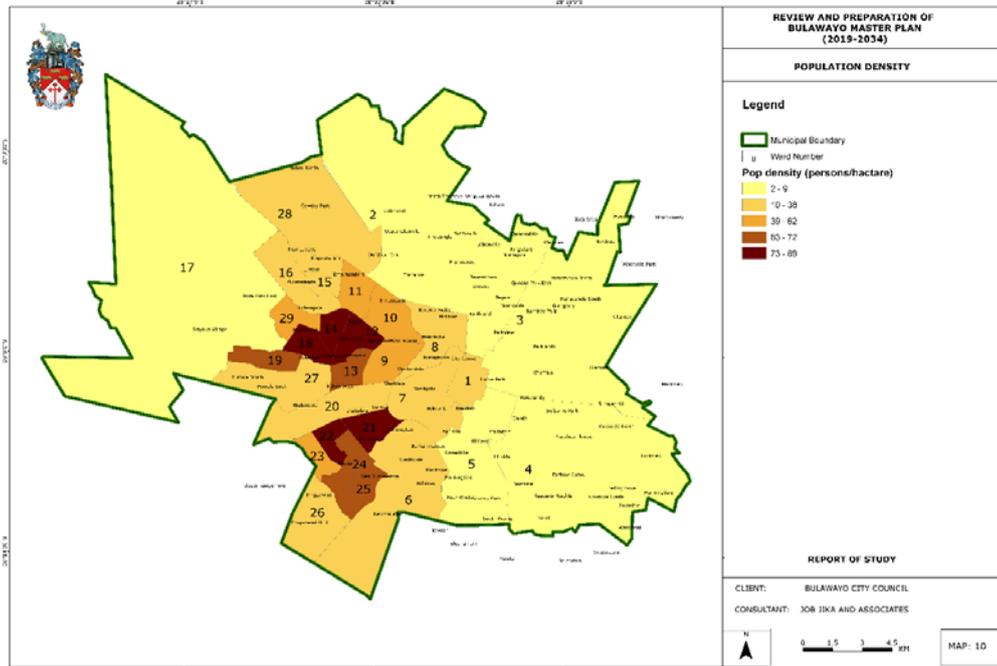
**Map 1. Bulawayo Proposed Tram Routes.**

### 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 ( $0.8 \times [0.58 \times 655675] = 304233$ ). 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 ( $0.94 \times 304233$ ). 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

ward	Population			Households	
	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		304446	351229	655675	167092	3,9
Total						

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**

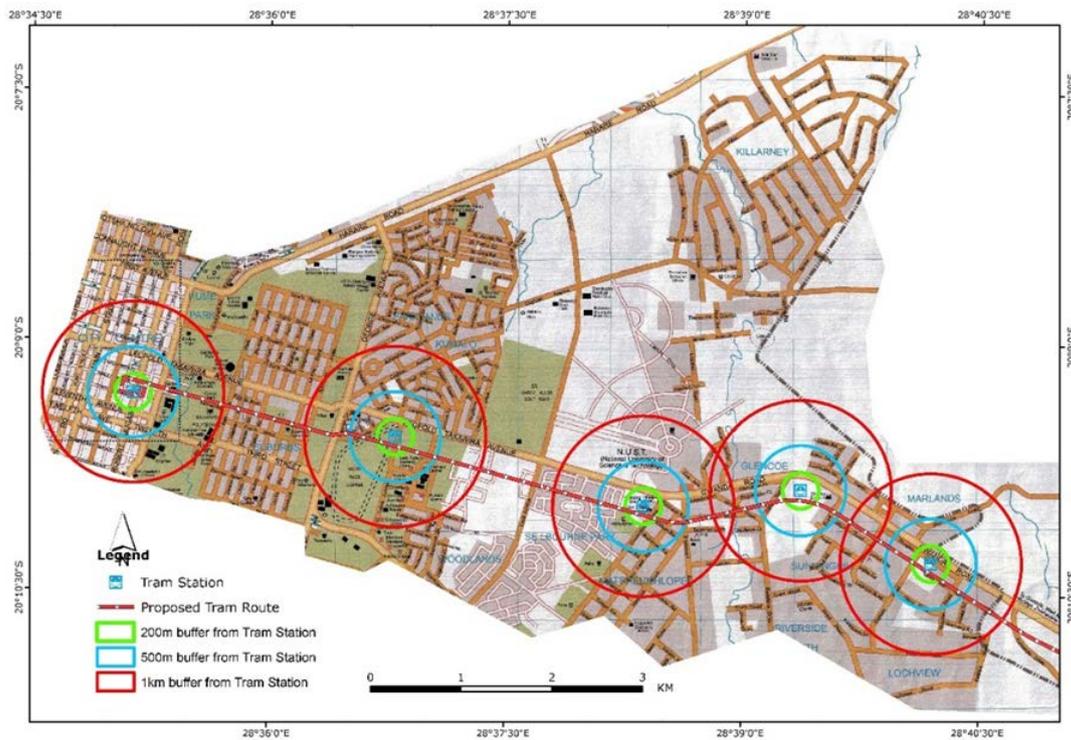
<b>Factors</b>	Station Precinct 1	Station Precinct 2	Station Precinct 3	Station Precinct 4	Station Precinct 5
1. Population Density > 10 000.					
2. Existence of a bus station or commercial centre, impending potential development					
3. Proximity and connectivity to other public transport services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

**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 be 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.

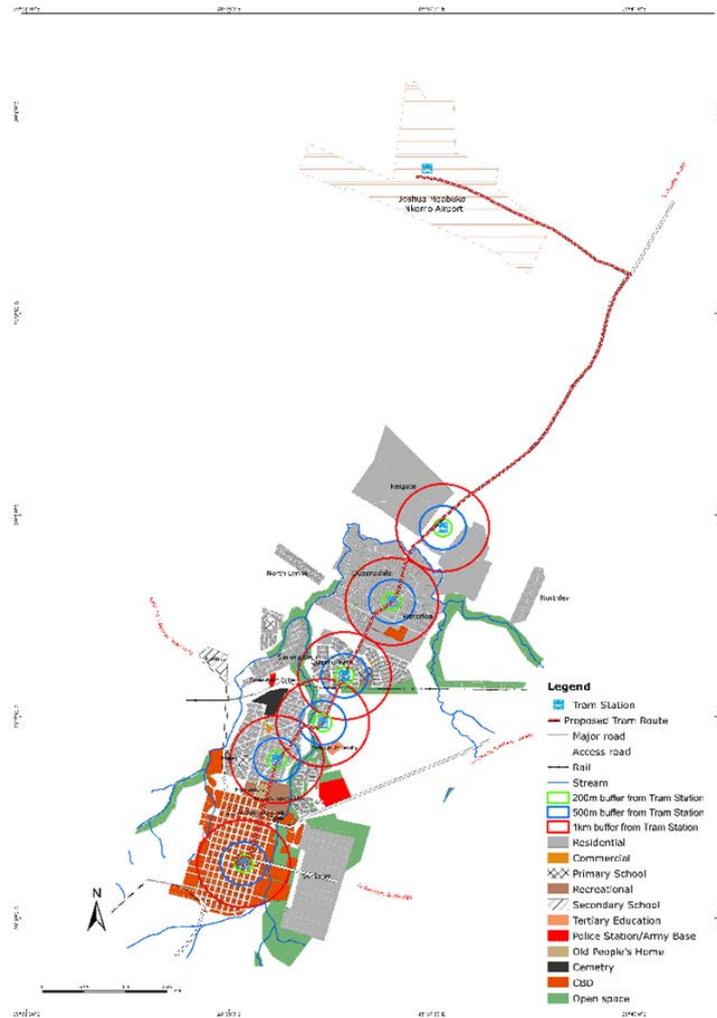
**Table 3. Route 1 TOD's Potential—Evaluation Results**

<b>Factors</b>	<b>Station Precinct 1</b>	<b>Station Precinct 2</b>	<b>Station Precinct 3</b>	<b>Station Precinct 4</b>	<b>Station Precinct 5</b>
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	✓✓✓	✓✓✓	✓✓✓		
<b>Average score out of 5</b>	✓✓	✓✓	✓✓	✓	✓

**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**

<b>Factors</b>	<b>1 Station Precinct</b>	<b>2 Station Precinct</b>	<b>3 Station Precinct</b>	<b>4 Station Precinct</b>	<b>5 Station Precinct</b>	<b>6 Station Precinct</b>
	✓✓	✓✓				✓✓
	✓✓	✓✓	✓✓✓	✓		✓✓
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	✓✓	✓✓	✓✓✓	✓		✓✓
	✓	✓	✓	✓	✓	✓
<b>Average score out of 5</b>	✓✓	✓✓				
	✓✓	✓✓	✓✓✓	✓		✓✓
	✓	✓	✓✓	✓	✓	✓✓

**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.

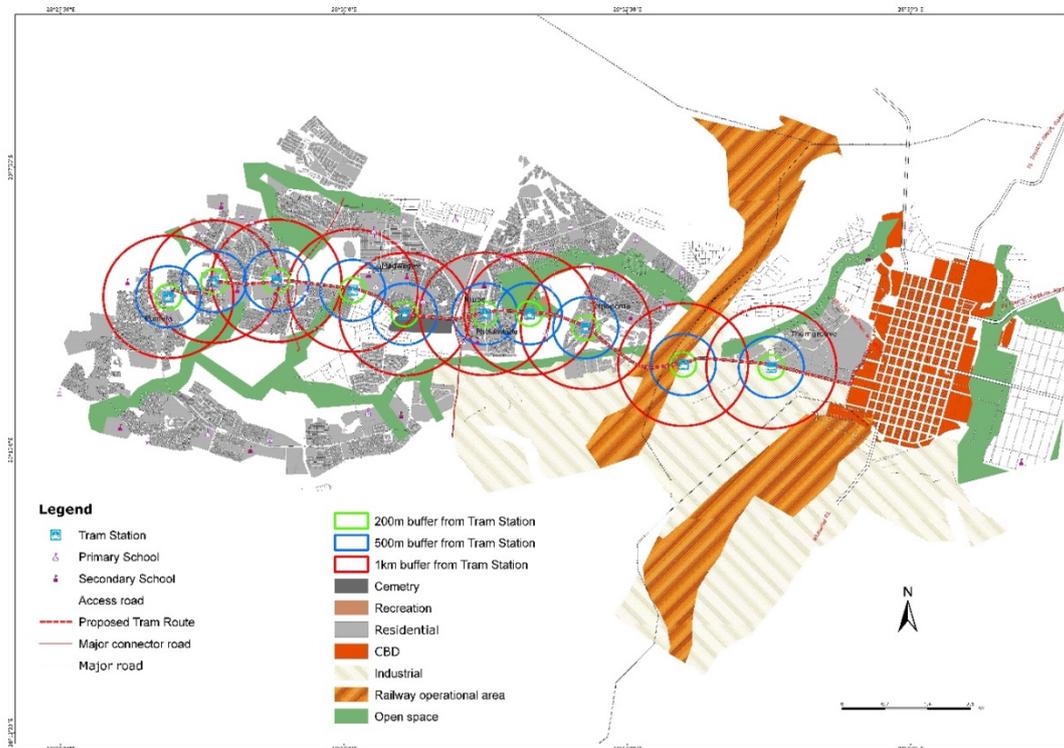
**Table 5. Route 3 TOD's Potential—Evaluation Results**

Factors	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	✓✓	✓✓	✓✓	✓✓	✓✓	✓		
	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
	✓	✓	✓	✓	✓	✓	✓	✓
<b>Average score out of 5</b>	✓✓	✓✓	✓✓	✓✓	✓✓	✓		
	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
	✓	✓	✓	✓	✓	✓	✓	✓

**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.

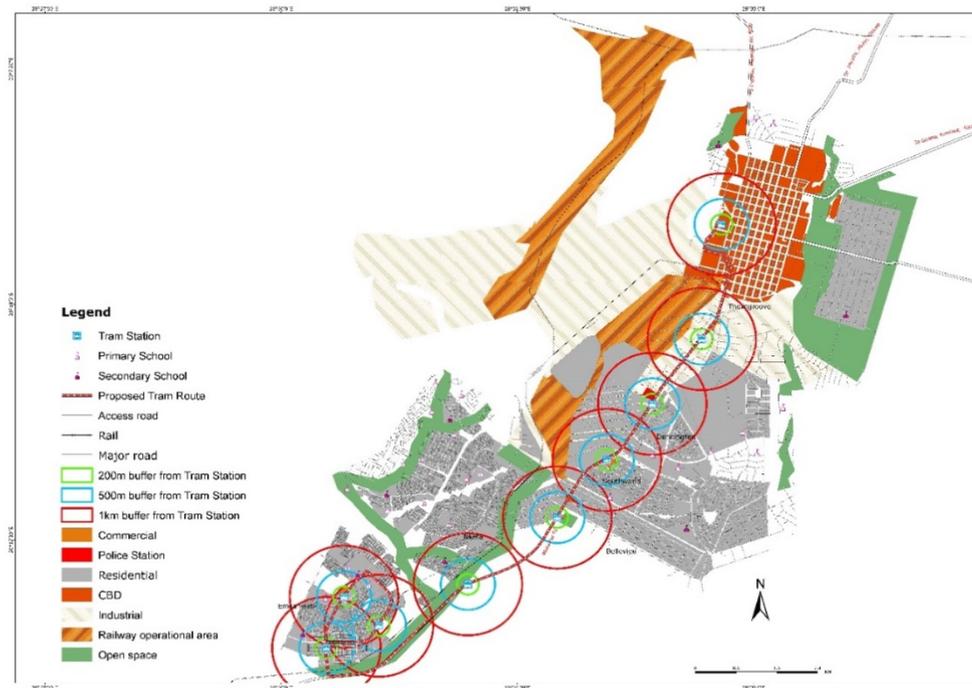
**Table 6. Route 4 TOD's potential—Evaluation Results**

Factors	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 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	✓	✓	✓✓	✓✓	✓✓	✓✓			✓	✓
<b>Average score out of 5</b>	✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓
	✓	✓	✓	✓	✓	✓✓	✓	✓	✓	✓

**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	2	3	4	5	6	7	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	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓
<b>Average score out of 5</b>	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓

**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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#### **Publication 4: Co-Author Statements**

##### **To whom it may concern**

I, Vinnet Ndlovu, contribute **80%** of the paper/publication entitled

Ndlovu, V., & Newman, P. (2020). A Public-Private Partnership procurement approach to sustainable transport - Zimbabwe case. *The World Bank Research Observer Journal*.

{submitted}

Vinnet Ndlovu (**80% Contribution**)

Signature of candidate:

Date 13.12.2020

I, as co-author, endorse that this level of contribution by candidate indicated above is appropriate.

Co-author Professor Peter Newman (**20% Contribution**)

Signature:

Date 13.12.2020

#### **Publication 4**

Ndlovu, V., & Newman, P. (2020). A Public-Private Partnership procurement approach to sustainable transport - Zimbabwe case. *The World Bank Research Observer Journal*.  
{submitted}

This is an exact copy of the submitted journal paper (manuscript) referred to above.

# A Public-Private Partnership procurement approach to sustainable transport - Zimbabwe case.

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# A Public-Private Partnership procurement approach to sustainable transport - Zimbabwe case.

## Abstract

Zimbabwe has serious financial constraints so the only viable option to procure infrastructure is through engaging the private sector in public-private partnerships to enhance the chances of successfully undertaking public projects like sustainable transport. This study creates the basis for a potential PPP with a trackless tram/solar energy project in Bulawayo which has multiple advantages for SDG's. It identifies six other projects in Zimbabwe that can provide some guidance for developing an appropriate PPP that could assist procure such infrastructure. The projects are drawn from the three critical sectors of the economy: power generation, highways/transport, and water/sanitation. Empirical investigations of these projects reveal the effectiveness of the PPP concept to deliver infrastructure for emerging economies. This suggests an ideal PPP arrangement that increases the likelihood of getting projects like the proposed sustainable transport project in Bulawayo implemented quickly and efficiently, especially if formulated to incorporate the project's local socio-economic dynamics.

**Keywords:** Public-Private Partnership, Public Infrastructure, Transit Oriented Development, Trackless Trams, Solar Energy, Sustainable Development Goals, Internal Rate of Return.

# 1 Introduction

Most low to middle income countries in Africa are finding it increasingly difficult to fund the construction and maintenance of critical public infrastructure for the development of their economies, even though these countries are much endowed with high value natural resources that have potential to catapult them into high-income economies. What is needed is the ability to develop infrastructure that will facilitate and drive the necessary economic development and growth (Bhoroma, 2020). The prevalent vicious cycle of poverty is partly because of the lack of capital to develop these public projects that are necessary to unlock economic potential. New approaches need to be explored so that the governments of these countries can fund such infrastructure-based developments, especially in their major cities, and contribute to global and local sustainable development (Newman et al., 2017).

Transport and energy are two fundamental infrastructure systems in any city. There are new technological opportunities that can enable cities in the developing world to leapfrog into a better future by combining these: a new electric transit technology labelled trackless tram systems (TTS) and the new low cost roof-top solar power or photovoltaics (PV) that can be integrated into the TTS (Ndlovu & Newman, 2020). This paper will show how a PPP procurement system can be created to enable such a TTS-PV infrastructure Model to be built in a city like Bulawayo in Zimbabwe.. The idea has already received considerable interest in the city based on this research (Kazunga, 2019, May 09) and private sector interest in providing investment as part of a Transit Mall has been generated locally.

Newman et al. (2018) discussed four approaches to funding urban rail systems that have emerged since ‘the second rail revolution’ has created much more interest from private finance in rail projects. Approaches discussed are the fully private funded, fully public funded and the two in between, with each having a bias towards either a private or a public funded majority. The research indicated that the more private funding was injected into the project the more urban development was integrated into the transport project as they are able to make use of land value increases. This integration is difficult when governments alone run transport projects. By adding a solar energy component into a transport project may make this even more useful and interesting

for private investors to become involved in a land development-based financing of an infrastructure project. The paper therefore will work towards a procurement partnership model that can bring as much private money as possible into the preferred PPP approach whilst enabling common good outcomes required by governments. Such a model will be suggested as a way for any emerging city to pursue economic development with significant opportunities to simultaneously meet climate and SDG outcomes.

The paper will review other PPP-based infrastructure projects in Zimbabwe to see what lessons can be learned for pursuing this sustainable transport project. The research has selected financially viable projects that are current and appear to be critical for Zimbabwe's future. The study will identify the ideal public-private partnership (PPP) model that will likely see such projects being fully implemented before 2030. It will then apply the PPP model to the TTS-PV Model for Bulawayo.

Below are the projects that the study has found to have a high potential to be implemented through a public-private partnership (PPP) funding mechanism:

- Batoka Gorge Hydro Project
- Gwanda, Insukamini and Munyati Solar Projects,
- Gwayi-Shangani Water Project,
- Kunzvi-Musami Water Project,
- Beitbridge-Bulawayo-Victoria Falls Highway, and
- Beitbridge-Harare-Chirundu Highway.

This study will identify the PPP arrangement that suits the implementation of each identified project given the capital constraints faced by countries like Zimbabwe. The study will answer the following questions:

- What is the Public Private Partnership (PPP) concept and how has it progressed over time?
- Which are the high impact projects that can be successfully implemented through the PPP concept in emerging places like Zimbabwe?

- What are the key requirements to enable greater adoption of PPPs in Zimbabwe and similar emerging nations?
- How can this be applied to a TTS-PV project to enable an integrated transport and solar energy leapfrog project to happen?

## 2 Public Private Partnership (PPP) concept

A Public Private Partnership (PPP) is where the public sector partners with the private sector to build, develop and maintain public services while sharing the risks, benefits and costs that accrue from it. Koppenjan (2005) refers to PPP as a procurement approach where the project is undertaken with a broader span of contractual obligations between the public and private sector to provide an asset and/or a service. The two definitions align with the World Bank (2014) description which suggests a PPP is a procurement model to deliver public infrastructure or service that cuts across various sectors such as transportation, water treatment, energy, environment, education, health and amenities among others. There are a range of different types of PPP's (Yuan et al, 2015; (Buljevich & Park, 1999; Yescombe, 2014) and these are briefly summarised before proceeding to see which ones are best for African infrastructure and for the TTS-PV.

### 2.1 PPP Types and how they work

The most common types of PPPs are service contracts, affermage or lease contracts, Build–Operate–Transfer (BOT) and similar arrangements and joint ventures. These are discussed in greater detail below.

#### 2.1.1 Service Contract

This is a special type of PPP where a private partner is hired by the government to perform specified tasks or service as per the contract agreement for a period typically less than 3 years. The primary responsibility to provide the public service or infrastructure remains with the government while a portion of that responsibility

is contracted to the private sector partner. Quality standards to be adhered to are documented while the cost of the service to be provided is stated in monthly or yearly terms. The contract is honoured by the government through payment of an agreed service fee which is determined by the unit cost or arrived at using some other criterion. The private sector will therefore aim to efficiently manage operational costs and adhere to stipulated quality standards so as to realise incremental profits. This type of PPP is preferred by governments because it brings private sector expertise and efficiency in upholding service quality, a feature which can be missing in governments and increasingly governments are moving away from operational roles to more strategic and regulatory roles. However, service contracts are unsuitable for attracting new capital for large infrastructure projects (Asian Development Bank, 2008).

### 2.1.2 Affermage/Lease agreements

In this arrangement, the private sector is responsible for the entire service provision while meeting the agreed service standards and quality on behalf of the government. The government will however be responsible for any new investment or replacements on the public service or facility. Typically, service agreements last for 10 years with a possibility for renewal up to 20 years by both parties. Once the role of providing the public service passes from the government to the private partner, the latter will be liable for any losses and unpaid debts by the consumer. The lease agreement does not involve transfer of ownership or sale of assets. Like service contracts, lease agreements ensure that higher levels of efficiency and quality are achieved by the private sector partner in the process of chasing after higher revenues and profits (Asian Development Bank, 2008). In Asia, lease agreements are mainly utilised in the operation of airport terminals and seaport container terminals. Thailand and India have current lease agreements for the handling of containers at their seaports in Bangkok and Cochin. The contract for India was initially for 8 years while the Thai one ran for 7 years involving local companies. In China, the Keppel Group from Singapore operates the Guangzhou Baiyun Airport Terminal under a 15-year lease agreement (World Bank, 2016). Again, these lease arrangements do not bring in private investment.

### 2.1.3 Built-Operate-Transfer (BOT) and Similar Arrangements

The BOT and similar arrangements are widely used models of PPPs because of their clarity and ability to attract new capital. The private partner or consortium formed for that purpose develops and finances new

infrastructure projects or a major component of the project as per set performance standards by the public partner. Under BOT, the private partner owns the public asset for a period specified in the contract so as to recover investment costs through charging users usage fees. BOTs often require large financing schemes and longer repayment periods especially under situations where demand for the service or infrastructure is seasonal. Table 1 shows the various delivery options under BOT arrangements. BOTs have largely been adopted for many PPPs especially in public infrastructure construction and renovations as they have massive opportunities to attract private sector capital. Since the government is often the sole customer, BOTs tend to limit the level of commercial risk to the private partner.

**Table 1. Basic BOT Delivery Options**

Arrangement	Owner	Conceive	Design	Build	Operation & Maintenance	Financial Responsibility
Design-Bid-Build (DBB)	Public	Public	Private by fee contract		Public	Public
Design-Build (DB)		Public				
Build-Operate-Transfer (BOT)		Public	Private by fee contract			Public
Design-Build-Finance-Operate (DBFO)		Public or Private	Private by fee contract			Public, Public, Public/Private, or Private
Build-Own-Operate (BOO)		Private by contract (Concession)				

**Source: United States Department of Transportation (2018)**

However, the BOT model is modelled on the need for certainty on the part of contract partners in terms of honouring the contract in order to bring stability to the utilisation of the public service. In India, the Build-Own-Operate and Transfer (BOOT) was used to construct the Gujarat Toll Road. The contract for the 32km road facility included the construction of pavements, cross-drainage works, toll facilities, separators, bridges and medians. The contract also encompassed maintaining and managing the Gujarat Toll Road in terms of traffic regulation, toll collection and operation of the plaza. A fixed formula is used in calculating and determining toll rates by the contractor who enjoys relative autonomy from the government. A toll committee which advises the government is constituted from time to time to review toll fees in the face of inflation (World Bank, 2016).

#### 2.1.4 Joint Venture

A joint venture involves co-ownership of the public service or infrastructure by the private partner and the government. It can be viewed as partial privatisation since the public service will be managed via a Special Purpose Vehicle (SPV) or joint ownership of an established company through the sale of shares to the private investor(s). Sound corporate governance is however key in managing the delivery of a public service especially in maintaining independence from government and political interference. In most cases the government wields immense power as the co-owner, lawmaker, regulator and consumer; as such the temptation to interfere and dictate terms in the management of the JV is huge (Asian Development Bank, 2008). In 2009, The Chisumbanje Ethanol Project was commenced in Zimbabwe under the Green Fuel company name. Green Fuel is a joint venture of the Zimbabwe government's Agricultural and Rural Development Authority (ARDA) along with Macdom and Ratings Investments owned by a private partner. The \$600 million project is the biggest of its kind in Africa and produces approximately 100 million litres of Ethanol, enough to supplement 50% of Zimbabwe's petroleum needs. The project produces approximately 18 Megawatts (MW) of power as a by-product and supplies it to the national grid. The output is enough to power 30, 000 households while import substituting foreign currency (Mutambo, 2011).

Joint Ventures and BOT arrangements will be the focus of further analysis as they are able to provide private investment.

## 2.2 Public-Private Partnership and Transport Projects

In 1992, the United Kingdom government introduced the Private Finance Initiative (PFI) aimed at encouraging PPP initiatives and as a result there was a lot of private sector interest in public infrastructure development especially transport. Since then, most South American cities especially in Brazil and Chile have also effectively embraced the PPP models to partially or fully fund some of their major transport infrastructure projects. To date, PPPs are responsible for financing and managing about 24% of public services in the UK (All Answers Ltd, November 2018). Notable examples of countries that have done well with the adoption of the PPP concept to build their public infrastructure include China, India, Brazil, Chile, Malaysia and Poland. According to Willoughby

(2013), PPP projects in transport for developing countries totalled only approximately USD30 billion in 2006. The benefits that make PPPs largely successful were elaborated by Meidutė and Paliulis (2011) and Willoughby (2013) as follows:

- Financing advantage to resource constrained developing countries,
- Efficiency advantage brought about by the private partners to their public counterparts,
- Innovation advantage that are commonly associated with private sector,
- Growing need for infrastructure as most urban growth is outpacing the capacity of the public sector to provide the necessary infrastructure development,
- Quality improvement and reduction in public services costs.

Public transport has been very slow at developing PPP approaches (Newman & Kenworthy, 2015) but most OECD countries are now utilising PPP's for the development, construction and operation of light rail transit (LRT) projects. There is generally a sense that PPP's are working however the main issue is concern that the gestation of these PPP projects is typically 4-6 years (Willoughby, 2013); they are thus looking to reduce these times and their transaction costs with Spain showing the way with an average gestation period of 8 months.

According to Newman et al. (2018) there should be a linkage between investment in transit infrastructure projects and land development to share in the increased land value created. The best examples of this are in Japan and Hong Kong where it is estimated that on average the Hong Kong MTR generates 50% of its net earnings from its associated real estate business transactions that are built along its train stations and along its rail infrastructure. In China, the Beijing Mass Transit Railway (BMTR) Corporation and its sister company Beijing Capital Group (a local property developer) is another PPP success which has promoted the transit-oriented development (TOD) approach similar to the Hong Kong Mass Transit Railway (MTR) business model. The transfer of gains from property development into transport infrastructure budgets has now led to a new form of TOD-inspired PPP.

In order to create a TOD-based PPP it is necessary to structure a contractual partnership that correctly understands the expectations of each partner. It is expected that the private sector is driven by the profit maximisation philosophy, whereas the public sector is driven by the notion of increasing public service availability and satisfaction. Finding a balance between the desired expectations of the two partners at the onset of a PPP drafting is crucial for the partnership's success. Liang et al. (2018) attempted to develop a two-sided matching model to determine the optimal partnership between the public and private sectors. This model could be utilised to identify the crucial allocation of risks and benefits to the partners. The West European experience does show the efficiency of PPPs is maintained when there is harmony between partners (Meidutė & Paliulis, 2011).

Such novel procurement and funding schemes inevitably face a lot of resistance from local and traditional groups. Johannesburg in South Africa suffered from this type of resistance when it proposed to introduce its first Bus Rapid Transit (BRT) project. Santiago in Chile faced similar challenges for over a decade in the 1990s (Willoughby, 2013). However, Sao Paulo in Brazil had great success compared to most cities. It had breadth of involvement of most private parties across the transport sector than in Johannesburg and Santiago. According to Willoughby (2013), Sao Paulo city is now optimistic and confident about a PPP procurement concept to deliver infrastructure to the extent that it projects that from 2006 to 2025 the investment in its road infrastructure will be approximately US\$23 billion, with a third of that investment coming from PPP arrangements. As well as Brazil's successes, among the low to middle-income countries and OECD countries, Chile scores highly on the infrascope index (The Economist, 2015). Regardless of the resistance Santiago went through, it finally managed to reduce the aggressive competition on road for the traditional buses by reducing the numbers from 7700 to 5800 and introducing the BRT through a PPP concept (Willoughby, 2013).

Lack of a conducive legal framework and regulatory governance seems to have contributed to the uptake failures of some PPP projects, and in some cases weakened their performance. The factors that need to be considered to enhance urban transit projects are:

- Robust civic consultation systems,
- Integrated land-use/transport planning system,

- Land/property market management,
- Monitoring systems,
- Progressive policies,
- Economic regulation, and
- Public institutional framework for urban transport PPP (Willoughby (2013)).

Meidutė and Paliulis (2011) show that such PPPs are likely to lead to faster development and implementation of projects as long as all the terms and conditions which underpin the legal framework, risk evaluation and allocations, liabilities and dispute resolutions are explicit. The managerial expertise of the private sector is also likely to promote quick project implementation. They also suggest that the barriers to proper implementation of PPP projects are:

- The absence of clear and expedient political will,
- Poor legal framework for PPPs,
- The absence of public authority to manage PPP initiatives, and
- No public campaign to champion the PPP initiatives.

These shortcomings will need to be addressed if PPP projects are to be implemented successfully. Nigeria as an emerging economy has recognized the importance and positive impact PPPs have in enhancing its ability to develop its public infrastructure. According to Kadiri et al. (2015) this has led to Nigeria enacting the Infrastructure Concession Regulatory Commission (ICRC) Act of 2005 which provides a legal framework for the adoption of PPPs for infrastructure development.

According to Zin Zawawi et al. (2016) unsolicited PPP proposals have been acknowledged and are recognised in major international procurement frameworks including World Bank, Asian Development Bank, African Development Bank (AfDB) and European Bank for Reconstruction and Development. The most notable countries that have developed channels to receive unsolicited PPP proposals are: South Africa, Australia, China, Philippines, Taiwan, India, Indonesia, USA and Malaysia. Malaysia's *Guideline on Public Private Partnership* was

published in 2009 and according to Zin Zawawi et al. (2016) unsolicited proposals have proven to be a stimulant and catalyst for developing and procuring infrastructure and public services in Malaysia. South Africa is probably the leader on PPP's in Africa with the Economic Development in Africa Report (2017) showing that South Africa has the greatest cumulative experience of public-private partnerships in Africa, with over 50 such partnerships at the development or implementation stage from national to provincial level, some of these are in transit.

### 3 The PPP potential for Zimbabwe

Zimbabwe is a country with great potential, endowed with natural resources such as minerals. It can harness its natural resources through focusing on strategic national projects such as the ones identified in this study. However, as already noted the country has been going through economic decline for the past two decades, and is heavily in debt, and financially constrained (Ndlovu et al., 2020). Critical sectors of the economy that are vital for the resuscitation of the country's economy have been hit hardest during these past two decades of the economic decline, and hence the requirement of significant amounts of capital investment. The country has many potential projects that are under feasibility studies or have been parked because of lack of funds by the government.

The Zimbabwe Government has been reticent to negotiate PPP's but there is evidence from neighbouring country projects that governments can always negotiate a PPP model that reflects a win-win scenario acceptable to both parties. Such projects have been successfully implemented in the past in South Africa. The Limpopo Toll Bridge at the Beitbridge Border Post was built under a 20-year Build-Operate and Transfer (BOT) arrangement in 1994. The Beitbridge-Bulawayo Railway (BBR) line was implemented on a BOT model by Beitbridge Bulawayo Railway (Private) limited in July 1999. Similarly, the 820km Plumtree-Bulawayo-Mutare Highway rehabilitation was constructed by Group Five of South Africa with funding from Development Bank of South Africa (DBSA) in 2014. All these are examples of remarkable modern-day Zimbabwe projects which were implemented under PPPs and are benefiting the economy.

This study selected a few major projects which are under consideration and if developed in Zimbabwe would have a potential to immediately and significantly influence the economy of the country, if implemented correctly. For example, the potential power projects within the Zambezi basin have the potential to generate more than 600 000 direct and indirect jobs. Provision of affordable and reliable electricity is a key in alleviating poverty and re-industrializing the economy. The two water and sanitation projects discussed in the study have massive potential to turn the perennial arid and drought prone provinces of the country such as Matebeleland North, South and Bulawayo into green zones that will be able to foster agricultural production throughout the whole year. Jobs and income generation created in these new green belts will help reduce poverty levels while increasing demand for other goods and services for the local and national economy. The rehabilitated highway networks will promote trade and tourism in the Southern African region and increase the country's tourism visibility to international visitors. The trackless tram project outlined below will act as a catalyst to enable the city of Bulawayo to reconstruct/resurface its dilapidated roads, leapfrog into a new mid-tier transit technology, bring in solar-based urban regeneration and act as a stimulant for the economic revival of the city of Bulawayo (Ndlovu & Newman, 2020a; Ndlovu & Newman, 2020; Newman et al., 2019). Together these projects have the potential cumulative effect of creating more than 2 million jobs in Zimbabwe. It is therefore important to create a PPP legal framework so that these projects can be delivered.

## 4 A Framework for Assessing Projects' Potential for PPPs

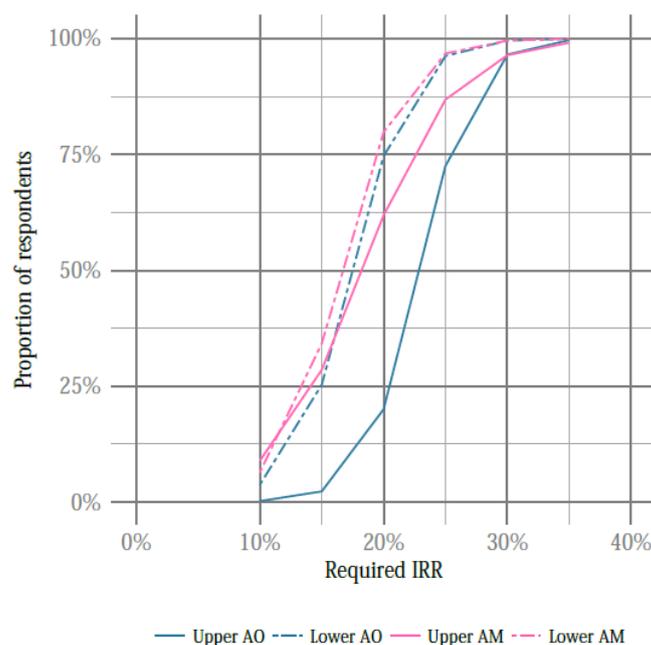
A simple framework for assessing a project is to enable a good internal rate of return (IRR) and a significant economic impact on the society and economy. The first indicator will enable projects to be attractive to private investors and the second indicator will be attractive to government. According to Blanc-Brude et al. (2017, p. 8) the rate of return in infrastructure investments in emerging economies is very high:

“...investments in private infrastructure in emerging markets invites a higher equity premium compared to investments in OECD markets (between 6% and 7%), and investors demand a premium to invest in merchant infrastructure” (p. 8)

A project that has a very high economic impact to the country, such as the Batoka Gorge Hydroelectric Scheme (BGHES) outlined below, will invoke the serious interest of any government. However, the risk of doing business in emerging economies, especially in Zimbabwe, is very high, hence, investors are only willing to invest in emerging markets if the IRR is on average above 16% compared to the average minimum requirement from the OECD markets of 10.6% (Blanc-Brude et al., 2017).

Figure 1 shows that if the project has a likelihood of providing an IRR that is above 16% it will attract investors and increase their willingness to invest in the emerging markets' infrastructure sector. The types of investors considered on figure 1 are Assets Owners (AO) and Asset Managers (AM). According to Blanc-Brude et al. (2017) an IRR should be used as a tool to negotiate for private investment into the public infrastructure sector, and can also be used as a standard means of presenting an investment proposition. As shown on figure 1, a government could come up with a marketing strategy that will guarantee the rate of returns between 16% and 30% depending on the nature, urgency and criticality of the project. This strategy will guarantee that there is interest from the private sector to explore the investment in the public infrastructure projects. The government could run a tender bid using the IRR band between 16% and 30% and the most efficient companies are likely to win the tender for the projects. Thus a critical minimum IRR of 16% is chosen to assess the viability of major projects' suitability for engaging in a PPP contract.

**Figure 1. Proportion of respondents willing to invest at the required IRR in emerging-market infrastructure**



Source: (Blanc-Brude et al., 2017)

The study has gathered the major projects in Zimbabwe listed in Appendix 1 and assessed them simply in terms of IRR (along with their extra benefits in terms of SDG-related economy-wide outcomes). These are then related to the ideal PPP frameworks to see what lessons can be learned.

To attract private investments, public projects need to have attractive returns that will cover the risk of investment as elaborated in detail by Blanc-Brude et al. (2017). Private investors do have the option to invest their capital in low risk investments; therefore, a project that will attract private investors should show that its returns are above the minimum returns required for low risk investments. In this study we have identified the critical sectors of the economy that are necessary to get the Zimbabwean economy, especially the local authorities' economies, back on their feet. The three sectors of the economy identified as critical by various international institutes such as the World Bank and other major developmental agencies are:

- The Energy sector
- The Road and Transport sector
- The Water and Sanitation sector

For this study's scope and demonstration, we opted to identify the top two major projects within each of these sectors that have the potential of higher returns to attract private investors, and have a very high potential for significant economic impact to interest the government. Thus, projects identified had to have the qualities below:

- Have a potential significant impact to the society and economy to be attractive to the government,
- Have a higher internal rate of return to attract private investors,
- Have undergone some feasibility studies, and
- Have a potential to be provincially owned (to allow local and central governments to be part of the partnership with the private partners).

The overall amount of capital required for all major potential public projects is approximately US\$12.0 billion. However, in our designated sectors above, we have selected specific projects that have potential for significant macroeconomic impact to the country's economy. Applying the above-identified qualities for project selection, we have identified the projects below in Table 2 covering the six projects in the three infrastructure sectors.

**Table 2. Zimbabwe Infrastructure Projects - IRR and Economic Impact assessments**

Zimbabwe PPPs Potential Projects						
	Project	Project Cost	Scope (size)	Economic Impact	Economic impact factor (out of 10)	Rate of return (IRR)
1	Batoka Gorge Hydroelectric Scheme (BGHES) at the Zambia-Zimbabwe Border (National)	\$2.6 Billion under a BOO PPP Model	<ul style="list-style-type: none"> <li>• Installation of 12 x 200MW turbines to produce 2400MW of electricity to be shared equally between Zambia &amp; Zimbabwe.</li> <li>• Project to be completed in 5 years</li> </ul>	Provision of affordable, reliable & sustainable renewable energy for both countries enough to power 50% of national electricity demand	10/10	>20%
				Foreign currency savings on power imports with potential to export surplus		
				Increase in renewable energy sources in electricity from 42% to 80% (Compliance on CO <sub>2</sub> emissions)		
				Creation of 600,000-1000,000 downstream jobs		
				Reduction in electricity generation costs, which translates to cheaper tariffs for all consumer		
2	Gwanda Solar Plant (Matebeleland South Province), Insukamini & Munyati Solar Plants (Both Midlands Province)	Gwanda (\$171 million), Insukamini (\$180 million) & Munyati (\$160 million) under a BOO PPP Models	<ul style="list-style-type: none"> <li>• Provision &amp; Installation of complete (turnkey) Solar Photovoltaic (PV) Panels and Transformers with a total capacity of 300MW.</li> <li>• To feed directly onto the national grid.</li> <li>• Projects to be completed in 18 months</li> </ul>	A competitive tariff to consumers and reduced imports of power from the region. This improves electricity availability thereby managing poverty levels	10/10	>16%
				Power Savings on Coal & Hydroelectric Plants during the day		
				Long term cost savings as solar has zero maintenance cost		

				Downstream economic activities for Gwanda, Gweru and Munyati residents and small businesses		
<b>3</b>	Gwayi-Shangani Dam & Pipeline (Matebeleland North Province) under the Matabeleland Zambezi Water Project	\$600 million funded via a BOT PPP Model	<ul style="list-style-type: none"> <li>•Construction of a 72 metre (H) x 305 metre (L) Roller Compacted Concrete Dam wall (Phase 1), Piping to connect Cowdray Park Water Works in Bulawayo (Phase 2) &amp; Zambezi River Piping (Phase 3).</li> <li>•Maximum water depth of 59 metres</li> <li>•Dam Capacity will be 634 million m<sup>3</sup></li> <li>•Project also involves construction of a 6MW power station and a water pump station on site.</li> <li>•Project to be completed in 5 years</li> </ul>	<p>Reliable water provision for more than 1 million people in Lupane and Bulawayo, thus solving perennial water shortages. Income generation for Bulawayo City Council through subsequent rate payments</p> <p>Irrigation farming for communities in Gwayi and Shangani area which are drought prone</p> <p>Fishing and Tourism activities for the community</p> <p>Power Generation for feeding into the national grid</p>	<b>10/10</b>	<b>&gt;16%</b>
<b>4</b>	Kunzwi-Musami Water Project (Mashonaland East Province) & Drinking Water Supply Project (DWSP) to Harare	\$865 million funded via a BOT PPP Model	<ul style="list-style-type: none"> <li>• Construction of Kunzwi-Musami Dam, conveyancing, piping &amp; water treatment works.</li> <li>• The dam will deliver 158.4 million m<sup>3</sup> of water daily at full capacity</li> <li>• Project to be completed in 5 years</li> </ul>	Provision of water for 2 million residents in greater Harare, Chitungwiza, Norton and Ruwa thereby curbing the risk of Cholera and reducing urban poverty. The project provides revenue streams for all the 4 local authorities who are struggling to provide clean water to residents.	<b>10/10</b>	<b>&gt;16%</b>

5	Beitbridge-Bulawayo-Victoria Falls Highway Project (Matebeleland South, Bulawayo & Matebelend North Provinces)	\$2 billion on a BOT PPP Model	<ul style="list-style-type: none"> <li>Widening of the 645 km highway, construction of two lanes in each direction (4-lane highway).</li> <li>Re-tarring and Bridges Construction</li> <li>New road signs, visible road marking and adding reflectors to the edges of the road.</li> <li>Construction of 6 tolls plazas</li> <li>The estimated completion date is 2023</li> </ul>	<p>Smooth facilitation of trade from South Africa to Bulawayo and Victoria Falls. The highway will support the Beitbridge-Bulawayo Railway (BBR) and open up a link to Zambia. The highway also links Zimbabwe to the Trans-African Highway which runs from Cairo to Gaborone through to Pretoria, Kimberley.</p> <p>Convenient, Cost Effective &amp; Safe travelling for self-driving tourists to Matopos, Khami Ruins, Victoria Falls, Binga and Hwange National Park. Hotspots accessibility</p>	10/10	>16%
6	Bietbridge-Harare-Chirundu Highway Project (Matebeleland South, Masvingo, Midlands, Harare & Mashonaland West Provinces)	\$2.7 billion under a BOT PPP Model	<p>The 971km project involves the dualisation, upgrading &amp; tolling of the highway.</p> <ul style="list-style-type: none"> <li>The road will be divided into three sections namely; <ol style="list-style-type: none"> <li>Beitbridge-Harare: 570km (8 Toll Plazas)</li> <li>Harare-Chirundu: 342km (6 Toll Plazas)</li> <li>Harare Ring Road: 59km (3 Toll Plazas)</li> </ol> </li> <li>The estimated completion date is 2023</li> </ul>	<p>The project will create employment opportunities across the country with a host of construction firms engaged directly on the project. The project will also create downstream employment for value chain suppliers and transit towns along the highway.</p> <p>Improvement of transport and trade in the SADC region via the North-South corridor. Trade brings transit fees for international cargo to Zimbabwe</p> <p>The busy tolls will provide a revenue streams to ZINARA for maintenance and rehabilitation of roads across the country.</p> <p>Reduction of road fatalities along the country's busiest road.</p>	10/10	>16%

				Appreciation of property values along the highway.		
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## 5 Project Case Study Assessment Results

The results suggest that all the projects selected have a high rate of return above 16% and a high economic impact factor (rated in this exercise as  $\approx 10/10$ ) with extra society and economic benefits. Most of these projects have the ability to promote much needed sustainable development goals for Zimbabwe as well as creating the jobs and economic activity that can reverse years of poverty. The high economic factor of the projects should incentivise the government to develop these potential projects, whereas the projects' associated high IRR will attract the private sector and increase their willingness to invest in these projects. Therefore, the above projects are ideal for the government and private sector to work together and forge a win-win partnership. Some detail is outlined on each project emphasising how they lend themselves to PPP's.

### 5.1 Power Projects

#### 5.1.1 Batoka Gorge Hydroelectric Scheme (BGHES):

According to the World Bank (2018) the BGHES project is estimated to cost US\$2.6 billion to construct and will have an installed capacity of 2,400 megawatts which will generate annual revenues of US\$663 million. If the operating and maintenance costs of 8% are deducted the expected net revenues are US\$608 million. A general simple calculation of the payback period shows a pay-off period of less than 5 years. However, Ansar et al. (2014) showed that in most cases budgets for such large-scale projects do go above the original estimates. Should the project construction costs for the BGHES double its original budget from US\$2.6 billion up to \$5.2 billion, the project's internal rate of return will still remain positive at 15.4% and 5.2% for Zambia and Zimbabwe respectively, and the payback period will still be attractive for private investors but is approaching the point

where it would not receive private investment. Hence it will need to be a very tightly managed project – and associated PPP – to prevent such a blowout in cost. Such a perspective shows how fragile can be the private investment market and the importance of delivering projects within the scope of a well developed PPP.

Zimbabwe and Zambia are currently reeling under heavy power deficits which often lead the two countries to resort to power shedding and importing emergency power at exorbitant rates. It is envisaged that the BGHES construction is likely to take 7 years to complete with a PPP arrangement that involves the two governments of Zimbabwe and Zambia. However, should the project be more inclined to a 100% private PP structure, construction could be shortened to within the planned 5 years.

Another factor with a hydropower PPP is that it is generally a predictable project where the outcomes are likely to be welcomed over the long term, especially in a world that is decarbonizing. As the World Bank has said: “Hydropower investments are characterized by stable, long-term revenue streams coupled with low operation and maintenance costs. These provide the basis for attracting repayable finance, which can include loans, bonds, and equity” (World Bank, 2018). Hence the reason why the BGHES should have a high visibility of attraction to potential private investors such as Superannuation Funds, to quicken its implementation. According to the World Bank (2018) the BGHES has a financial internal rate of return (FIRR)<sup>1</sup> of 16.1 percent and 17.2 percent for Zimbabwe and Zambia respectively; and its economic internal rate of return (EIRR)<sup>2</sup> is 20,6% and 26.7% for Zimbabwe and Zambia respectively. These are the rate of returns required by the private sector to invest in emerging economies as elaborated by Blanc-Brude et al. (2017); and they are (private investors) likely to be looking for PPP’s that can structure such opportunities. Institutional investors such as Superannuation Funds are the typical major private investors that have a large capital base looking for investments through large projects with an expected long-term revenue stream that usually run more than 20 years. These funds are also looking

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<sup>1</sup> Financial Internal Rate of Return (FIRR) calculates the interest rate from the flow of costs from the program (including debt flows) minus the revenues it will generate WORLD BANK 2018. Batoka Gorge Hydroelectric Scheme: A Macroeconomic Assessment of Public Investment Options (MAPIO). World Bank: Washington, DC.

<sup>2</sup> Economic Internal Rate of Return (EIRR) compares the project costs in the year they are incurred and stream of interest costs, with estimated additional GDP effects to calculate the EIRR *ibid*.

for Net Zero projects that can meet the objectives of groups like Climate 100+ with their increasing global commitment to Paris Agreement-consistent projects.

### 5.1.2 Solar Projects:

Solar energy projects are quicker and easier to deliver than large-scale hydro projects. The Gwanda, Insukamini and Munyati Solar projects have strong potential to be good investments in Zimbabwe. Figure 2 shows Zimbabwe's huge endowment of solar irradiance which the country can exploit to promote construction of huge solar farms as well as small scale rooftop solar projects in cities and villages (Green & Newman, 2017). However, according to the World Bank (2018) the uptake of solar power projects in Zimbabwe is hampered and constrained by low and uncompetitive tariffs. These distorted market tariffs discourage investment in renewable energy projects. Competitive tariffs are market signals that attract investments. The tariffs need to be competitive enough to ensure returns on investment within prescribed timelines. This also allows investors to secure loans and capital from private sector sources.

With competitive price mechanisms in place, various BOT PPP arrangements can be negotiated to facilitate investment into this critical sector of the economy. Daily peak demand for electricity in Zimbabwe and Zambia stands at about 1600MW, with deficits met by power imports from the region. A strategic plan of developing and harnessing the Zambezi basin's potential hydro power projects, and fully tapping of the solar power potential of Zimbabwe and Zambia can literally turn the countries' electric power deficit into a surplus and make them exporters of power.

Zimbabwe's current "subsidised" tariff is 9.86 USc per kWh. However, by calculating the correct market cost of energy production using the Levelised Cost of Energy (LCOE) formula, Zimbabwe's true minimal breakeven cost of energy is 14 USc per kWh. To truly attract investments into its solar power sector, the country will require negotiating and offering power purchase agreement tariff that is significantly above 14 USc per kWh.

This project is a good example of how a government can enable a PPP to happen by ensuring that a regulation can be adapted to ensure sufficient investment can be attracted to make the project viable. It should be a BOT

type of PPP because this type of project will require a long span of period 20 to 30 years for the investors to fully recoup their costs and make the expected returns to their investment.

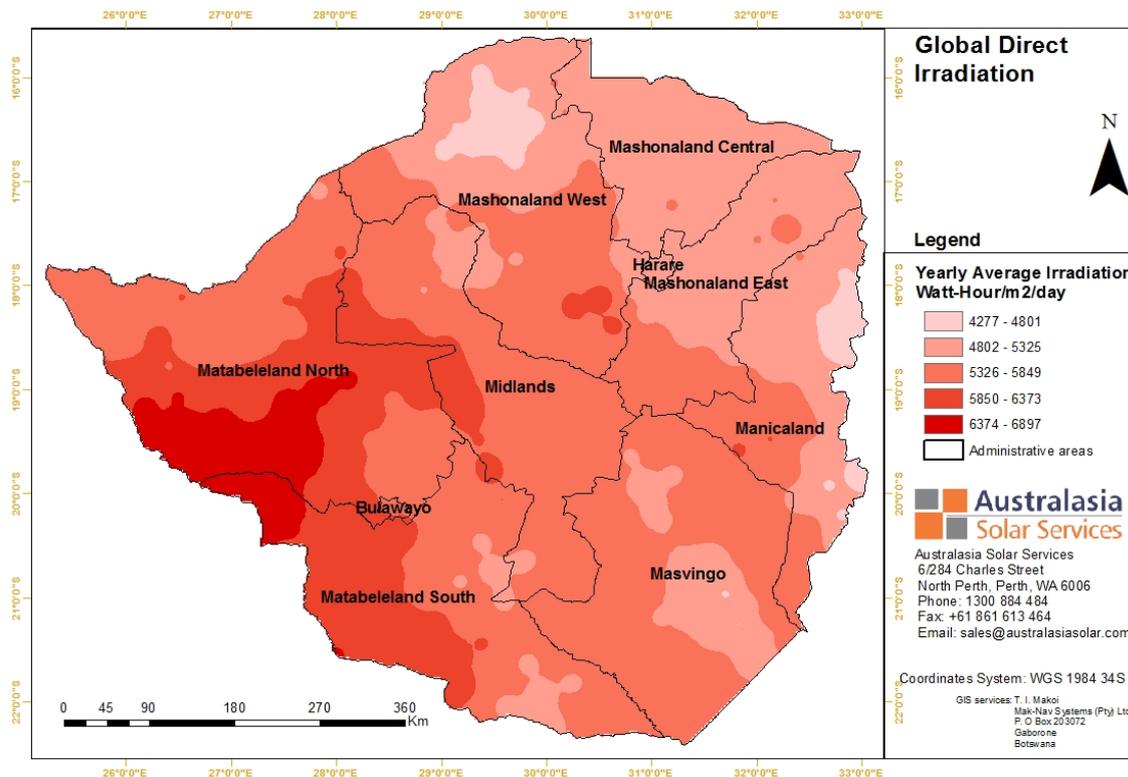


Figure 2. Indicative high horizontal radiation map of Zimbabwe.

## 5.2 Water and Sanitation Projects

Water and Sanitation plays a pivotal role in the economy of Zimbabwe and its inadequacy is a limiting factor in development of agricultural, industrial and mining activities as well as urban economic development. On the social end, water and safe running water provision is also a key defining factor in extreme poverty reduction. Zimbabwe's GDP growth is positively correlated to the country's seasonal rainfall pattern as agriculture feeds into manufacturing and financial services among others (Infrastructure Development Bank of Zimbabwe, 2020).

### 5.2.1 Gwayi-Shangani Dam and Pipeline

Bulawayo and Harare face perennial water shortages primarily as a result of rapid growth in population that has not been matched by investment in water and sanitation projects such as dam construction, water works, pipe

upgrades and maintenance. The Gwayi-Shangani Dam is providing water supplies to city of Bulawayo with a population of 1.2 million people which experiences water scarcity due to decreasing dam capacity in drought seasons and during mid-year as a result of the arid conditions in Matabeleland. The \$600 million Gwayi-Shangani Dam and Pipeline falls under the Matabeleland Zambezi Water Project and is expected to provide uninterrupted water supply to more than 500 000 households, farms and businesses in the province once complete. The dam will facilitate industrialisation through stable water supplies and will help unlock various socio-economic activities through the supply of irrigation water for agriculture projects in Gwayi, Shangani, Lupane and Bulawayo Urban catchments. Irrigation schemes such as the Agricultural and Rural Development Authority (ARDA)'s Jotsholo Estate are being affected by low water supply from Shangani Dam and stable water supplies will ensure all year-round farming and increased hectareage of cereal and horticulture crops for exports.

The project has strong IRR and economic impact and should have a straight forward PPP process as long as it is enabled through local and city governments who will be benefiting from the stable water supply.

### 5.2.2 Kunzvi-Musami Dam & Drinking Water Supply Project

The Kunzvi-Musami Dam & Drinking Water Supply Project (DWSP) is similar to Gwayi-Shangani except that it will enable a better future for the main city of Harare and its satellite towns such as Chitungwiza and Ruwa. Ruwa, Norton and Chitungwiza with a population of around 5 million. Suburbs in the northern parts of Harare have no running water due to low pumping pressure and limited supplies. The whole area has been affected by shortage of water treatment chemicals, water loss and droughts and as a result, 50% of the residents in Harare, Chitungwiza, Norton and Ruwa rely on buying water or sinking boreholes for their sustenance while the poor have to be content with shallow wells. The \$865 million Kunzvi-Musami Dam & Drinking Water Supply Project (DWSP) will provide water for domestic and industrial use at competitive rates, cheaper than the cost incurred in recycling wastewater at Morton Jeffrey and Marlborough Water Works. The dam project will provide affordable bulk water for these residents while taking care of industrial demands for economic production purposes. Market gardening and horticulture projects in Norton, Ruwa, Domoshava and Goromonzi will also benefit from the dam.

The PPP for this project will similarly be able to fulfil multiple objectives for the Harare area as long as it is linked into local and city governance to ensure it is well governed in its delivery and long-term operations. It should be a BOT-PPP as this project will require a long contract that will span between 20 to 30 years of operations to allow the investors to fully recoup their investment costs and earn the expected rate of returns.

### 5.3 Transport/Highway Projects

Zimbabwe has 88 318km of road network (21% being tarred) which is maintained by local authorities and the central government via disbursements from Zimbabwe National Roads Administration (ZINARA). Beitbridge-Harare-Chirundu Highway Project (971 km) and the Beitbridge-Bulawayo-Victoria Falls Highway Project (645 km) are the busiest highways in Zimbabwe connecting the southern parts of the country to the northern parts and facilitating trade and movement of labour in the Southern African Development Community (SADC) region. The routes are vital to Zimbabwe's economic fortunes as Beitbridge sits on the border with South Africa and the highway carries most of the goods transported between these and other adjacent countries. Decades of neglect have left the two busy highways in a poor state and it has been worsened by the haulage trucks which ply the routes. The construction of the highways is expected to improve the quality of the national road network, which has outlived its lifespan of 20 years by almost 35 years. The highways will provide passage from South Africa to countries such as Zambia, Malawi, Tanzania and DRC to the north via the north to south trade corridor. Rehabilitating the two highways is expected to help boost Zimbabwe's economy while also curbing fatal accidents on the narrow roads that connect Beitbridge to Harare and Bulawayo.

#### 5.3.1 The Beitbridge-Bulawayo-Victoria Falls Highway

The Beitbridge-Bulawayo-Victoria Falls highway is also significant for tourism to Matopos, Khami Ruins, Victoria Falls, Binga and Hwange National Parks. Accessibility to tourism hotspots boosts Zimbabwe's status as a tourism hub while providing foreign currency earnings for tourism companies. Tourists will also be a big part of the toll fees that can ensure the PPP has an effective IRR.

### 5.3.2 The Beitbridge-Harare-Chirundu Highway

The Beitbridge-Harare-Chirundu Highway accounts for more than 60% of the national traffic in Zimbabwe, thus the payback period for the project via payments of toll fees will be shorter than other highway project. The highway is pivotal in the provision of consistent revenue streams for the national roads manager (ZINARA) and maintenance of other country roads by the District Development Fund (DDF), Rural and Urban Councils that receive periodic allocations from the collected vehicle licensing and toll fees. The highway is the lifeblood for business activities in transit towns such as Ngundu, Rutenga, Masvingo, Chivhu and Chinhoyi.

The construction of the two highways will provide direct employment to a number of civil engineering contractors and thousands of jobs for various value chain players in the economy. The projects will encompass widening of the highways to SADC standards, resurfacing and dualisation when approaching major towns and cities. In 2017, ZINARA collected \$212 million from Toll Fees and Vehicle licenses, suggesting that the country has capacity to be able to repay the rehabilitation of the two strategic highways from toll fees while enabling economic growth.

PPPs under the Build Operate and Transfer (BOT) model are ideal for these two highway projects as they can be financed by the road users via Toll and Transit Fees over time.

## 5.4 Case Study Conclusions

The case studies are all good in terms of their IRR's and their potential broader economic impacts thus attracting private sector investment as well as ensuring broader common good objectives that government requires. The PPP's are all going to require an ability to relate to local socio-economic conditions through local and city governments, they may need regulations being reviewed such as the tariff rate for power projects and they can all be delivered using either the BOO and BOT structured PPPs.

## 6 Trackless Trams-PV Project in Bulawayo and Application of the PPP Model.

### 6.1 TTS and Sustainable Development agenda

Most of the projects identified above are more nationally oriented, however, the trackless tram-PV project is a localised project for the city of Bulawayo. This project has the potential to attract private investment to bring the major capital required to a significant transport problem in the city, through redeveloping a Transit Mall and providing opportunities for urban regeneration along several key corridors that can enable a return to the investors drawn into the project (Ndlovu & Newman, 2020a). It can also solve many common good issues such as enabling the City of Bulawayo to transition towards transit-oriented development (TOD) through the selected transit-activated corridors (TACs) and to begin to utilise more roof-top solar in the city's future energy system as it moves towards more electromobility. The roof-top solar system is now the cheapest of all power sources and can be made part of a national power grid with ability to not just provide power during the day but by introducing electromobility to a city with recharge options involving vehicle batteries (the TTS has batteries on its roof) then these can be used to provide grid balancing and other grid services (Newman, 2020a).

Urban regeneration is likely to be attracted to the corridors where the trackless tram is built due to value uplift that can be used to attract the developers (Newman et al., 2018). Ndlovu and Newman (2020a) have suggested the positive impact that TTS will have on the city of Bulawayo as:

“...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”.

Thus it is possible to see that there are multiple SDG outcomes from this project with potential to move to even more regenerative development opportunities (Newman, 2020b).

## 6.2 TTS and its PPP model

The TTS-PV project has strong IRR and economic impact credentials as set out in Table 3.

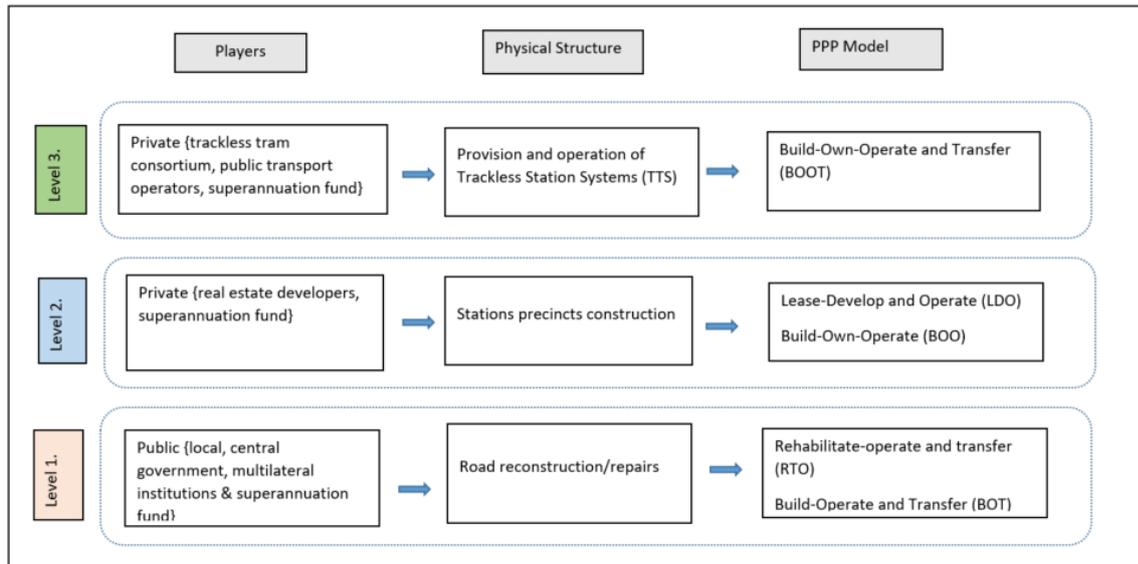
**Table 3. Bulawayo TTS-PV Project IRR and Economic Impact assessment**

Bulawayo TTS-PV Project						
	Project	Project Cost	Scope (size)	Economic Impact	Economic impact factor (out of 10)	Rate of return (IRR)
	Bulawayo Trackless Trams-PV project	\$380 million under PPP (BOO) Models	<ul style="list-style-type: none"> <li>Resurfacing of 5 transit activated corridors (TACs)- wide roads (4 lanes each), with an expected cumulative length of approximately 50 km. \$80m</li> <li>Construction of 30 station precincts \$180m</li> <li>Purchase of 60 Trams of three carriages \$120m</li> </ul>	<ul style="list-style-type: none"> <li>Improved transport system</li> <li>Technological advanced and safe transportation system</li> <li>Transit oriented development of the corridors</li> <li>Employment opportunities</li> <li>Economic stimulant for the city of Bulawayo</li> </ul>	<b>10/10</b>	<b>&gt;16%</b>

### 6.2.1 TTS and the PPP structure

The structure of the PPP that would work best for the TTS-PV would be a BOO model using three layers or levels of PPP arrangements as set out in Figure 3.

Figure 3: The Three Multifaceted PPP Model (TMPM)



Source: Ndlovu and Newman (2020b)

This model of the potentially best PPP arrangement for the TTS project for the city Bulawayo was developed in detail by Ndlovu and Newman (2020b). The study constructed a PPP model referred to as a Three Multifaceted PPP Model (TMPM). The TMPM model is composed of three layers of players each required to structure a separate PPP arrangement. A Trackless Tram Consortium would be formed after procurement and a PPP created based on three layers with different levels of private and public investment and hence responsibility. According to this model:

- Layer 1, the city council would lead the first layer responsible for road resurfacing (this would cost \$80m roughly to resurface the 50 km of roads required in the city);
- Layer 2, the private sector developers would lead the second layer and be responsible for the purchase of the Trackless Trams (costing \$120m for the 60 three-car sets), and construction of station precincts including the solar-based TOD's (costing around \$180m for 30 stations and surrounding precincts); and
- Layer 3, the Trackless Tram consortium will operate the trams with shared public and private responsibilities.

The TTS project does indicate the potential to yield high positive economic impact for the city and the project has a very high IRR due to the opportunity to tap into urban development as the main source of commercial return rather than tolling as is done for private investment in road projects. This makes the TMPM model more

pragmatic and more realistic to enable the delivery of the TTS project to the City of Bulawayo using a BOO type of PPP. More details of the TPM is found in Ndlovu and Newman (2020b) study.

The trackless trams (TTS) project has the potential to kick-start the economic activities of the City of Bulawayo. It will provide the capability for the City of Bulawayo to leapfrog technologically with regards to its public transportation network as well as assisting with establishing a roof-top solar power system within the city. Numerous public and private benefits can be derived from the adoption of trackless tram technologies as highlighted in previous studies (Ndlovu & Newman, 2020a; Ndlovu & Newman, 2020b; Newman et al., 2019).

## 7 Conclusion

The Trackless Tram-Solar project being assessed in this project has been found to fit a PPP structure of a Build Own Operate (BOO) system. This PPP has been suggested as being best delivered in three layers of differing levels of public and private investment and responsibility. These three levels are set up to ensure that there is strong government involvement where steps are needed that involve public infrastructure and needs while other levels involve strong private investment leadership where their strengths are needed. This model is based on a review of six large infrastructure projects in Zimbabwe in energy, water and transport sectors. The assessment based on the review of the six case study projects showed that both a high internal rate of return (IRR) and a high economic impact on the broad economy and SDG's, can be achieved. A key insight was the need for local involvement in not only the local government but also in understanding the local socio-economic dynamics that are needed for the achievement of a PPP that can deliver benefit to both private investment outcomes and public common good outcomes.

## Acknowledgement

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## Appendix 1. List of Zimbabwe Infrastructure Projects

Title	Sector	Contract Sum
Batoka HES*	Energy Power	\$2,600,000,000
Gwanda, Munyati and Insukamini Solar°	Energy Power	\$390,000,000
Hwange 7 & 8 Expansion Project	Energy Power	\$1,500,000,000
Hwange Life Extension Project	Energy Power	\$450,000,000
Gairezi	Energy Power	\$110,000,000
Bulawayo Repowering	Energy Power	\$96,000,000
Harare II Repowering	Energy Power	\$72,000,000
		<b>\$5,218,000,000</b>
Graniteside /Waneka Phase 2	Housing	\$10,650,000
Clipsham Views	Housing	\$ 6,700,000
Dzivarasekwa Phase 2	Housing	\$5,538,500
New Marimba	Housing	\$2,500,000
Parklands Mews	Housing	\$1,951,543
Mbizo 22 - IPHC	Housing	\$ 780,000
		<b>\$ 28,120,043</b>
Central Registry	Project & Infrastructure Finance	\$11,400,000
Bindura State University	Project & Infrastructure Finance	\$10,625,527
Lupane State University	Project & Infrastructure Finance	\$10,203,830
Midlands State University	Project & Infrastructure Finance	\$9,543,274
		<b>\$41,772,631</b>
Beitbridge-Harare-Chirundu Highway Project*	Transport	\$2,700,000,000
Beitbridge-Bulawayo-Victoria Falls Highway Project <sup>5</sup>	Transport	\$2,000,000,000
		<b>\$4,700,000,000</b>
Kunzvi-Musami Water Project & Drinking Water Supply Project <sup>k</sup>	Water & Sanitation	\$865,000,000
Gwayi-Shangani Pipeline <sup>v</sup>	Water & Sanitation	\$ 478,267,078
Gwayi-Shangani Dam <sup>2</sup>	Water & Sanitation	\$ 121,732,922
Tugwi-Mukosi Dam	Water & Sanitation	\$ 285,000,000
Semwa Dam	Water & Sanitation	\$ 140,000,000
Marovanyati Dam	Water & Sanitation	\$ 33,000,000
Beitbridge Water Supply	Water & Sanitation	\$ 11,370,373
Chinhoyi Municipality	Water & Sanitation	\$ 2,878,321
Gwanda Municipality	Water & Sanitation	\$ 1,800,000
Chipinge Town Council	Water & Sanitation	\$ 1,100,000
Hwange	Water & Sanitation	\$ 1,000,000
		<b>\$ 1,941,148,694</b>
<b>TOTAL CONTRACT SUM (VALUE)</b>		<b>\$11,929,041,368</b>
<b>Footnotes:</b>		
*° Of the total Energy projects' sum (value) of \$5.2 billion, our selected projects equate to ≈ \$3.0 billion, ≈60% of all the projects' value.		

<sup>xs</sup> These are the two major highway projects that have been issued to the public for EOI and the Beitbridge-Harare-Chirundu Highway is currently being implemented, but slowly due to govt's financial constraints

<sup>kvz</sup> The total sum (value) of our selected Water & Sanitation projects is ≈\$1.5 billion of the overall projects sum of ≈\$2.0 billion.

Source: *Infrastructure Development Bank of Zimbabwe (IDBZ)*

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## **Publication 5: Co-Author Statements**

### **To whom it may concern**

I, Vinnnet Ndlovu, contribute **80%** of the paper/publication entitled

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Signature of candidate:

Date 13.12.2020

I, as co-author, endorse that this level of contribution by candidate indicated above is appropriate.

Co-author Professor Peter Newman (**20% Contribution**)

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# How Would the Trackless Tram System and Public-Private Partnership (PPP) Apply to Bulawayo?

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## Abstract

The City of Bulawayo urgently needs to rebuild its dilapidated infrastructure and stimulate its economic activities. A Public-Private Partnership funding mechanism could enable the implementation of Trackless Trams on its corridors bringing mobility, a new solar power system and other multiple economic and social benefits, especially demonstrating the intention of Bulawayo to leapfrog into a 21st century future. This study designs a PPP model referred to as a Three Multifaceted PPP Model (TMPM) that will enable the implementation of the Trackless Tram project in Bulawayo. The TMPM model is composed of three layers of players each required to structure a separate PPP arrangement. The city council would lead the first layer responsible for road construction. The real estate developers would lead the second layer and be responsible for constructing station precincts especially the construction of a solar-based Transit Mall. The Trackless Tram consortium and public transport agency will manage the third layer that provides and operates the trams. The split of the project into three layers should enable its quicker delivery by lowering capital risk through spreading it over a number of players. Climate finance could be tapped. This model should be replicable to other developing cities.

## Keywords

Trackless Tram System, Light Rail-Light Metro Transit, Public-Private Partnership, Three Multifaceted PPP Model, Bankability Assessment, Capability Evaluation

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## 1. Introduction

The City of Bulawayo was not spared from the effects of Zimbabwe's two dec-

ades of economic meltdown. That episode has left the city's infrastructure at the verge of almost total collapse (City of Bulawayo, 2020b; Ndlovu et al., 2020). The once envy of many cities in Africa in terms of its robust and well-managed infrastructure, it is now one of the poorest cities in Africa. Not only have the road and water infrastructure almost totally collapsed, the city has experienced a major episode of deindustrialisation (Zaaijer, 1998). According to the information from its latest strategy document (City of Bulawayo, 2020a: p. 11), the city's industry is operating at less than 30% of its capacity. Though the structure of its industry and urban system is still in existence, Bulawayo urgently needs to rebuild most of its public infrastructure especially its road network. However, the city is facing financial challenges and has few resources to rehabilitate its critically needed public infrastructure and reactivate its economic activities. The city will need to show it wants to become a major urban centre in 21st century to provide a good African life and economic activity. To do this it will need to explore the possibility of adopting technologies that could ideally leapfrog it technologically into a city of the future (Ndlovu & Newman, 2020). Trackless Tram Systems (TTS) have the potential to do just that for the City of Bulawayo given the city's current physical situation and socioeconomic settings. The adoption of this technology will have a profound effect on the psyche of the local and business communities, and promote the perception of Bulawayo as a city that is geared to be a leader in innovation (Ndlovu & Newman, 2020a; Ndlovu & Newman, 2020; Ndlovu et al., 2020).

Besides the leapfrogging capabilities, the TTS will simultaneously give the city the impetus and opportunity to start the reconstruction of its infrastructure, especially its roads that currently are in a dire state. It will also give the city a chance to move into solar energy as part of the recharge system for the electric (battery-based) TTS and provide new urban regeneration opportunities from investment around the new stations. As discussed by Ndlovu et al. (2020) the TTS should enhance and stimulate the City of Bulawayo's economic regeneration agenda.

However, there is a need to create a way of enabling the TTS to be funded as the City of Bulawayo is not able to access such project funding with its current financial challenges (Ndlovu & Newman, 2020b). Thus a Public-Private Partnership funding mechanism has been suggested to be the best strategy for Bulawayo to build this critically needed public infrastructure project. The city needs to reach out to the private sector who is able to fund such major public infrastructure as expounded by the Secretary General of the International **Telecommunication Union (ITU)** (2014) who proposed that the private sector has the capacity to fund such public projects through Private-Public Partnerships (PPP) arrangements.

PPP's can also enable other skills to be brought into the project through expertise in such 21st century technology as TTS, solar energy and smart systems that support these leapfrog projects. The Trackless Tram System could be im-

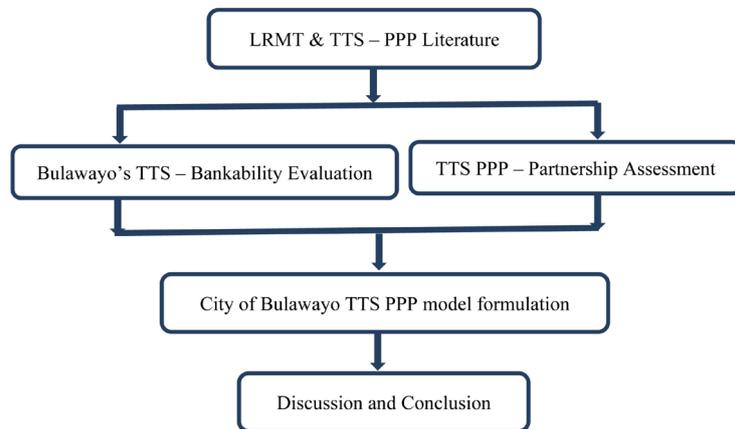
plemented through a mechanism such as the entrepreneur rail model, the concept discussed in detail by Newman, Davies-Slate, et al. (2018). To reconstruct and regenerate its public infrastructure by adopting game changing technologies like TTS the City of Bulawayo will have to engage the private sector through a win-win PPP arrangement that carefully works out the best way to achieve the broader public goals as well as enabling the innovation and funding to create a successful project financially.

The PPP model can also enable urban regeneration to be linked to the project and with the TTS enabling value increases to the land around stations, then the project has a sound basis in land development to enable it to attract good investors to the city. There is no doubt that the private sector will be crucial to the city's strategy to regenerate its corridors and resuscitate its economic activities (City of Bulawayo, 2020a, 2020b; Newman et al., 2018). The City of Bulawayo is already geared towards allowing the private sector to lead in regards to the reconstruction of its public infrastructure and revitalisation of its economic activities (City of Bulawayo, 2020a: p. 24). Therefore, a well-constructed PPP arrangement could see the city implement its TTS project, its energy and even its water infrastructure projects that will help it to reindustrialise again. This study will design a PPP model that should enable the implementation of a TTS on the City of Bulawayo, creating transit activated corridors (TACs) identified in the study by Ndlovu & Newman (2020a).

In order to design an ideal PPP arrangement, this paper will endeavour to address the research question "How would the Leapfrog innovation of a Trackless Tram System and PPP's apply to Bulawayo?", through examining literature on PPP's and applying this to the financial and management capability of the City of Bulawayo. The paper seeks to show how the City of Bulawayo could build a new culture of creativity and innovativeness going forward that can help it to be a future leader in the utilisation of leapfrog technologies such as TTS.

## 2. Methodology

The study will initially conduct a literature review to ascertain the fundamentals necessary for formulating a successful PPP with this kind of infrastructure, known as mid-tier transit, or as The World Bank calls it "light rail-light metro transit" (LRMT) PPP (Mandri-Perrott & Menzies, 2010). This World Bank Report will be explored extensively as it has set the scene for all the rest of the literature. Informed by this the study will formulate the bankability evaluation and capability assessment frameworks for Bulawayo's TTS project. With the understanding of the relevant fundamentals that are ideal for a functional LRMT PPP, the study will then structure an ideal PPP arrangement/model for the City of Bulawayo's TTS project. The study will then further discuss the results of the assessment and evaluation frameworks and the proposed Bulawayo TTS PPP model. **Figure 1** gives an overview of this study's structure and methodology.



**Figure 1.** Study's structure and methodology.

### 3. City of Bulawayo's Future with PPPs

Bulawayo has a good record of successfully implementing various funding mechanisms for its construction and urban development projects. It was the first city in Zimbabwe to adopt the Public-Private Partnership (PPP) arrangement to build low-cost houses for its residents. The Cowdrey Park suburb was built through a PPP arrangement between a Zimbabwe–Malaysia Holdings company to construct up to 15,000 housing units (Mbiba Beacon & Ndubiwa Michael, 2008). Given its robust governance and forward-looking reputation, Bulawayo could implement a similar strategy adopted by Colombia's City of Bogota during the short stint of its mayor Antanas Mockus Sivickas (Willoughby, 2013). Bogota achieved its implementation through PPPs especially its transit-oriented development projects. During his short tenure, Antanas Mockus Sivickas undertook various PPP projects structured in a way that emphasised the public sector (City of Bogota) to lead in the construction of stations and infrastructure, while the private sector was enabled to lead in the provision of buses and their operations. This PPP arrangement led to the City of Bogota establishing its first BRT project. A similar type of PPP arrangement could suit the City of Bulawayo and enable it to implement its Trackless Trams project. As elaborated by Meidutė & Paliulis (2011), PPP arrangements are very attractive especially during economic crises, for they are likely to sustain or stimulate the economy, hence allowing the public sector to allocate scarce funds to other crucial areas. This is ideally suited to the City of Bulawayo as it has been in a financial crisis for some time and is looking for mechanisms that will stimulate and resuscitate its economy.

To avoid falling into the Lithuanians' PPP pitfalls identified by Meidutė & Paliulis (2011), there is a need for the City of Bulawayo to evaluate its readiness to adopt the PPP funding mechanism and to manage the process. The council authorities will need to deal with the issues that might surround the adoption of the PPP approach as elaborated by Bhoroma (2020). The methodology and results of determining what will be needed for the council to do will therefore be elaborated next.

#### 4. Public-Private Partnership in Light Rail Metro Transit and Trackless Trams

According to Mandri-Perrott & Menzies (2010: p. 9) interest is growing in the use of light rail–light metro transit (LRMT) this interest has also seen the increase in the usage of public-private partnerships (PPPs) to support these initiatives. This study will assume TTS is classified as a type of LRMT as it has similar LRMT attributes or metrics portrayed by Mandri-Perrott & Menzies (2010: p. 17) and Newman, Mouritz, et al. (2018: p. 85). Mandri-Perrott & Menzies (2010) postulate that ever-expanding urbanisation (urban sprawl) has driven cities around the globe to look for better ways to improve their transportation services. LRMT if implemented correctly can help resolve this challenge for any city but especially fast growing ones like in the developing world. Such cities, not only can resolve their transportation issues, but they are also environmental friendly and socially responsible technologies that will reduce urban sprawl as well as vehicular carbon emissions (p. 11). However, to achieve efficient transportation systems through the introduction of the LRMT or TTS requires a well thought-out and strategic approach of implementation. Hence the postulation by Mandri-Perrott & Menzies (2010) that “designing properly integrated, intelligently planned, and well operated public transportation networks typically requires a centralized transportation or transit authority” (p. 14). As discussed by Mandri-Perrott & Menzies (2010), LRMT projects have very high capital expenditure investment, and they usually do not collect enough fares revenues to cover their operating costs. However, as already elaborated Trackless Trams (TTS) do provide all the benefits associated with LRMT, and are considerably cheaper to implement than the traditional LRMT and have the potential to raise funds through urban development to help pay for the infrastructure (Newman et al., 2018: p. 84).

According to Mandri-Perrott & Menzies (2010) one of the four fundamental factors that govern a good PPP framework is a well prepared PPP model. The purpose of this study is to structure an optimal PPP model that will enable the delivery of Bulawayo’s TTS project publicised by Kazunga (2019) and discussed by Ndlovu & Newman (2020a). Such high profile projects as the adoption of TTS and LMRT will require the support of not just the local government but also the central government to enhance the success of such initiatives. At the same time the PPP will need to go beyond transport issues and involve urban development processes and outcomes that can be fully integrated into the project. According to Mandri-Perrott & Menzies (2010), “an integral part of the government’s transport policy will require specific support for the procurement of a developer to undertake all or some parts of the LRMT scheme” (p. 46). The integration of transport and land use is guaranteed by enabling such a process.

When it comes to designing a PPP model or agreement, each one depends on the specific context though similar principles can be applied in all cases. For

example an underlying principle is that a good PPP arrangement is one that allocates and matches risks and rewards accurately between the project sponsors and the developers; however, this will vary considerably in different contexts in how the allocations are worked out.

The standard PP model was developed in the 1970's but in transport they were much slower to adopt the model. As transport has been dominated by governments the early transport PPP's were much more rigid approach with a high government element. For example, below are the common PPP base models discussed by [Colin Buchanan and Partners \(2002\)](#) with regards to the common transport projects across Europe:

- Management contract
- Gross-cost contract
- Net-cost contract, more commonly known as a lease
- Net-cost contract with investment (NCCI), more commonly known as the concession, build-operate transfer (BOT) form or finance-design-build-operate maintain (FDBOM)

According to [Colin Buchanan and Partners \(2002\)](#) the most common and appropriate PPP model for a transport project is to provide depots and other relevant infrastructure through a Build, Own and Transfer (BOT) partnership. This arrangement is usually for a long contract spanning a period of 20 to 30 years to allow the investors to recover their investment costs. The BOT model falls under an arrangement commonly known as the “unified approach” to the PPP agreement. It is now seen as being too rigid by the World Bank as set out by [Mandri-Perrott & Menzies \(2010\)](#). This study needs much more flexibility in how it approaches the partnerships needed to deliver the project in Bulawayo. What is needed in Bulawayo and probably any developing city, will be to utilise the alternative approach known as the “layering approach”. In this approach, “the project may be split among two or more separate PPP agreements addressing the construction of infrastructure, the procurement of rolling stock, and the operation of the system” as elaborated by [Mandri-Perrott & Menzies \(2010: p. 64\)](#). The very successful Docklands Light Railway (DLR) PPP uses this approach with separate PPP agreements for different components of its light rail services.

Countries with significant perceived risks do find it hard to attract private sector investments, because their weighted cost of capital to undertake business initiatives will have to factor in a very high-risk return, making the cost of capital extremely high. Capital grants and project subsidies might have to be availed to the developers to undertake such projects as the TTS for Bulawayo a city located in a country perceived as very risky. According to [Dauskardt & Ganguly \(2020\)](#):

“Globally, governments have had to contribute to the financing of infrastructure projects implemented through PPPs, across emerging and developed PPP markets. The public contribution comes in various forms, including construction grants, viability gap grants, availability payments, eq-

uity investments, concessional loans, and operational subsidy etc.” (p. 6).

As already hinted by [Mandri-Perrott & Menzies \(2010\)](#), most LRMT’s fare income are often insufficient to cover the operating and maintenance costs and the major investment costs of new construction, renewal, and renovation, hence the need for the subsidy and capital grants from the government. However, they still maintain that private participation is still possible even if fares do not cover costs (p. 96). This highlights the need to structure PPP models that should avoid asset sweating. As outlined below there will be less risk in the Bulawayo TTS as first the post Covid era has much lower global interest rates than when the above literature was being written, and second the project seeks to build in land development as a way to make the project less risky and more able to create profits than just fare box models. This approach is explained by The World Bank as the “value capture” approach and is very common in Asia and some emerging cities but less so in Europe and America ([Suzuki et al., 2015](#)). One other component of the PPP for a TTS would be needed and would appear to fit the situation in Bulawayo is that of providing solar electricity to any buildings associated with the station precincts; this would be to bring a 21st century and affordable power system to the TTS corridor and to enable the trackless trams to be recharged at particular stations.

As posited by [Dauskardt & Ganguly \(2020\)](#), “PPPs deliver value for money for governments by leveraging private innovation to provide public services more efficiently” (p. 5). African countries, doubly so Zimbabwe and unavoidably Bulawayo, are struggling and need a new approach to development that can bring funding, expertise to match the local knowledge and expertise. PPP’s around a TTS appear to be a possibility as “PPPs can be an alternative source of finance for infrastructure investments in African countries, while potentially also delivering higher quality and efficiency in public assets and services” ([Dauskardt & Ganguly, 2020: p. 5](#)). However, the next section will drill down to try and see if the “layering approach” could work in Bulawayo.

## 5. Evaluation of Bulawayo TTS Project’s Bankability and Partnership Assessment

The main factors that determine whether major projects such as the TTS or LRMT succeed is their bankability, and their developers’ capabilities. According to [Mandri-Perrott & Menzies \(2010\)](#), the term bankability goes beyond just the usual assumed financial analysis. Below are the four broad criteria identified by [Mandri-Perrott & Menzies \(2010: p. 11\)](#) that should constitute a true bankability assessment:

- Creditworthiness
- Legal viability
- Economic viability
- Technical feasibility.

The introduction of TTS into the corridors of the City of Bulawayo will largely

entail three major components of the project's milestones/undertakings:

- 1) Road reconstruction
- 2) Station precincts' and the surrounding neighbourhood construction
- 3) Provision and operation of the rolling stock.

The above undertakings do confirm this to be a major and complex project that will require different players with different capabilities. Since bankability and capability are the main determinants for the deliverability and implementation for most PPP projects, this study will utilise the four broad criteria identified by Mandri-Perrott & Menzies (2010: p. 11) to formulate a framework to evaluate the bankability of each of the three TTS project's undertakings identified above. After the overview Bankability Assessment of the above project's undertakings, the study will further conduct an evaluation of the partners/players' (developers) capability with a focus on their intrinsic comparative advantages. The assessment of the players will entail testing and identifying each player's capabilities to deliver the projects' undertaking of components/milestones identified above. These results will inform the study on how to structure an ideal PPP model using the case study of the TTS project for the City of Bulawayo.

### 5.1. TTS' Bankability Assessment

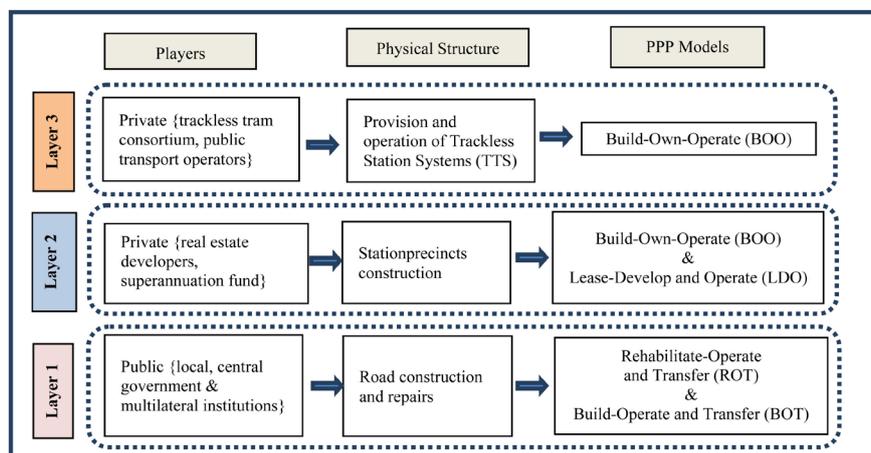
Bankability Assessment of TTS project for the City of Bulawayo is set out in **Table 1** using the framework developed by The World Bank (Mandri-Perrott & Menzies (2010). The simple assessments given are based on the previous academic research on this topic (Ndlovu & Newman, 2020a; Ndlovu & Newman, 2020; Ndlovu et al., 2020) as well as local knowledge (Newman et al., 2018).

### 5.2. Evaluation of PPP Partner Capabilities and Comparative Advantage

TTS players' capability and comparative advantage evaluation are set out in **Table 2** also using the framework developed by The World Bank (Mandri-Perrott & Menzies (2010).

### 5.3. The Three Multifaceted PPP Model

Based upon the results of the Bankability Assessment of the Bulawayo TTS project and the evaluation of the capability of the potential partners in this PPP arrangement through a Partner Capability, this study now recommends an ideal PPP model supported by the metrics of the evaluation and assessment frameworks. This study recommends the City of Bulawayo adopt a TTS PPP model depicted in **Figure 2**. This has a high likelihood to enable the implementation of the Trackless Trams project on Bulawayo's major corridors. This model is structured around three layers of players/developers that will constitute three different PPP arrangements that would be integrated finally into one package for delivery. The study refers to this proposed PPP structure/model as the Three



**Figure 2.** The Three Multifaceted PPP Model (TMPM).

**Table 1.** City of Bulawayo TTS project bankability assessment.

Bankability assessment of TTS project for the City of Bulawayo					
TTS project's major components/milestones	Variables				Assessment
	Demand/Urgency	Legal viability	Economic viability	Technical feasibility	
Road construction*	5	4	4	5	4.5
Trams station precincts construction**	5	4	5	5	4.8
Rolling stock acquisition and operations***	5	4	3	4	4.0
<b>ASSESSMENT</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>4.4</b>

Legends	
Metrics	Values
High	5
Low high	4
Moderate	3
Low moderate	2
Low	1

Metrics highlights: \*According to the report of study for the City of Bulawayo (p. 258) approximately 40% of the city's roads are in poor and unaccountable state. This makes it a top priority for the city to resurface and reconstruct its roads. The urgency for this task is high and the technical ability to undertake this task by the council is high. \*\*Currently the waiting list for affordable houses for the city is standing at 115,000 according to the City of Bulawayo (2020b: p. 128). The proposal to introduce TTS on the corridors with the potential of having station precincts that can also cater for residential property development through private developers is a great opportunity for the city and that can resolve its huge housing waiting list. Thus, there is huge demand for affordable housing and the private sector have the capital and expertise to undertake this task efficiently and quicker. Developers are available with plans to pursue such projects and in conversation have expressed interest in how a PPP could enable a land development-based approach with an emphasis on solar electric systems for the housing as well as to recharge the TTS. \*\*\*Bulawayo is having some significant issues with its public transport systems evidenced by the sudden reintroduction of the State bus company, Zimbabwe United People Company Omnibus (ZUPCO). This alternative public transport system has run down the already poor city's public transport system. An alternative sustainable transport system is urgently required to catalyse the city's corridors' renewal and regeneration capacity. Trackless trams have the potential and capability to enable corridor renewals and regeneration (Ndlovu & Newman, 2020; Newman et al., 2019).

**Table 2.** City of Bulawayo PPP partners’ capabilities evaluation.

TTS Partners/players	Project milestones		
	Road construction	Trams station precincts construction	Rolling stock acquisition and operations
The City of Bulawayo*	3	2	2
Real estate developers**	2	3	1
Transport operators (TTS Consortium)***	1	2	3

**Legends (Comparative Advantage)**

Metrics
High
Medium
Low

Metrics highlights: \*Given its over 100 hundred years of experience and background in road construction, the City of Bulawayo have the comparative advantage in undertaking these tasks compared to other partners. Therefore, a partnership arrangement will do well in parcelling the risk of road construction to the City of Bulawayo as it stands well in managing this kind of risk in the project. \*\*Real estate developers’ core business is to develop commercial and residential properties (including station precincts and their surroundings), thus they should have some comparative advantage in managing such tasks efficiently compared to the other developers/partners in this potential PPP arrangement. This is a good opportunity for the City of Bulawayo to untangle itself from the old traditional culture of providing housing for its low-income residents and regulate to enable the developments around stations to include a certain proportion of affordable housing. The PPP would also enable other commercial and residential markets to be met along the TTS corridor as a way of helping to fund the TTS as part of the PPP. This must also involve the State Ministry of Housing. The private sector especially real estate developers should take a lead in the provision of residential properties and malls/station precincts as part of the PPP. The real estate developers will have a comparative advantage in leading this task, and they will be able to source capital from the private sector much more efficiently and easily compared to the other partners/developers in this potential arrangement. \*\*\*Transport operators have acquired the knowledge, experiences and comparative advantage to manage transport related entities. This acquired expertise does lead to some intrinsic comparative advantage for these players to undertake this task of providing and managing the operation of the rolling stock. Government’s role will be to integrate the TTS into the road network, regulate fares and routes to enable fair outcomes as well as facilitating a viable business.

Multifaceted PPP Model (TMPM) due to its emphasis on having three layers of business entities/corporations. This approach of structuring a PPP arrangement is referred to as the “layering approach”.

According to *Dube & Chigumira (2010)* the rehabilitate-operate and transfer (ROT) type of PPP involves an arrangement that is structured around an already existing infrastructure which is in a dilapidated state. Accordingly, the infrastructure is handed over to the developer who would refurbish, maintain and recondition it. The developer will then operate the infrastructure for a given period to recover its investment costs and get some return on the investment. After the agreed period, the infrastructure is to be transferred to the public authority. This seems as the best PPP arrangement that will suit the City of Bulawayo in order to upgrade almost half of its entire road network that are in a dire state as revealed by *City of Bulawayo (2020b: p. 258)*. The ROT arrangement is suitable

for the proposed layer one of the TMPM model.

The second layer/level of the TMPM suits the real estate developers and their associated multilateral institutions. These developers will be involved in the construction of the tram station precincts and the residential properties in the surroundings. These constructions are to be designed and built with a purpose to enhance and enable a transition towards achieving transit-oriented developments (TOD) of the corridors as discussed in the study by Ndlovu & Newman (2020a). The station-based precincts should enable the suburbs to leapfrog developmental and technological barriers (Ndlovu & Newman, 2020a; Ndlovu & Newman, 2020). The type and level of development on these precincts should incorporate the construction of the latest technologies such as large scale community based solar charged battery stations, rechargeable battery station for electric vehicles, distributed energy resources (DER) and fully functional malls to give the feel of new “town centres” as expounded by Ndlovu & Newman (2020a). These town centres or TOD’s should be designed with a focus to be the net negative electric cities portrayed by Kennedy et al. (2018). Within this layer, there are various standard PPP arrangements that could be considered for adoption depending on the developers’ risk tolerance levels. The ideal PPP arrangement for this layer is the build-own-operate (BOO) arrangement. This arrangement will cover the construction of the malls, commercial and residential properties around the station precincts. Should the city council be interested in providing funding for the construction of some infrastructure then a lease, develop and operate (LDO) arrangement could be considered as well. The estate developers will have to negotiate for partnership with various multilateral institutions such as the superannuation funds and local governments. Under the LDO the private sector/developers could also lease an existing facility and modernise it before assuming operations for a fixed time (Dube & Chigumira, 2010). The preferred type of PPP in this layer should ideally be structured as a BOO arrangement and thus allow the full potential of the private sector especially property developers’ creativity and innovativeness to flourish through building new multi-benefit infrastructure and properties that will lead the City of Bulawayo to be a city of the future, especially in an African context.

The TTS consortium, local transport operators and other public transport related operators will take a lead in this third layer of the proposed TMPM. The TTS consortium will reach out to the currently existing public transport operators and propose a new business corporation venture. Reaching out to the already existing players is crucial in order to reduce resistance which could delay the implementation of the project as was experienced by Sao Paulo, Santiago and Johannesburg in their BRT projects (Willoughby, 2013). The ideal PPP arrangement for this layer of the TMPM model is the build-own-operate-and-transfer scheme (BOOT). The BOOT arrangement has been widely adopted in most countries when it comes to public transportation projects. This arrangement is very flexible; it will allow players on this layer of the TMPM to provide and op-

erate the trams with little interference from authorities apart from setting regulations for integration into the city's road and transit networks, and the setting of fares. Thus, this layer will need to necessitate public good outcomes as well as enabling the players to recoup their investments costs and returns as quickly as possible.

## 6. Discussion and Conclusion

The two main determinants that enhance success of PPP projects are the bankability of the project, and the capability of the developers. What determines the bankability component is its financial viability, and the determinant of the capability component is having the right partners that are capable to undertake the tasks allocated to them efficiently. Both components are necessary and they depend to a large extent on each other. For example, structuring a partnership that will deliver PPP arrangements requires the allocation of various risks in the project to the right partner who is capable of managing that risk adequately. Allocating the wrong risk to a partner who is not capable of managing it could put the whole PPP arrangement into jeopardy and undermine its bankability. Thus, undertaking a partnership Bankability Assessment and a Capability Evaluation together in a way that recognises the local context depend a lot on determining what each partner should undertake in the project. This study has demonstrated how this combination of the two assessment components depends on a "layering approach" with three different PPP layers which together enable a PP to recognise the strengths of each partner, both government and private developer. This is the TMPM model for the potential TTS project for the City of Bulawayo.

The World Bank Group (WBG) does have various funding programs whereby they can provide loans to PPP project companies via Special Purpose Vehicles (SPVs), and also provide financing to the public sector side of PPPs through sovereign loans. This means with a multilayered PPP model, different partners could utilise different funding arrangements from the WBG. Also, according to [Dauskardt & Ganguly \(2020\)](#) the IFC Subnational Finance Program of the WBG provides municipal financing directly to municipal and regional governments, and their service entities including for PPPs that provide key subnational infrastructure services. The City of Bulawayo's credit ratings are higher than the country's ratings making it ideal for it to access the IFC municipal loans for its potential PPP projects.

It is also possible to access funding from the UN Climate Fund as the electric transit with solar-based urban regeneration is a model for leap frogging in any emerging city seeking to contribute to reductions in global warming as set out in the Paris Agreement ([Masson-Delmotte et al., 2019](#)).

The TMPM model developed in this study is pragmatic and more realistic to enable the adoption of the TTS by the City of Bulawayo. The model also factored in some lessons learnt from some observed PPPs that were successfully implemented in public transportation sectors around the globe especially in South

American countries. The study also utilised the Polish experience of limiting the capital risk exposure to the players by delineating the project into three small manageable segments or layers. Poland utilised the strategy of segmenting the construction of its A2 Toll Motorway project into smaller construction phases or sizes. In a little deviation to the Polish approach, the TPM model does split the “vertical” size of the project into smaller sizes thus lowering the capital risk exposure by distributing it to many players while still implementing the whole project. The TPM structure is ideal for the City of Bulawayo on many fronts, and it can also be easily adopted by other cities that are facing some financial difficulties funding their public infrastructure projects and who would also like to seek other multiple benefits as in this project.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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