



UNIVERSITY OF  
**KWAZULU-NATAL**

---

INYUVESI  
**YAKWAZULU-NATALI**

**University of Kwa-Zulu Natal**

Howard College Campus

**School of Built Environment and Community Development**

-----MASTERS IN TOWN AND REGIONAL PLANNING-----

Name:

**PHUMLANI Z.M GUMEDE**

**(210509228)**

Topic:

**Energy & Transportation Planning: Evaluating an integrated active pavement template for transport interchange zones, as a renewable energy strategy for informal trade - The case study of the Warwick Transportation Precinct located near the eThekweni Central Business District**

Supervisor:

Prof. M. Dayomi

## **DECLARATION**

Submitted in fulfilment/ partial fulfilment of the requirements for the degree of **Masters in Town & Regional Planning**, in the Graduate Programme in School of Architecture & Planning, University of KwaZulu-Natal, Durban, South Africa.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. I confirm that an external editor was/ was not used and that my Supervisor was informed of the identity and details of my editor. It is being submitted for the degree of Masters in the Town & Regional Planning in the Faculty of Humanities, Development and Social Science, University of KwaZulu-Natal, South Africa. None of the present work has been submitted previously for any degree or examination in any other University.

---

**Student name**

---

**Date**

## **ACKNOWLEDGEMENTS**

I would like to firstly thank the *Spirit of Humanity* that has guided my instincts through the unknown, until I was able to reach this milestone of completing my master's research. I would also like to dedicate this research paper to my mother, Thokozile Nkomo, who has been my unseen inspiration and deep well of motivation to doing the best that I can at all times'. I would also like to thank all of my close friends, family members, UKZN staff members and complete strangers who were able to give me a moment of their time to engage them on my research and were able to positively comment on how to stay innovative whilst also being realistic. And also I would like to send my deepest gratitude to my supervisor Prof. M Dayomi.

## ABSTRACT

In trying to find alternate renewable energy sources and harnessing methods, the one method that could have mass scale potential within the Warwick transportation precinct is that of integrated active pavements. These are pressure membranes or piezoelectric material that could be integrated into the pavements of high frequency mobility spaces, to harness the mechanical pressure and convert it into electric energy. By formulating a spatial template for transport interchange zones (taxi ranks) within Warwick Junction and along Julius Nyerere Road, by conducting on-site observation studies, focus group interviews with public traders and in-depth interviews with municipal officials and civil society organisations and pedestrian counts along the corridor, we could map out the potential catchment areas for harnessing mechanical energy from pedestrian and vehicular traffic; this would be in accordance with tolerance thresholds of the piezoelectric materials used. Beyond the implementation of such a spatial template within Warwick Junction, we also hope to expand the scope of the municipal renewable energy strategy to include piezoelectric pavements and the mutual existence of public traders. The latter party, public traders, has been marginalized over time whenever development has come upon the Warwick Junction Precinct and therefore, the voices and views of public traders have been largely considered within this research.

Even though renewable energy strategies can be simple in process, the conceptualization of integrated development would call upon an urban development strategy that is resilient and is able to maximise the knock-on effects of socio-economic growth, local innovation and carbon emissions reduction. By understanding the spatial function and socio-economic nature of mobility spaces, we can explain how pavements have a dual purpose that could see local off-grid energy-generating systems, making a positive contribution towards local renewable energy generation and in improving spatial efficiency by acknowledging all variables that make up an African City.

**Keywords:** African City, piezoelectric pavements, precinct planning, public traders, renewable energy, mobility spaces, kWh, sustainable, transport interchange zone, integration, infrastructure, pedestrians, resilient, smart growth, Warwick Junction, Julius Nyerere Road

# TABLE OF CONTENTS

<b>1. CHAPTER 1 – RESEARCH INTRODUCTION</b> .....	1
1.1 INTRODUCTION.....	1
1.2 BACKGROUND AND MOTIVATION FOR THE STUDY.....	1
1.3 RESEARCH STUDY AREA .....	3
1.4 STATEMENT OF THE PROBLEM .....	8
1.5 THE HYPOTHESES .....	8
1.6 AIM AND OBJECTIVES OF RESEARCH .....	8
1.6.1 RESEARCH AIM .....	8
1.6.2 RESEARCH OBJECTIVES.....	9
1.7 RESEARCH QUESTION AND SUB-QUESTIONS.....	9
1.7.1 RESEARCH QUESTION .....	9
1.7.2 SUB-QUESTIONS.....	9
1.8 LIMITATIONS TO RESEARCH.....	10
1.9 KEY DEFINITIONS.....	11
1.9.1 PUBLIC TRADER .....	11
1.9.2 PIEZOELECTRIC SYSTEM .....	14
1.9.3 ACTIVE PAVEMENTS.....	15
1.9.4 MOBILITY (PEDESTRIAN) SPACES .....	16
1.9.5 PUBLIC TRANSPORTATION INTERCHANGE ZONE.....	16
1.10 METHODOLOGY .....	17
1.11 STRUCTURE OF THE DISSERTATION .....	18
<b>2. CHAPTER 2 – THEORETICAL FRAMEWORK &amp; LITERATURE REVIEW</b> .....	20
2.1 THEORETICAL FRAMEWORK .....	20
2.1.1 INTRODUCTION.....	20
2.1.2 URBAN MANAGEMENT .....	20
2.1.3 INTEGRATED AREA DEVELOPMENT .....	25
2.1.4 PAVEMENT ECOLOGY.....	36
2.1.5 GREEN ROAD CONCEPT.....	51
2.1.5.1 MICRO-RENEWABLE ENERGY SOURCES.....	55
2.1.6 CONCLUSION TO THEORETICAL FRAMEWORK .....	61
2.2 LITERATURE REVIEW .....	63

2.2.1 INTRODUCTION .....	63
2.2.2 INFORMAL ECONOMIES AND RENEWABLE LIVELIHOODS .....	63
2.2.2.1 PUBLIC TRADERS .....	65
2.2.2.2 URBAN PAVEMENT FUNCTION .....	68
2.2.2.3 INFROMAL INNOVATION .....	70
2.2.2.4 THE GREEN ECONOMY AND INFORMALITY .....	73
2.2.3 PIEZOELECTRIC TECHNOLOGY.....	80
2.2.3.1 STRATEGIC APPLICATION OF PIEZOELECTRIC TECHNOLOGY WITHIN TRANSPORTATION PLANNING AND URBAN PLANNING .....	81
2.2.3.2 CO-EXISTANCE TO DRIVE THE GREEN PAVEMENT ECOLOGY .....	82
2.2.4 SUSTAINABLE ENERGY TO POWER AND EMPOWER URBAN DEVELOPMENT .....	83
2.2.4.1 ENERGY HARNESSING SPATIAL TEMPLATES DEVELOPING URBAN DISTRICTS .....	84
2.2.4.2 SOUTH AFRICAN PRECEDENCE.....	87
2.2.5 CONCLUSION TO LITERATURE REVIEW .....	90
<b>3. CHAPTER 3 - RESEARCH METHODOLOGY .....</b>	<b>92</b>
3.1 INTRODUCTION.....	92
3.2 RESEARCH METHODOLOGY APPROACH .....	92
3.2.1 RESEARCH PARADIGM .....	92
3.2.1.1 QUANTITATIVE DATA .....	93
3.2.1.2 QUALITATIVE DATA .....	94
3.3 RESEARCH DESIGN AND PURPOSE .....	95
3.4 THE DUAL SYSTEM APPROACH .....	96
3.5 RESEARCH SAMPLING METHOD.....	98
3.5.1 NON-PROBABILITY.....	98
3.6 RESEARCH TOOLS AND METHODS .....	98
3.6.1 PROXEMICS PARTICIPANT OBSERVATION STUDY .....	99
3.6.2 IN-DEPTH INTERVIEWS.....	99
3.7 DATA COLLECTION & ANALYSIS PROCEDURE .....	102
<b>4. CHAPTER 4 – DATA ANALYSIS .....</b>	<b>104</b>
4.1 INTRODUCTION.....	104
4.2 INTERVIEW ENGAGEMENT.....	105
4.2.1 Urban Practitioners.....	105

4.2.2 Public Traders.....	110
4.3 CONCLUSIONS TO CHAPTER FOUR. ....	118
<b>5. CHAPTER 5 – RESEARCH FINDINGS .....</b>	<b>119</b>
5.1 INTRODUCTION.....	119
5.2 THE PIEZOELECTRIC PAVEMENT TEMPLATE CONCEPT .....	119
5.3 PIEZOELECTRIC PAVEMENT TECHNICAL COMPONENTS .....	122
5.4 SPATIAL TEMPLATE FOR PIEZOELECTRIC PAVEMENTS .....	125
5.5.1 RENEWABLE ENERGY PAVEMENT ECOSYSTEM .....	128
5.5.2 PREFESABILITY STUDY ON JULIUS NYERERE ROAD .....	130
5.5.2.1 BENEFITS TO ETHEKWINI MUNICIPALITY .....	133
5.7 CONCLUSION TO CHAPTER FIVE .....	134
<b>6. CHAPTER 6 – RESEARCH SYNOPSISIES .....</b>	<b>136</b>
6.1 INTRODUCTION.....	136
6.2 REVIEW OF RESEARCH QUESTIONS AND OBJECTIVES .....	136
6.3 RESEARCH SYNOPSSES .....	137
6.4 RECOMMENDATIONS.....	139
6.5 CONCLUSION.....	142
REFERENCES.....	143
APPENDIX.....	151

## **LIST OF ABBREVIATIONS**

CBD	Central Business District
GDP	Gross Development Product
Kwh	Kilo-Watt Hour
KZN	Kwa-Zulu Natal
LED	Local Economic Development
MWh	Mega Watt Hour
NDP	National Development Plan
NMT	Non-motorized Mode of Transportation
PZT	Piezo Zirconate Titanate
SG	Smart Growth
TIZ	Transit Interchange Zone
TOD	Transit-Oriented Development
UIP	Urban Improvement Plan

## **LIST OF DIAGRAMS**

Diagram 1: Multiple layers of '*public trade*'

Diagram 2: Kinetic energy converted to energy

Diagram 3: Smart Growth (SG)

Diagram 4: Road hierarchy and classification

Diagram 5: The three pillars of Green Urbanism

Diagram 6: Main urban dimensions for creating a smart green city

Diagram 6: Asphalt Solar Collector

Diagram 7: Piezoelectric pavements

Diagram 8: Application and uses of piezoelectric pavements



Diagram 9 : Electro-kinetic ramp for road use

Diagram 10: Piezoelectric pavement implementation within a mobility corridor

Diagram 11: Piezoelectric pavement template at an intersection

## **LIST OF GRAPHS**

Graph 1: Annual production of solar electricity from SolaRoad project

Graph 2: Transport modal share of 3<sup>rd</sup> World Cities

Graph 3: EThekwini Municipality Electricity Demand

## **LIST OF FIGURES**

Figure 1: Julius Nyerere Road - Study Locality Plan

Figure 2: Aerial photograph showcasing intersections and significant land uses

Figure 3: Aerial photograph locating Julius Nyerere Road



# **1. CHAPTER 1 – RESEARCH INTRODUCTION**

## **1.1 INTRODUCTION**

The purpose of this dissertation is to present a theoretical solution worth evaluating, which is the use of piezoelectric pavements, which could be utilised as a strategic tool to integrate transportation planning and energy planning for the sustainable development of public transportation interchange zones. By proactively formulating a spatial template of where piezoelectric pavements could be implemented within mobility spaces, the research sets out to explore the efficiency of harnessing the frequently available kinetic energy from pedestrian foot-fall, into a renewable energy source that empowers informal trader (informal catering trade) innovation and public infrastructure efficiency within public transportation interchange zones. It is the researcher's assumption that pedestrian foot-fall within public transportation precincts could guide the application of piezoelectric pavements at well-located catchment areas, with regards to frequently utilised pavement routes. The pedestrian footfall pattern could connect the pedestrian mobility space network throughout the city, thus yield enough renewable energy to power and sustainably empower the informal catering trade, which is synonymous with public transportation interchange zones in most South African cities.

## **1.2 BACKGROUND AND MOTIVATION FOR THE STUDY**

If precinct planning for integrated transport nodes, such as those at Warwick Junction, for example, were to consider the renewable energy production potential of strategic active pavements, in meeting growing energy demands of public/informal traders, whilst contributing to precinct energy efficiency, then this could be an innovative application for public transport hubs to be able to empower their own economic activities in an energy self-sufficient manner, that is also sustainable (DPLG, 2000, Nomico and Sanders, 2003, DoE, 2008, Bekker et al., 2008 ,SANEDI, 2011).In the context of an African city , which is plagued by unsustainable energy trends such as frequent power disruptions, a heavy fossil fuel (coal, gas, wood) dependency by public traders and illegal electricity connections by various informal traders as well (O'Connor, 2013, The African City :41), precinct planning requires greater detail when planning the shape, form and function of public spaces and their mobility networks. If local municipalities and

metropolitan cities such as Durban seek to find resilient solutions to the growing energy demands of the informal sector, then there needs to be an understanding of the African City before we can start conceptualizing a renewable energy future for African cities.

The African city exists and needs to be developed according to its spatial and functional merits as highlighted by leading African academics in planning and architecture, such as Osman and Motsepe (Nomico and Sanders, 2003). In addition, the African city is also characterised by an urban form that imitates the western system in terms of spatial layout, yet co-exists with traditional ways of trade that are unique, resourceful and innovative in response to local public needs (Web.1: Sturgis,2015). The socioeconomic status quo is predominantly informal, whether it is by illegal spatial occupation or informal infrastructure, and public traders partake in informal economic activities to generate an income and sustain their livelihoods. Within a precinct such as Warwick Junction, the informal sector has become a sphere or hub of trade, where a variety of traders have gathered and have developed advanced socioeconomic networks and trading strategies, that serve the purpose of either the individual trade who is trading at a survivalist level or at a sustained accumulative rate. The difference between the former and the latter is that, the survivalist trader is usually operating illegally and the latter operates under a municipal permit at a designated spatial location for informal traders (Lourenço-Lindell, 2002).

This foundational framework helps to identify the Warwick Junction as a precinct that is characterized by the African city status quo for trade by its physical function and form as a market place and a regional public transportation hub. The latter is of higher importance to the research as the precinct enjoys a high level of commuter traffic utilising mini-bus taxis, buses, trains, private vehicles and other non-motorized modes of transportation (Open City Project, 2012). Drawing from the views held by Nomico and Sanders (2003:211), the obvious path for development of African cities is the development of pedestrian corridors that will supplement the already existing vehicular pavement so as to ease the flow of commuter traffic in a canalized manner.

What makes Warwick Junction a relevant site for research is that it offers the opportunity to evaluate, within an African City context, how the informal trading space, that being pavements for pedestrian mobility, could be successfully integrated into a strategic spatial template for public transport interchange nodes (taxi ranks), in an attempt to create a public-space that has a self-sufficient energy system that meets local trader (informal catering) needs (lighting or heating) at a reasonable price for the municipality.

It is the researcher's intention to take advantage of the high pedestrian footfall movement generated within public transport interchange zones at the selected Warwick Junction and evaluate the potential for future implementation of piezoelectric pavements.

### **1.3 RESEARCH STUDY AREA**

Within the Warwick Junction, the primary objective of the research was to focus on the main trunk road or regional corridor that is, Julius Nyerere Road (R102), which has been the skeleton frame for the manifestation of the vibrant mobility corridor for pedestrian commuters and also lucrative for all sorts of public traders, such as the informal catering trade that's situated alongside the bustling motor vehicle lane or within a taxi-rank. In its functional capacity as a regional transportation precinct that is situated on the western edge of the Durban CBD, it is the connecting point to the N2, N3, and R102 roads throughout the province and beyond and in its structural form, it is formed by the linking of the Berea Train Station, Victoria Bus terminus and the Early Morning Market (Web 1.). The extent of the study area alongside the Julius Nyerere Road will be at intersection points from University Avenue up to North Old Dutch Road intersection, resulting in a 660m stretch of a high density mobility corridor. The urban corridor that is Julius Nyerere Road, has surrounding land that is used for enterprises that are able to attract and satisfy commuter amenity needs. There are retail supermarkets such as Cambridge, Jwayelani and Simunye Meat Market, fast food franchises such as Pie City, Chicken Licken and Honchos and clothing retailers such as Ozzys and Kwa Malume. In addition to these formal establishments for business, we find a high number of public traders/ informal traders who

occupy the pedestrian reserve and vehicle pavements of the mobility corridor (eThekweni Municipality, 2014)<sup>1</sup>.

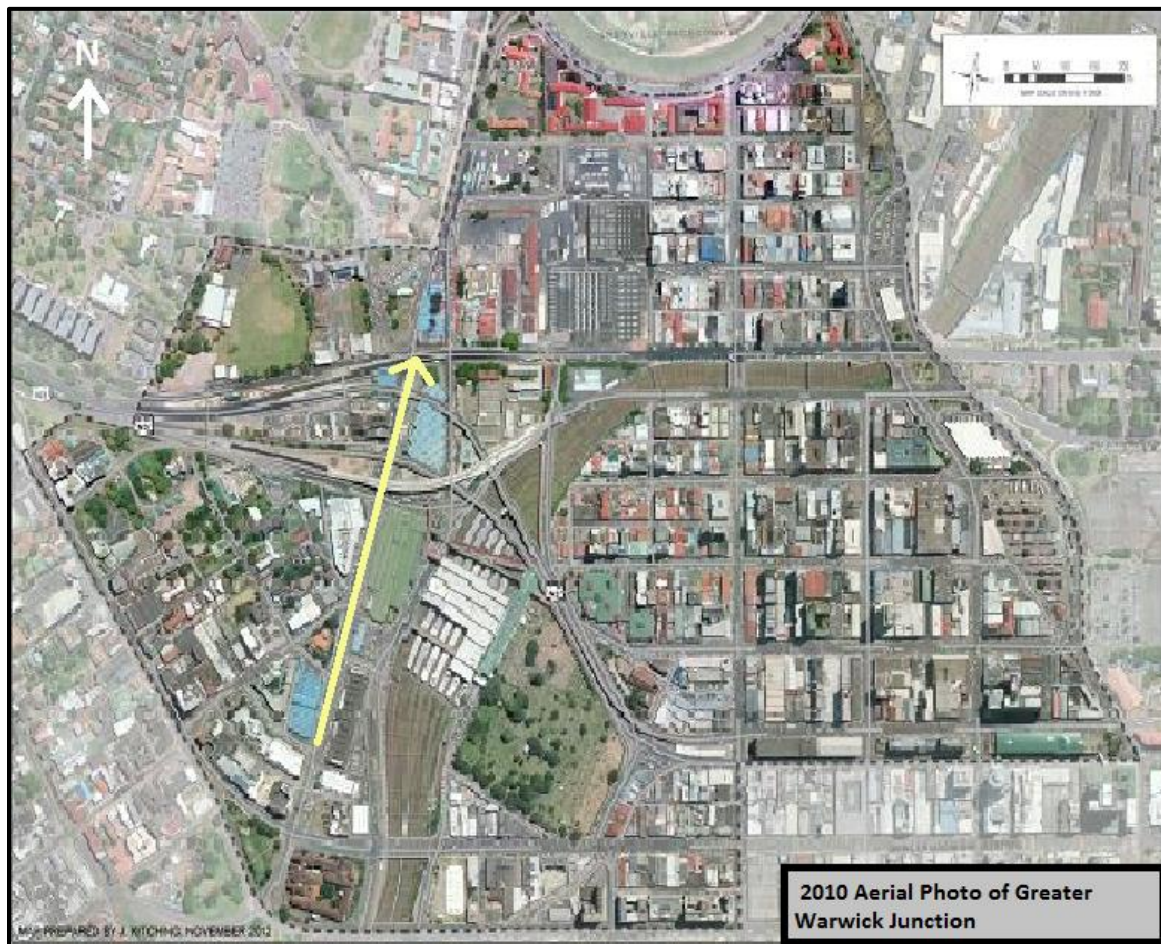


Figure 1: Julius Nyerere Road - Study Locality Plan (UIA 2014 Durban, 2014)<sup>2</sup>

Pavement activity is mainly characterised by informal trade and the majority of that trade deals with the selling of food, some of which is prepared on site. Other items include fresh fruit. There is also a large presence of street vendors who are seasonal and who are also a lot harder to cater for as they are mobile through the city as they seek the best spot to sell their non-perishable goods. The trading constituency is made up of 40 percent trading in fresh produce, 35 percent involved in informal catering and on-site preparation of food, 15 percent trading in

<sup>1</sup> *Greater Warwick Project Area Socio-Economic Needs Assessment* of 2014 was viewed at the GO! Durban offices, under the supervision of Nick Combrink on 06/30/2015, due to it having been approved by the municipal council for publication at the time of research.

<sup>2</sup> The aerial photograph was sourced from [http://www.uia2014durban.org/student\\_competition/warwick\\_junction\\_site\\_diagrams.htm](http://www.uia2014durban.org/student_competition/warwick_junction_site_diagrams.htm) (Accessed:6/30/2015).and it was edited by the researcher.

non-perishable goods such as clothing, shoes, hardware material, electronic goods (CDs and DVDs) and electronic material (lighting globes, conducting wire) and finally 10 percent of the mobility space is utilised for pedestrian commuting, public vending for cell phone starter packs, and public advertising. The informal cart hauling of goods does not occur on the pavement reserve as the space is limited but follows the pedestrian route along the vehicle reserve staying as close to the pavement as possible. There are some traders who have taken to the fringes of taxi ranks and are able to service commuters within the taxi rank and the regular pavement commuters through the corridor (eThekweni Municipality, 2014)<sup>3</sup>.

On a daily average, the Warwick precinct receives and accommodates 460 000 commuters and at least 6000 street vendors (Web 1). It also has four major regional taxi ranks and many start points for local mini-bus taxis, along the vehicle pavement reserve of Julius Nyerere Road that serves as an informal public transport interchange zone and there is one major bus terminus opposite Cambridge Supermarket. This makes Warwick Junction open spaces a thriving location for sustainable socio-economic opportunities for the majority of the public traders and sets an example for other thriving African city public transportation hubs to enhance the development of a sustainable informal/public economy within the precinct to alleviate urban poverty (South African Regional Poverty Network (SARPN), 2003: 6). However the 660m road segment along Julius Nyerere Road, that's of research interest has 6 intersecting roads when traveling north-bound (eThekweni Municipality, 2014; 426)<sup>4</sup>.

- **University Avenue -15574 pedestrians per day**
- **Wills Road - 17242**
- **Lancers Road - 22888**
- **Acorn Road - 29304**
- **Cannongate Road / N3 North bound - 36456**
- **North Old Dutch Road – 32550**

---

<sup>3</sup> Greater Warwick Project Area Socio-Economic Needs Assessment of 2014 was viewed at the GO! Durban offices, under the supervision of Nick Combrink on 06/30/2015, due to it having been approved by the municipal council for publication at the time of research.

<sup>4</sup> Greater Warwick Project Area Socio-Economic Needs Assessment of 2014 was viewed at the GO! Durban offices, under the supervision of Nick Combrink on 06/30/2015, due to it having been approved by the municipal council for publication at the time of research.



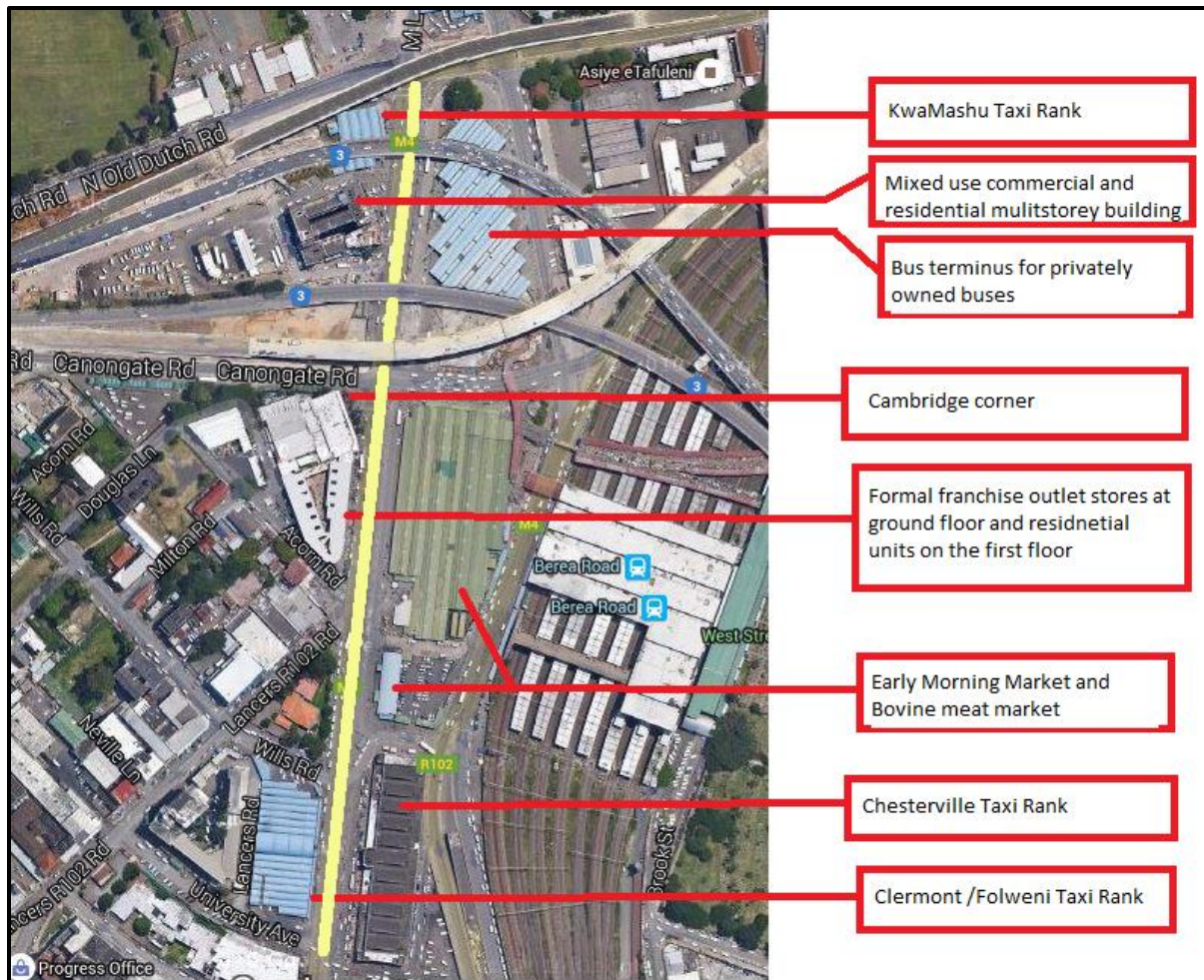


Figure 2: Aerial photograph showcasing intersections and significant land uses (Source: Google Maps)<sup>5</sup>

In total, these intersections are able to accommodate 154 014 pedestrian commuters per day and this was just along one of the major mobility corridors in the city and Warwick Junction Precinct as a whole. This figure took account of their being two main peak sessions of pedestrian commuting (eThekweni Municipality, 2014; 426)<sup>6</sup>. The map above illustrates the multiple land uses that are available along the 660m mobility corridor segment and also highlights the issue of dense zones that could be the primary areas for the implementation of the piezoelectric pavement. There is a contingent of approximately 76 public traders along the 660m section with an average of 8 – 9 traders for every metre of the pedestrian road reserve

<sup>5</sup> The aerial photograph was edited by the researcher and Julius Nyerere Road is depicted in yellow.

<sup>6</sup> *Greater Warwick Project Area Socio-Economic Needs Assessment* of 2014 was viewed at the GO! Durban offices, under the supervision of Nick Combrink on 06/30/2015, due to it having been approved by the municipal council for publication at the time of research.



as obtained from physical observation on Julius Nyerere. This may seem congested, but the spatial organisation of each trader is to interact with commuters as they are canalised while moving along the mobility corridor.

On average per intersection, we find that;

- From University Avenue to Willis Road there are taxi ranks that attract more than 6000 commuters a day. This large contingent of informal catering outlets exists adjacent to the Early Morning Market and seems complimentary, planning wise, and convenient for commuting customers. Some have permits while others operate at the risk of having goods confiscated.
- From the Willis Road intersection to the Lancers Road intersection, we find the prevalence of fresh produce trading and also informal catering. This portion of the road is also utilised for mini-bus taxi holding during off-peak hours of the day from 9 a.m. to 3 p.m.
- At the intersection of Lancers and Acorn with Julius Nyerere Road, we find that there are a lot of street vendors, informal caterers and fresh produce traders. We also find that there is also a prevailing number informal cart haulers parked on the road reserve or along the vehicle pavement.
- From Acorn Road intersection to the Cannongate we find a lot of non-perishable goods traders and street vendors who occupy the space outside formal chain stores and businesses. The *Cambridge corner*, as it's known to taxi drivers, is densely populated by pavement resident trading, itinerant traders and also a high vehicle traffic zone since the Cannongate road is an on-ramp to the N3 national freeway. A few fresh produce traders are present but not as many as in other areas.
- From Cannongate Road to Old North Dutch Road, we see informal caterers, fresh produce traders and also public vending that's occurring on the vehicle reserve and also on the pedestrian pavement.

The dense spatial nature of the Warwick Junction, provides the opportunity to exploit integrative energy strategies that can accommodate all present stakeholders through unlocking

the renewable energy potential, beneath pedestrian footsteps, as proposed for all municipalities within the National Development Plan (NDP) for 2030 (2012: 60)

#### **1.4 STATEMENT OF THE PROBLEM**

It is the researcher's assumption that public transport interchange zones within urban commercial districts are starved of a sustainable alternative energy source to prevent the informal catering industry from utilising fossil fuels and making use of illegal power connections. Even though many pavement traders are not set up in formal trading structures, they are regarded as parasites occupying public transport precinct pavements. On the other hand, the informal economy of Warwick Junction still contributes millions of rands annually to the over-all GDP of the eThekweni Municipality (Open City Projects, 2012). It attracts pedestrian foot-flow towards formal business and is an unemployment safety net (Skinner, 2009). Pavement occupation is a sensitive subject for the Municipality, but informal/public traders and civil society groups, are key stakeholders who would have to play a major role in the success of the piezoelectric pavement application. Since the city is still seeking innovative ways for area-based development under the *Urban Improvement Precinct (UIP) Policy*, the main focus on developing public transport and public trading precincts, should begin with pavements and mobility spaces, which could pave the way to having energy efficient public spaces that are sustained by a renewable energy economy within the Warwick Junction (Open City Projects, 2012).

#### **1.5 THE HYPOTHESES**

The researcher hypothesises that the implementation of piezoelectric pavements within public transportation precincts and public transport interchange nodes could leverage from intense pedestrian traffic at strategic intersections and along pedestrian corridors, a renewable energy source for on-site utilisation.

#### **1.6 AIM AND OBJECTIVES OF RESEARCH**

##### **1.6.1 RESEARCH AIM**

The main aim of the research is to evaluate the possibility of harnessing piezoelectric energy from strategic pavements, within the public transportation precinct at Warwick Junction, which

could be a renewable energy source for the informal economy within the perimeters of the precinct. Efficient precinct planning could be part and parcel of a proactive strategic approach towards spatial planning and energy planning, as the energy generated on site could be utilised for the benefit of all stakeholders and income-generating activities within the public transportation precinct.

### **1.6.2 RESEARCH OBJECTIVES**

- I. To identify the potential of Warwick Junction pedestrian/trading (mobility) spaces and their pavements, as being the focal point for harnessing piezoelectricity from pedestrian movements and public transport traffic at strategic points and corridors within the precinct.
- II. To investigate if proactive precinct planning of public transport nodes could maximise energy generation to meet energy demands of informal/public traders within the Warwick Junction pedestrian/trading (mobility) spaces.
- III. To evaluate how effective the Warwick Junction piezoelectricity harnessing pavement system would be for Julius Nyerere Road informal/public traders, by formulating an energy generating spatial template.

## **1.7 RESEARCH QUESTION AND SUB-QUESTIONS**

### **1.7.1 RESEARCH QUESTION**

*Could proactive precinct planning for public transportation precincts, be able to take advantage of the high rate of pedestrian movement on pavements within public transport node perimeters, in order to provide a reliable and efficient source of renewable energy?*

### **1.7.2 SUB-QUESTIONS**

- Which spatial principles need to be followed to uphold the factors of sustainable development?
- What are the current energy consumption patterns of informal/public traders and where does the energy come from?
- In relation to pavements being strategic zones to public transport nodes and with reference to energy generation, to what extent could we benefit from the high volume of pedestrian movements within public transportation precincts, such as Warwick Junction?

- How does harnessing of renewable energy via the piezoelectric pavement system compare to any other renewable energy technology?
- How can access to renewable energy increase economic development within these mobility spaces?
- Within the framework of the National Development Plan (NDP) for 2030 and other comprehensive plans by the municipality (eThekweni Municipality IDP, 2010 Greening Durban, 100 Resilient Cities Centennial Challenge), how can the implementation of renewable energy technology empower people and help sustain energy use?

## 1.8 LIMITATIONS TO RESEARCH

- With regards to pavement infrastructure, the pedestrian sidewalk within the precinct is not maintained to the best standards by the municipality due to budget constraints. The storm water and road services to some transport nodes is poor and thus would prove challenging for strategic pavement implementation. Flooding that is caused by a build-up of litter in drainage channels reduces the circulation of pedestrians within the vicinity of the area.
- Some transport nodes (taxi start-point) are informal in terms of their location, even within the transportation precinct.
- Another point of contestation is that the informal/ public traders are already illegally occupying the pavements and running businesses that do not abide by Municipal by-laws for trade and energy use in a public space. Informal/public catering traders in public transport nodes have not fully transformed public trading space that is suited to their energy needs for a variety of economic activities.
- Traders already have a tried and tested method of preparing their food and so convincing them to utilise new technology may be difficult if the cost offsets are not in their favour in terms of profit margins.
- Pedestrians do not always follow the formal pedestrian pavement reserve that is already provided. This habit has been exacerbated as they walk from the perspective of convenience, which means moving from point A to B directly and not along the road

sidewalk. This means that pin-pointing the strategic points of pedestrian traffic alongside the sidewalk is crucial.

- Public traders may feel that the municipality is unjustly leaching off their presence, since the public transportation precinct is characterized by mini-bus taxi interchange zones (taxi ranks) and the predominant presence of informal trading activities.

## 1.9 KEY DEFINITIONS

Since the research topic requires the integration of constructive concepts within transportation planning, spatial planning and energy planning in a manner that has not been undertaken before in town planning literature, the researcher has provided key terms with their appropriate definition, which compliments the research objectives set out earlier.

### 1.9.1 PUBLIC TRADER

The term 'public trader' encompasses all of the terms that are illustrated in the diagram below to show how the term 'public trader' may be able to drive the point home as to how and why it is the most suitable term to define the public space enterprise agents within the African city context. According to the *Improved Management and Control of Itinerant Traders - Policy Framework of 2012*, which was the follow-up policy document to *Durban's Informal Trader Policy of 2001* we are presented with the following definitions that are vital pillars profiling public traders.

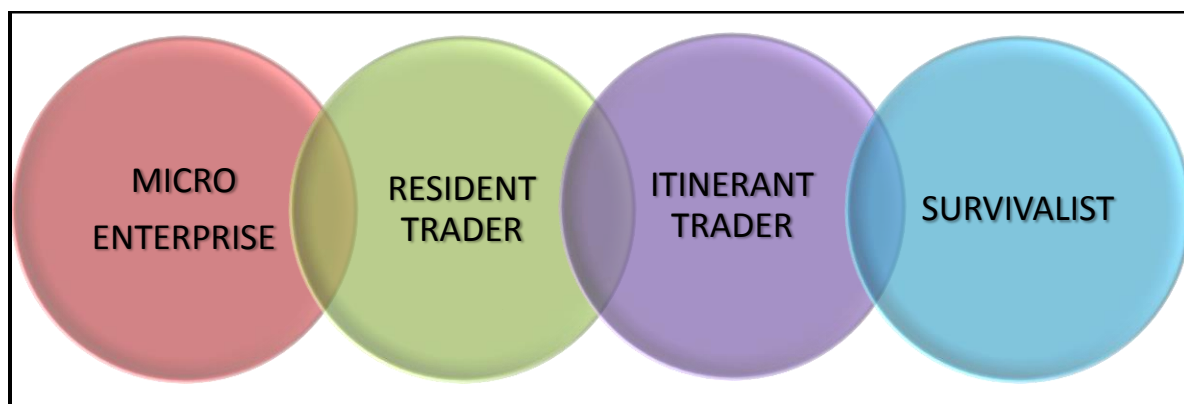


Diagram 1: Multiple layers of 'public trade'(Source: Researcher, 2015)<sup>7</sup>

<sup>7</sup> The inter-relatable terms that describe the prevalent agents of public trade that exist within the public transportation precinct of the Warwick Junction

### **AGENTS OF PUBLIC TRADE**

- A Micro enterprise refers to very small businesses, characterised by the owner and some family members who are working for the business and at most two paid employees.
- Resident traders are area based traders who trade from a specific site. Usually site access is via a permit issued by the Municipality. The trader may also have to travel some distance to get to the trading site.
- Itinerant traders are mobile traders who travel as they trade. These include cart vendors, and those who use different modes of transportation such as trains, private vans or they walk using display means such as polystyrene boards. They have no fixed space or formal location for their trading activities.
- Survivalist traders operate on a small scale. The enterprise is limited to one man/woman, whose income hardly sustains the trader and his family.

(Source: *Improved Management and Control of Itinerant Traders - Policy Framework of 2012:2*)

The term 'public trader' implies that all trading activities that are to be undertaken by individuals or a group of individuals, shouldn't be categorised as being informal due to not being operational from a formal structure made of bricks and mortar (*Itinerant Traders - Policy Framework of 2012*) but should rest on how trading activities are undertaken and also as to the spatial perimeters within which the individual or individuals are operating. The 2001 policy document only dealt with resident informal traders, who were informal due to them not operating from mortar and brick structures, having no legal trading permits and also mainly trading from pavement reserves (Durban's Informal Trader Policy, 2001). In the 2012 policy document we saw official consideration being extended to those who were mobile and weren't resident traders or operated a micro enterprise but were survivalist in their nature of operation and were in contractual agreements to trade within public spaces in a manner that is

categorised as ‘informal trading’ for a formal and reputable franchise like Pie City (Itinerant Traders – Policy Framework, 2012).



Image 1: Itinerant traders along Julius Nyerere Road

(Source: Researcher, 2015) <sup>8</sup>



Image 2: Formal franchise trading in an itinerant manner along the mobility corridor and within the Warwick Junction precinct. (Source: Research, 2015)<sup>9</sup>

---

<sup>8</sup> On-site visit and observation

<sup>9</sup> On-site visit and observation





Image 3: Fresh produce resident traders at an intersection along mobility corridor (Source: Google Maps, 2015)<sup>10</sup>

### 1.9.2 PIEZOELECTRIC SYSTEM

Piezoelectric systems are able to harness the excess energy that is lost on to pavements due to the application of mechanical pressure from kinetic energy sources such as footsteps and/or motor vehicle wheels (U.S. Department of Transportation, 2013). When there is a pressure load on the piezoelectric-embedded pavement, there is a displacement of an electrical charge from piezoelectric generators which are the crucial component for the generation of this electricity (Pramathesh and Ankur, 2013 and Innowattech Energy Harvesting System, 2012). The key is that the energy harnessed is then converted to electrical power that could be utilised on-site in transportation facilities (Pramathesh and Ankur, 2013). In an age when renewable energy sources have the capability to improve the efficiency of local energy provision at a competitive price, the development of smart grids by utilising the piezoelectric pavement system could be a

---

<sup>10</sup> Micro – enterprises operating along the mobility corridor where they can get maximum exposure to commuters, whilst trading from informal infrastructure, as resident traders. This is at the intersection of Lancer and Julius Nyerere road.



viable alternate source to supplement the national grid when energy demand threatens the grid capacity (Pramathesh and Ankur, 2013, Innowattech Energy Harvesting System, 2012).

The application of strategic kinetic (active) pavements (energy harnessing segments of pedestrian walk ways) leading to public transportation precincts must be feasible and the pavement material needs to be durable and resilient to all sorts of pressure, strains and climatic conditions (U.S. Department of Transportation, 2013, Pramathesh and Ankur, 2013). They need to be able to resist wear and tear, and damage due to excessive pedestrian presence and also from vehicular presence, which would require the use of multiple generator platforms that are constructed from thin piezoelectric ceramic or polymer layers (Web.4).

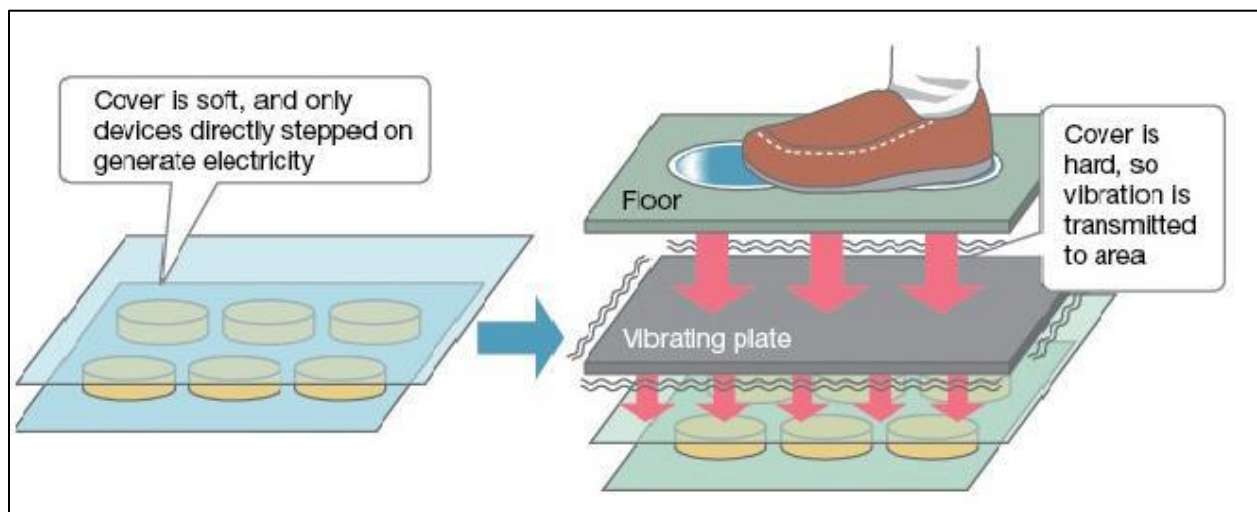


Diagram 2: Kinetic energy converted to energy (Source. Pramathesh and Ankur 2013:261)

### 1.9.3 ACTIVE PAVEMENTS

Active pavements are piezoelectric embedded pavement surface areas within mobility spaces that are stepped on by pedestrians to produce an electric charge that is to be stored on-site (U.S. Department of Transportation, 2013). Besides being referred to as active pavements they could also be seen as strategic kinetic pavements embedded with piezoelectric generators, since they would be well-located at public transport nodes and at busy pedestrian intersections within public transportation precinct perimeters. By taking advantage of the most frequently utilised pedestrian routes and taxi rank high rise kerbs that host a variety of public traders, we could maximise energy generation potential over high pedestrian footfall zones. (Web 2)

#### **1.9.4 MOBILITY (PEDESTRIAN) SPACES**

These are urban corridors that are mainly utilized by those on non-motorised modes of mobility, such as walking. They attract a high concentration of diverse informal/ public traders, mixed use development and are all linked to public transportation interchange zones. They are potential areas where maximum pedestrian footfall within a precinct could be utilized, since they are primarily high pedestrian traffic routes to access different areas supporting mixed use urban activities. Mobility spaces are formalised by the canalisation of pedestrian walk ways by public traders as they try to provide a walk-through service for pedestrian commuters along a mobility corridor (Eberhard et al., 2011, Skinner, 2009, SARPN,2003, Web.3).

#### **1.9.5 PUBLIC TRANSPORTATION INTERCHANGE ZONE**

Public transportation interchange zones are public transport nodes or hubs that provide various modes of public transportation such as mini-bus taxis, trains, buses and they are found predominantly within transportation precincts within the CBD (SARPN, 2003, World Economic Forum, 2010). These transportation zones accommodate various forms of informal/public trade and also attract a high rate of pedestrian traffic within a given space, throughout the day (Skinner, 2009, SARPN, 2003, Web.1). An example is the Warwick Junction, since it also serves as a regional transportation and informal/public trading hub according to Rich Dobson, who headed the Inner eThekweni Renewal Urban and Management Plan for the Warwick Junction (ITRUMP), and who highlights the need for better public facilities, such as water and electricity (SARPN,2003:17, Web.1, Nomico and Sanders, 2003).

To conclude, it is evident that the piezoelectric system, once incorporated and applied to public space pavements in strategic zones, could be a progressive tool for onsite energy planning and urban layout, if implemented within pedestrian intense mobility spaces. Since active pavements can be applied even to retro-fitting scenarios, they can improve energy security for public transportation interchange zones and also they can be the impetus for energy efficient street facilities for informal caterers and public traders.

## 1.10 METHODOLOGY

The research is set to understand, by observation, the nature and pattern of pedestrian traffic at intersections and public transportation precincts that encompass Julius Nyerere Road and its numerous intersecting roads. By identifying and quantifying the spaces intensely occupied by pedestrian movement and public trader presence, and by using a proxemics approach, we can appropriately identify in which segments to implement piezoelectric pavements, in a pedestrian traffic responsive setting (Babbie 1998 & Bandini, et al. 2011).

According to research design approaches by Babbie (1998:96), the concept of the ecological fallacy is suitable as it sets out to contextualise the appropriate variables necessary to meeting the researcher's objectives. To carry out an evaluation on a future strategic implementation such as the active pavement system, the researcher would require the identification of possible end-users by the sort of informal catering provided by public traders (e.g. pavement meat grill or mealie cookers). The extent of the study area is broken up into segments, since a template needs to encompass all predominant spaces utilized by pedestrians accessing the transport precinct, over the duration of time that footfall presence is intense. The research will be focusing on all pedestrian modes (including wheel chairs).

Starting with observing and quantifying the pedestrian mobility within highly dense spaces from on-site surveillance, we need then to locate public traders and see how often pedestrians come into contact with these traders. By doing so it will then be possible to determine by in-depth interviews with stakeholders, which informal trading activities require most energy and how much would be necessary for street lighting, heating and maybe traffic signage. By understanding the pavement ecosystem of the Warwick Junction public transportation precinct, the researcher could formulate an effective strategic active pavement system template to generate enough renewable energy to improve the overall sustainable capacity of various public trading activities.

## 1.11 STRUCTURE OF THE DISSERTATION

The presented research consists of six chapters that are structured in the following way:

The First Chapter serves as an introduction to the research, the background and motivation of the study within the study area context. The problem statement and proposed hypothesis for the research are presented, in alignment with key aims and objectives of the research. The research questions are posed and the research limitations were declared. Since the research is the first of its kind within planning, the researcher provided key definitions, and defined a suitable methodology and declared the research scope and limitations.

The Second Chapter consists of the conceptual and theoretical frameworks that has helped set up the pillars and constraints for the argument for active/piezoelectric pavements, as a strategic tool for area-based economic development. The chapter presents the case for the application of the piezoelectric spatial template within transportation interchange zones, within Warwick Junction. The multidimensional aspect is unpacked as the relevant themes will engage with necessary policy legislature, in an alignment with the first and second objectives of the research. The overarching purpose of this chapter is to try and answer the burning question posed by the researcher.

The Third Chapter specifies the suitable method to conduct such research. It considers the research limitations, the research tools and the procedures which have been described in detail. Appropriate justification was provided for the chosen sampling method, research approach and also the relevant stakeholders necessary for the interviewing process.

The Fourth Chapter was utilised as the data analysis platform, where the surveillance images and verbal responses from stakeholder interviews is presented and a better understanding of the third objective was sketched out from the guidelines of chapters two and three.

The Fifth Chapter synthesizes the critical components for piezoelectric spatial template integration within Julius Nyerere Road. A spatial model has been formulated and its potential efficiency could be presented for future studies.

The Sixth Chapter draws conclusions from the entire research and possible linkages and future research opportunities outlined. Key findings are drawn up in relation to the research objectives.

## **2. CHAPTER 2 – THEORETICAL FRAMEWORK & LITERATURE REVIEW**

### **2.1 THEORETICAL FRAMEWORK**

#### **2.1.1 INTRODUCTION**

A theoretical framework is meant to provide a perspective of the research that is based on contemporary views within the academic arena. By following the outline set out by the research objectives, the scope of the theoretical framework could be simply theory based in literature or it could also be a general approach to understanding physical phenomena, such as through an understanding of indigenous knowledge that's prevalent on pavements. Typically, a theoretical framework defines the kind of variables that the researcher considers to be valuable for the study and to provide a more accurate basis for an academic argument to support the objectives. The theoretical framework is meant to help set up the pillars and constraints for the second chapter of the research paper.

#### **2.1.2 URBAN MANAGEMENT**

The urban complexities such as, how public traders use their space to sustain socio-economic livelihoods have to be considered. The researcher believes that sustainable technology integration needs to be advocated for the Warwick Junction Precinct. The social complexities of the area and its affected constituency need to be understood if we are to meet the socio-economic needs of public traders as well as to provide sound reasons to municipal officials as to why mobility spaces should be occupied by public traders, as long as they are well regulated. The success of technology implementation rests with how well immediate needs are met, since that could open the door to unlocking barriers to ideological change for public traders who conduct their business activities according to cultural and social practices including how to obtain and use energy. Political and legislative factors that impact on public traders who occupy mobility spaces whilst trying to access economic opportunities and technical resources, need to be re-directed towards sustaining public infrastructure in and around densely populated public facilities so as to prolong the lifespan of the implemented technology. Technology could be a means to align the African city with the global trends of urban development that could unlock the potential of integrating public traders with other sectors such as the green economy and telecommunications. The possibility of having progressive socio-economic development within

urban precincts such as Warwick Junction depends on what premises we use as building blocks for resilient grass-roots development. The social complexity could be seen as a phenomena of having to integrate a piece of technology within a competitive and contested environment, such as the research study area, that will only be beneficial internally and externally for the precinct as a whole, if all stakeholders come together and consolidate a multi-disciplinary renewable energy plan for the precinct.

It is the researcher's assumption that within the 21<sup>st</sup> century, the African City's development needs to encompass local innovation and community action as core values if it is to develop in a manner that secures sustainable livelihoods for those who eke out a living within the compact and marginalised urban spaces. There also needs to be an understanding of the energy consumption trends and drivers within the urban precinct, so that a comprehensive plan can be formulated as to how trader presence and their energy culture could be more resilient, by utilising active mobility spaces as a bargaining chip for a progressive green economy. The incentives should speak to the needs and livelihoods of the informal trading community as a whole, since we would be making changes to an arena of economic contestation that is already marginalised by formal development motives.

#### **2.1.2.1      ADVOCACY AND PLURALISM IN PLANNING**

Departing from the objective to attain greater spatial equity through the Municipality's Spatial Development Framework, one can think of numerous infrastructure and socio-economic projects to enhance the current trends of growth within the present trading environment, however, we need also to question the objectives or so-called essence of those projects when development is to impact a community of livelihoods within such a densely populated trade hub (eThekweni IDP, 2013). The correct process for planning in such conditions is pluralism, as we try to provide greater socio-economic, spatial justice, spatial resilience and spatial equity (SPLUMA, 2013), as established by Davidoff, and echoed in the argument made by Benner and Pastor (2014), the correct role of the planner in the sphere of development is to advocate for:

- (a.) The focus on physical space leading to a mutually beneficial outcome for the community;
- and

(b.) The purpose of buildings is to serve people. Their functional use of space is of primary concern. Spaces and structures only take on true meaning when examining them in relation to social and economic conditions.

In the late 1960s, Davidoff had a vision as to how the planning process should be carried out and it was something that lived within him and it drove him towards planning objectives that would integrate the marginalised into urban design for the greater common good (2003:388). By taking into cognisance that the urban fabric functions at different levels to meet different social ends, it is still interrelated in its processes of resource consumption and so an open conversation channel should exist between trader communities and the municipality (Benner and Pastor, 2014). At present, architects, engineers, land surveyors and private developers have the financial and institutional will to carry out all means of urban reconfiguration, but they see the poor as parasites occupying valuable sections of the urban fabric. It is in this vein that the researcher feels that within planning, this umbrella of advocacy and pluralism should be raised so that the urban poor and powerless can make a plea to be empowered by the very steps that their customers take as they trade with them, within their own informal space of business in the mobility spaces.

The main aim for the research is to define a means of reaching a well-integrated urban plan that sees the social fabric of transport nodes being woven into economic growth from the generated power beneath every foot-step, to empower those travelling through and sustaining a livelihood in space. By having a well-integrated precinct plan, pavements could then be used to encourage a socio-economic equality that does not pose a threat to the functioning capacity of the urban environment, while being able to close the gap of access to basic services such as electrical power.

Generation of renewable energy for traders, who occupy so much space when collectively quantified throughout the Durban CBD, could be the perfect implementation tool to stimulate grassroots development for the greater central region of the eThekweni Municipality, in a simple, yet direct, pluralistic approach (Benner and Pastor, 2014 and Coetzee et al., 2014). Instead of trying to uproot and change the local character of the precinct, as was evident in the



2010 resistance to an upgrade of the Warwick Junction into a walk-through mall over the Berea train station that would have seen the displacement and exclusion of public traders, thus changing the intrinsic character of the precinct (Markets of Warwick, 2010 and Open City Projects, 2012). A compromise could have been reached by actually undertaking communicative engagement to flesh out the needs of the public traders and the possible means of the developers along with municipal officials with a development rationale informed by the PGDS and translated in the eThekweni SDF. Functional area plans for a precinct are only effective if they are able to articulate development in a manner that is well-informed by the foresight of those who occupy those spaces of opportunity (eThekweni Draft IDP for 2014/2015, 2014).

#### **2.1.2.2 COLLABORATIVE PLANNING**

When engaging the role of Municipal authorities within the eThekweni Municipality, which is to provide or assist the local community of public traders in gaining adequate access to basic services that are to be well-facilitated so that all stakeholder needs are well-represented (Coetzee et al., 2014), we need more than a planning approach, but rather an actual collaborative engagement between planning professionals within the development arena. When looking to invest in infrastructural developments, it is essential to weigh up the key objectives of the necessary development project in the context of other urban features that can benefit from its presence or function. What positive socio-economic outcomes could there be from this project, and to what extent can we maximise local benefit from such a development (Benner and Pastor, 2014)? A collaborative effort should look at how we can find middle ground for all stakeholders to progress towards a solution that sees holistic growth for all. The municipality may not always be at financial liberty to cater for all, and public traders require public facilities that are well-serviced. The pavement is becoming more contested and congested by the day and there is still an energy crisis that plagues all urban functionality. We need a new banner to march behind in delivering socio-economic justice and spatial resiliency.

For strategic spatial planning outcomes such as harnessing renewable energy from active pavements to be realised, it has to be within an enabling environment for all economic activity to coexist and thrive. The collaborative planning approach has a multitude of urban

management aspects which could be the catalyst to reaching the proposed outcomes in a manner that brings about greater social justice and public trader equity (Benner and Pastor, 2014, Coca-Stefaniak and Bagaeen, 2013 ). Strategic planning in the 21<sup>st</sup> century could be seen as an inclusive feat that promotes progressive means to be utilised in fostering the spirit of public trader innovation. With informal innovation being misunderstood and seen as mischievous in some respects, we as planners and urban developers need also to learn from the resilient solutions that have diversified so many livelihoods. According to Coca-Stefaniak and Bagaeen, in our time, planning needs to be a tool that is engaged with at all levels and it should ensure that all relevant parties are involved in the planning process (2013).

The Warwick Junction Precinct has been identified as a thriving trading hub in the inner city of Durban, and has long been considered one of the best examples of collaborative urban management practices between the local government and public traders (van Schilfgaarde, 2013). The introduction and integration of new technology needs to meet the will of grassroots initiatives that are set to benefit the development agenda of the local community. If we are to align the necessary suite of plans ,those being the NDP, the KZN PDP and the eThekwini IDP, then a collaborative path towards attaining sustainable socio-economic development could be forged (eThekwini Draft IDP for 2014/2015, 2014). With the environment conducive to accommodate more traders we may see a sprawling trend of adding value to the social capital that already exists (informal mechanics, informal electricians), by giving them the formal skills to maintaining the immediate pavement infrastructure. If we are to make a parallel reference to the implementation of solar panels in low-cost housing, as a renewable energy strategy that has not taken-off as expected for the eThekwini Municipality, then the issue stems from having a lack of immediate assistance to maintain the infrastructure and local communities ended up selling parts for scrap metal (MILE Research Symposium, 2014, Coetzee, 2014 and Benner and Pastor, 2014).

The supporting rationale is that a renewable strategy that would entail the use of the public space that is occupied by civilians and public traders should be seen as a tool that could unlock further economic diversification such as cheaper heating and lighting, and could produce an

economically responsive spatial arrangement that's beneficial not just to immediate public traders, but also to the municipality as a whole. Infrastructure provision and infrastructure management are part of the development life-cycle if we hope to get the point of sustainability. The piezoelectric pavements that should be integrated into framework catchment areas can provide energy, while also being a means to securing formal labour within the precinct. If a community feels that an idea contributes to their well-being, then it should be protected by those who benefit from it.

### **2.1.3 INTEGRATED AREA DEVELOPMENT**

The clear articulation of spatial intentions and necessary infrastructure implementation to stimulate and sustain economic development within a spatial framework is crucial if we are attempting to create an integrated area development that is successful (eThekweni SDF 2015/2016, 2014). If one hopes to introduce a novel means to provide basic services, then there needs to be a strategy that speaks to the local status quo and integrates this with smart design that conforms to the local area plan, while still being in line with the strategic policy of the eThekweni Municipality Central Region SDF (eThekweni SDF 2015/2016, 2014). The development and management of priority precincts can create internal employment opportunities, stimulated by municipal interventions that reinforce the notion of economic growth that is not reliant on fossil fuels to meet energy demands.

If the African City is to have a unique identity, then local initiatives need to provide a new path to a green economy where the consolidation of densely occupied road reserves and mobility spaces fuse into an active pavement framework. If localism is the essence of place-making and node development, then spatial design should be lending itself to improving and diversifying sustainable livelihoods (Sturzaker, 2013:507-509 and SPLUMA, 2013:15-16). Integrated area development is meant to see the realisation of better quality and efficiency of public facilities and to facilitate the strategic development of nodes and precincts in alignment with the suit of plans available from the municipality. It is the public involvement of public traders in the development of active mobility spaces that could see innovation and smart growth in sustainable development.

### 2.1.3.1 SMART GROWTH

If we are to try and accomplish a manner of transport development for urban areas, that is energy-efficient while caring about the environmental impact of its presence, then it is of importance to have the appropriate spatial planning and urban design approaches that complement the greater urban development framework, thus making such a venture realistic in a planning sense (Lehmann, 2010). According to Lehmann, 'Smart Growth' (SG) is an urban planning and transportation theory that concentrates growth by allowing compact public infrastructure developments to prevent urban sprawl. NMT and public transportation systems in urban centres are strongly advocated for, so as to reduce the high volume of vehicular traffic. The scope and objective for NMT proliferation, which is of interest to this research, involves the provision of compact, transit-oriented, walkable, bicycle-friendly mobility spaces that enjoy abundant access to amenities, while being linked to potential catchment areas for capital footfall traffic. The following relevant SG principles, such as those outlined in the *Smart Growth Manual/Toolkit (2012)*, have been identified, and this could result in the strengthening and appropriately directing road infrastructure development as a catalyst for bridging the gap between transportation planning and energy planning under the umbrella of urban planning.

Smart Growth (SG) as an urban concept, is aligned with *The New Urbanism* agenda of the 21st century, impacting on the debate within the spheres of urban planning theory and on actual local practice in the real world. SG champions novel solutions within and beyond theory, resulting in a progressive urban environment that's resource self-sufficient. The theoretical gain of SG is that it advocates for new ways to strategically manage the urban development process so as to unlock economic opportunities that promote urban growth, protect the natural environment by utilising integrated planning tools, resulting in an enhanced sense of community vitality and urban rejuvenation (Smart Growth Network, 2011).

In the African City context, it is necessary that the general trend of urban development seems to integrate sound solutions for development needs. By trying to capture the local frame of development, smart growth integrates various sectors and approaches such as; transportation, energy, spatial management, environmental consideration, while still trying to address socio-economic injustices brought upon by apartheid (Smart Growth Network, 2011 ). In the present day the theory advocates for growth in its compact form to improve the quality and efficiency of walkable urban centres to prevent sprawl.

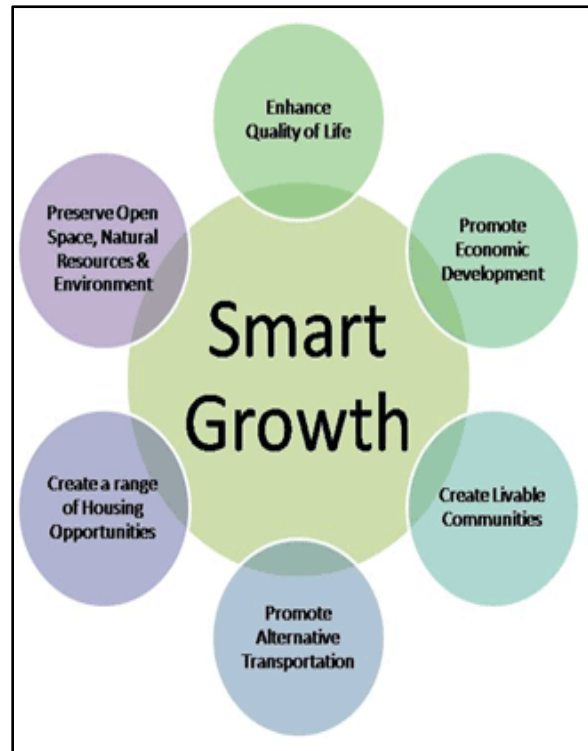


Diagram 3: Smart Growth (SG) (Smart Growth Network, 2011)

The compact spatial form is one that seeks to meet the sub-objectives of SG by having compact energy-efficient urban nodes and precincts, then transit-oriented development that propels the use of public transportation systems and alternative non-motorised modes of transportation can be progressive, if the right process and methods for sustainable development are followed (SG Network,2011). By integrating a diverse land-use matrix along high traffic routes, the author believes that it could increase local access to amenities and informal pavements within a dense mobility space, and, since we would be making use of best practice, we would also be able to mitigate our carbon footprint when speaking about a comprehensive energy mix to facilitate sustainable development.

Smart growth values and endorses the long-term projection of potential growth for spatial pockets that one would attract investment when considering sustainable urban development. In the context of regional municipal consideration for greater sustainability in renewable energy technology implementation, there will be some obstacles to face before widespread proliferation of this technology. For example, what importance could strategic pavements have for the central regional growth of the eThekweni Municipality, in relation to creating an urban space that harnesses the footfall potential? In the light of trying to link the national agenda to grow the green economy, could such spatial pockets be able to generate and secure an off-grid provision of clean energy for informal traders and for other public facilities?

The overarching goals of sustainable development are met within the framework process of Smart Growth when one sees that a detailed comprehensive plan of the envisioned path for urban growth, that stimulates, while enhancing integrated planning and infrastructure investment into public spaces and facilities, has been produced in a satisfactory manner. By aligning, coordinating and leveraging from current government policies and strategies, a strategic approach could be made towards the provision of energy from human surroundings such as solar energy from roof-tops or piezoelectric pavements at transport precincts. The establishment of green councils within the country has endorsed an international agenda to develop in a manner that's environmentally sound, while making economic sense. A comprehensive spatial template could play a significant role in how the municipality handles environmentally-friendly energy generation and energy supply.

Smart Growth initiatives create a sense of safety and local identity that acts as a pull factor for commuters to view walking as a viable transportation choice. To plan inviting pedestrian spaces one needs to leverage off the existing activities that strengthen the identity of mixed land uses. One such existing activity is the informal catering industry on pavements. In trying to forecast future trends of urban development and the diversification of the informal economy to coincide with the green economy, the infrastructure that is to deliver economic emancipation, to the marginalised, has to be resilient. The energy to empower this urban sector could be harnessed through pedestrian and vehicular traffic pressure, if the right minds apply themselves to the

task. By planning the African city with a smart growth agenda that has an innovative will, we could open up access to multiple avenues that could see off-grid energy management systems, localised response to energy insecurity by meeting demand and distribution needs within high traffic precincts. The potential to exploit independent renewable energy sources from piezoelectric pavements requires the presence of design initiatives that incorporate smart technologies to guide the innovative will to fill the energy void created by the national energy provider.

### 2.1.3.2 AN INNOVATIVE CITY

Smart Growth, in a progressive African City, rests on the capacity to obtain a reliable, affordable, energy source for traders in transport interchange zones. According to Seyfang and Smith, in their paper *Grassroots innovations for sustainable development: Towards a new research and policy agenda*, innovation is defined as “the successful exploitation of new ideas – incorporating new technologies, design and best practice” (2007:586). The ability to find new solutions to local issues should rest on innovative measures and applications when considering urban development. In the 21<sup>st</sup> century the securing of a reliable energy source for our development trends determines the resiliency and efficiency of those cities that have planned in advance for future needs.

The researcher believes the vehicle that could be utilised to carry the idea of piezoelectricity pavements could be local innovation, with a hint of strategic thinking that would link spatial efficiency to an energy-harnessing spatial template that involves multidisciplinary approaches. The third objective of the research was to enquire into the effectiveness of piezoelectricity pavements for the Warwick informal traders. Innovative alterations to pavements within the precinct could provide energy to traders in the precinct which would discourage illegal connections and other hazardous energy practices that cost the ratepayers of the city so much (*Open City Project, 2012*).

Innovation for the African City is determined by context as the local community of informal traders tries to be more resilient whilst diversifying trade. If innovation could be incorporated into grassroots development, then local communities would be able to meet urban challenges

within the 21<sup>st</sup> century, one of which is securing a reliable energy source to cater for urban growth trends. The ability to find new solutions to local issues rests with finding the right mix of smart technologies and energy culture interventions (Verhoog, Ghorbani, Dijkema and Weijnen, 2013). Within the local scope of renewable energy sources, active pavements could be seen as an innovative asset that utilises the informal trader presence, channelling traffic through the transport and socio-economic hub, in a manner that sees a harnessing of energy from pedestrians and vehicles within mobility spaces. Rather than trying to retro-fit new ideas, why not empower future ideas of how we interact with mobility spaces and those who occupy those spaces for socio-economic needs?

Innovation is a wave awaiting a guest for high-tide, meaning that innovation has all the potential, but it awaits implementation for it to be economically viable (Verhoog, et al., 2013). In South Africa the rising tide is that of the green economy and renewable energy. The factors that will prompt implementation of innovation are urban growth, the high rate of unemployment and a deficiency in energy resources. The informal sector has grown in recent years, and, to some extent, shapes our urban landscape, as streets and pavements have become compact mobility spaces in which to eke out a living and spaces in which to sustain a livelihood. In Africa, telecommunications and financial services have become the growing sectors that meet the immediate needs of those who were previously marginalised and, taking into consideration the coupled development of energy connections, we could have the power to liberate the informal and formal sectors within municipal precincts. The informal sector with its spirit of innovation might be able to exploit new smart technologies within the very spaces they operate in, thus, in the long run, they could diversify their livelihoods.

The key objective of this idea of resilient and sustainable development is to articulate a message of local innovation in support of the economy transformation that empowers individuals to develop their own alternatives that would allow them to thrive in a robust trading atmosphere such as the Warwick Junction. A knowledge based economy that takes into consideration local/ precinct social networks, customer perceptions and trends of trade, could add to the quality and success of such technologies that are being proposed by the researcher.



There needs to be a belief amongst urban planners and policymakers, that South African innovations in science and technology can combat the negative effects of climate change in Africa, by developing sustainable energy solutions, devising ‘intelligent’ materials and manufacturing processes, revolutionising our communications in terms of endorsing green technologies and by changing the work we do and the way we do it (Department of Science and Technology, 2007).

Network theory, applied to the space economy, posits that cities act as hubs of connectivity within the global space economy. Cities further integrate spaces (and people living within those spaces) that are less connected. Networked regions have been shown to be important in fostering innovations and in creating markets (Economic Development & Job Creation, 2013). Cities and the regions of the world are being transformed under the combined impact of a restructuring of the capitalist system and a technological revolution (2013: 12). Throughout history, cities have been the generators of wealth and economic agglomeration, cities have always been better generators and processors of information and technology and innovation. However the present tide calls for greater integration of knowledge, information and technology to keep this growth occurring at a sustainable rate. The current importance of spatial agglomerations as generators of wealth and knowledge has grown.

### **2.1.3.3 SUSTAINABILITY**

Our country’s sustainable development vision is outlined as follows:

*“South Africa aspires to be a sustainable, economically prosperous and self-reliant nation state that safeguards its democracy, by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration”*

(Green Economy Summit, 2010:4).

Most plans and strategies produced within post-apartheid South Africa, call for stronger ties of cooperation and integration between national and local sectors to find the most efficient way

to deliver a better life for all. Since global reports indicate that 50 percent of the global population will be residing in urban areas by 2050 (Green Economy Summit, 2010, Coca-Stefaniak & Bagaee, 2013), the need for sustained infrastructural development is linked to the research aim which is to maximise footfall catchment areas in compact high priority nodes, for the sake of harnessing energy. According to the *2030 KZN Provincial Growth and Development Plan* (KZNPGDP), infrastructure development is the foundation for poverty reduction and economic growth in developing countries (2014:88). In the long run this would mean that there should be enough renewable energy to promote greater levels of local economic production for thriving urban nodes and/or regions like the eThekweni CBD/Municipality.

And since KZN hopes to embark on an integrated path to sustainable development so as to achieve greater socio- economic growth, which meets the unfulfilled development desires of many, then the backlog in the provision of services and infrastructure should be addressed immediately at its most fundamental point which is at local level (Warwick Draft of Needs Assessment Report, 2014). In relation to the research aim, which is to explore the possibility of producing sufficient energy that could sustain localised precinct infrastructure to benefit public (informal) traders within mobility spaces and therefore create a piezoelectric template for other precincts to take on, the necessity to align local inner development plans of a province with national goals shows a synchronisation of programmes and projects that could have multiple knock-on effects (KZNPGDP: 2014). For sustainable local area/ precinct development that's meant to promote urban regeneration, it's crucial to link spatial justice and spatial resiliency to meeting our built, environment short-comings in a local environment whilst being a catalyst for greater change (SPLUMA, 2013).

If we were to consider the progressive steps that would be made by the proposed development on pavement infrastructure, then focusing on urban corridors and high activity nodes, should bring us closer to the intended possibility of creating a much more compact urban form that is energy efficient and innovatively resilient. This would also provide new insight into how the densely occupied mobility spaces could be transformed into strategic footfall zones that secure and contribute to a sustainable mode of urban energy provision. The

future beckons for an integrated energy-transport approach, and the potential of harnessing renewable energy from compact transport network environments could shed light on how pavement infrastructure could have a multi-purpose use (Pramathesh and Ankur, 2013 and Gkoumus, Petrini and Bontempi, 2013). This idea would be based on efficient public transport systems that utilise alternative energy sources to provide power for mixed-use amenities and public spaces for traders and general occupants and commuters. The researcher believes that through the use of localised off-grid energy generation and distribution from alternate sources, by utilising progressive and innovative methods, cities like Durban can meet their energy resilient goals while supplementing national grid failure, like our own country has been experiencing. The output from this research will be an active pavement template that could be used to complement other plans for implementation of smart growth principles to solve local service delivery issues. The presentation of a sustainable spatial development tool of this nature should assist when consideration is given to the socio-economic needs assessment report which is linked to the overarching development objectives of the eThekweni Municipality. This approach would be beneficial to all as it would unlock prospective urban pockets of densification with the potential to generate energy. Spatial developments within the 21<sup>st</sup> century have to uphold a sense of order and self-sufficiency in order to maintain metropolitan growth and bolster the application of piezoelectric pavements in such a way that such initiatives can make positive strides in realising a sustainable African city within our lifetime.

#### **i. SUSTAINBLE SPATIAL DEVELOPMENT**

According to *SPLUMA* (2013) Section 7 (a) (b), sustainable spatial developments are targeted at the urban constituency that is marginalised from equally accessing a secure supply of basic services. The urban capacity (secure infrastructure provisions), whether on a global or local scale, needs to attend to accommodating a growing urban demographic trend, greater economic disparities and the unchecked expanding built environment, since falling short has already led to socio-economic issues relative to the quality and variety of sustainable livelihoods within the urban environment being brought into question (Hutton, 2013). The

integration of various sectors belonging to state departments and civic groups could be the necessary approach to having a holistic solution to energy demand and consumption.

On the other hand, for planners to execute sustainable development frameworks within an urban context that seeks to harness renewable energy from the mobility of pedestrians, it is crucial to understand the elements that influence sustainable urban mobility (Hutton, 2013). Transit-orientated development could be the key that unlocks the prospects of taking advantage of the informal economic activities that exist within public spaces, as public traders channelize pathways for pedestrians. Sustainable development projects that impact or alter the spatial arrangement of any land feature should, according to Chapter 2 Section 8 (2) (b), *“promote social inclusion, spatial equity, desirable settlement patterns, rural revitalisation, urban regeneration and sustainable development,”* (SPLUMA, 2013:17). Therefore, by introducing a spatial template that is able to be a spatial tool for implementing piezoelectric pavements, we should be able to increase the access to basic energy services.

SPLUMA (2013), under further reading expresses consideration and reason as to why obtaining a sense of self-sufficiency in terms of resources for economic activities within high priority public nodes, would help uphold sustainable spatial development principles as stated by Section 7 (c) principle of efficiency (SPLUMA, 2013). These lend themselves to an expanded idea of how possible sectors and stakeholders, such as telecommunications and foreign traders, could further entrench the ethos of sustainability within such spatial strategies. In going through the literature, the pillars of sustainability (social and economic) are usually generically separated, however I propose to group complementary components to uphold the core principles of sustainability. Prior to that, though, I would like to state that there is an existing shortfall in infrastructure provision and economic engagement from the Municipality within Julius Nyerere Road and the Warwick precinct as a whole (eThekweni 2015/2016 IDP, 2014). And to remedy such would require integrated strategies that engage with public trader needs, so as to add meaning to the sustainability framework of the Warwick precinct as a whole. The infrastructure limitations in relation to economic growth need to be pegged against the dynamic nature of renewable energy markets and the emergence of an informal/small scale

economy that may seem to be a contributing factor to our nation's GDP growth (eThekweni 2015/2016 IDP, 2014).

Legislative revision is by far the most important factor in bringing about any sort of redress to past spatial injustices and in offering an olive branch to the declining social capital. The green economy is set to unlock and promote a variety of green strategies for appropriate sectors, however, the Green Economy strategy dictates that social equity is key to sustaining our growth as an African powerhouse (eThekweni 2015/2016 IDP, 2014). But, in trying to link the overarching idea of spatial self-sufficiency to sustainable developments, it is important to keep in mind all of the socio-economic implications of development that promote local community energy-efficient schemes, local participation and decision-making, capacity building, and knowledge-sharing. Locally rooted actions generate socially embedded changes in behaviour (Burgess et al., 2003), therefore creating an atmosphere that favours the distribution of resources amongst urban public traders who are ranked according to comparative levels of productivity. This implies that individuals or institutions are free to pursue the ventures of their choice. Social equity should not be confused with welfare programmes (socialism) where the productive segment of the population agrees, or is coerced into supporting a non-productive segment (eThekweni 2015/2016 IDP, 2014); our main aim is to redistribute a common resource so that there is a sense of spatial equity for those who occupy and trade in mobility spaces. This atmosphere of spatial justice and equity can only be effective as judged by the programmes that it puts out. Renewable energy strategies cannot be enshrined in policy alone, but need to be further tailored to local conditions and local area plans. Since this research looks to harness energy from a transportation network, it is then more fitting to engage the eThekweni Transport Authority IRPTN and the eThekweni Energy Plan. The active pavement template can only be sustained if there is localised support to personally assure a high quality of pavement infrastructure that is well maintained and monitored. Our national infrastructure projects are usually destined to fail in the long-term, due to an inability to diversify the labour pool, in context of local skills into the maintenance of renewable energy systems, thus pulling the carpet from under the feet of those striving for a greater quality of life. In terms of adding value to community social capital, local skills development coupled with technology integration, could

be the only way that spatial justice, as mentioned in section 7 (a) of SPLUMA, could have enabled vanguards to fight off urban decay and charter new innovations for the green economy.

Economic efficiency and Environmental responsibility require conditions permitting higher levels of economic productivity, while being environmentally considerate in terms of how natural and labour resources are utilised to produce the required level of growth (eThekweni 2015/2016 IDP, 2014). Growth focuses on capabilities, competitiveness, flexibility in production and on providing infrastructure and services that supply a market demand. Within this area of concern is the demand and supply of electrical power. This approach to sustainability involves an ecological footprint that is not within the capacity of the environment to accommodate, in terms of pollution produced in the process of economic productivity. Its core principles, when looking at energy, focus on energy conservation and reuse of renewable resources.

A sustainable spatial network, stimulated by a secure supply of basic services can provide the necessary scope for interlinking urban routes between complementary land use precincts. This would show that mobility spaces could be the catalyst for the structural growth of economic activity around commuter hubs, public nodes and activity corridors. The growth of street trading in terms of the surface area coverage has multiplied over the years, however urban strategies have not been able to keep up or to become aligned with the socio-economic livelihood objectives of public traders. The overall expected outcome to sustain the energy thirst of the urban constituency while sustaining development, is to develop an urban form that fits the character of Section 7 (d) of SPLUMA. Urban resilience is the future element to sustain that growth that makes valuable contributions to the green economy and its self-sufficient spatial arrangements.

#### **2.1.4 PAVEMENT ECOLOGY**

In trying to introduce a pavement eco-system that would feed into a smart-grid and green economy, for renewable energy production from piezoelectric mobility spaces, it is then important to unpack the existing pavement ecosystem in its socio-economic context. This could be done by understanding the spatial and economic correlations within mobility spaces for

public trader presence, and how the supposed public infrastructure could positively contribute to national strides, in championing the green building revolution within the region and, in a local context, boosting socio-economic opportunities, within the Warwick Junction Precinct (NDP, 2012, eThekweni 2015/2016 IDP, 2014). The pavement ecosystem of the Warwick Junction could exemplify how a functional correlation between **mobility sources** and **stationary sources** could be utilised as a guiding tool to efficient precinct pavement design and green economy development from easily available renewable energy for the Municipality.

Underinvestment in infrastructure over the last 20 years has led to infrastructure challenges around electricity, rail, road and public transport (SONA, 2015). In the present day, with the built environment consuming 40 percent of all energy supply, the threats of load-shedding require such novel ideas as proposed in this study. By utilising the Green Road technologies to be mentioned in the following section, road construction and transport planning would be infused with on-site renewable energy generation and the utilisation of off-grid storage and distribution networks. Off-grid energy storage could be the supplementary source to the regional and national grid when local energy security is threatened by load-shedding (Electricity and Economic Growth in eThekweni, 2012). Retro-fitting existing pavements and mobility spaces with energy harnessing technology would formalise an energy mix that sustains the local network of public trading activities.

The long-term vision and goal for the developing state is proactive planning that ensures that energy supply infrastructure is prioritised, including a more structured planning relationship between government, civil society and the private sector (NDP, 2012 and Electricity and Economic Growth in eThekweni, 2012). Following the path that was set from the SONA 2015, government has already signalled its intention to place greater reliance on nuclear power, natural gas and various renewable forms of energy (Department of Science & Technology, 2007, SONA, 2015). The first two options (constructing new nuclear power and the potential of fracking for natural gas) do not provide a solution to the immediate needs of our nation's failure to secure a reliable energy source in marginalised locations. The third option (piezoelectric pavements) is one that seems to be more environmentally and economically



sound, in terms of sustained long-term growth, as we have an abundance of natural resources to commercialise a renewable energy mix (SANEDI, 2011 and SONA, 2015). The secure provision of renewable energy and reinforcing green urban practices has brought about a transformation that is fast becoming a reality for our society and a major planning focus around the globe.

#### **2.1.4.1 CLASSIFICATION OF JULIUS NYERERE ROAD**

The classification of the Julius Nyerere Avenue road, which was previously known as Warwick Avenue, is to show the local and regional character of the study area (Open City Project, 2012). The regional scale (Class U1) of the R102 road is that it acts as a provincial corridor road that stretches from boundary to boundary along KZN, from Empangeni in the North too Port Shepstone in the South. The eThekweni Municipal region its capacity as the R102 (Class U2) and within the eThekweni/Durban CBD it serves as an activity spine (Class 4A: Commercial Collector Street) that also serves as an arterial through-route within the city and also within the region.

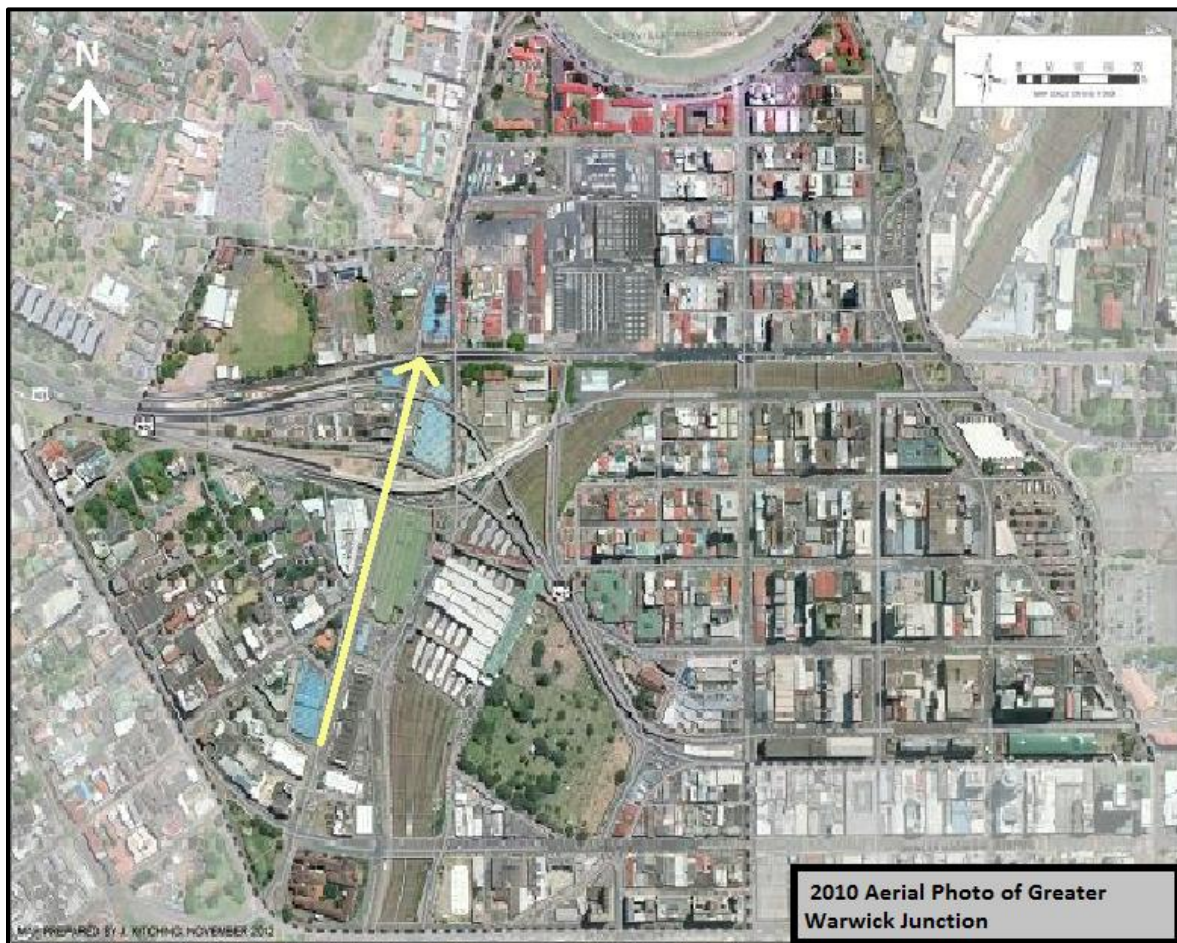


Figure 3: Aerial photograph locating Julius Nyerere Road



According to the *South African Road Classification and Access Management Manual of 2013* (pp.26-30), such a road would be classified as a Class U1: Urban Principal Arterial for provincial travel, then a Class U2: Major Arterial within the municipal capacity, and finally a Class U3: Urban Minor Arterial that as has multiple Class 4A inlets: Commercial Collector Streets connecting to it within the CBD and Warwick precinct as a whole.

Since having such a predominant role in regional transportation, prevalence of large commuter volumes and the requirement to carry high traffic flows over long distances, this characterises the Warwick precinct as a regional economic and transportation hub for goods and commuters (Open City Project, 2012, eThewkini 2015/2016 IDP, 2014). The study area focuses on a 660m segment from University Road to North Old Dutch Road, which has 6 main intersections. Julius Nyerere Avenue runs in the middle of the precinct as an activity corridor and at the precinct/local level, these are adjoining the arterial road/activity spine. These intersections are Class 4a: Commercial Collector Streets, which are characterised by high volumes of pedestrian and public transport traffic. With an average of 25 000 motor vehicles thought to be circulating through these streets (South African Road Classification and Access Management Manual, 2013). In terms of providing access and mobility, the collector streets could provide greater levels of funnelling and circulation of commuters through various commercial, economic and residential land uses, therefore aiding the establishment of a catchment route for the spatial template.

The Julius Nyerere road however is of interest since it is a multifaceted role with Durban and at its main collection and distribution point (Warwick Junction) links with other modes of public transportation. This makes the urban principle arterial road and intersecting commercial collector streets, worthy of research as the pedestrian footfall attracted to public traders could be the source of renewable energy.

Even though pavements take up just 30 percent of all site developments (planning rule of thumb), the researcher strongly believes that with catchment areas strategically retrofitted into already existing high pressure mobility spaces by commuters, we could extract a viable amount

of energy from this source. The pavement catchment sites could utilise micro-renewable energy technologies such as piezoelectricity pavements, solar pavements and pressure membranes.

The process of land use and transport integration and the identification of nodes and corridors must therefore be a joint exercise of the town planning and engineering departments (SA Road Classification and Access Manual, 2013).

The growth of economic centres or hubs along regional roads or activity spines within the African city is synonymous with the mutual benefit of public transport nodes and other public facilities, e.g. the Dube Trade Port attracting traders from the surrounding area and also having a taxi rank within the vicinity of the trade port and airport. Since it is our objective to harness renewable energy from footfall pressure within mobility spaces, we need to appreciate the regional magnitude of commuter traffic that is accommodated and redistributed within the Warwick Triangle node. The node itself has been classified as an activity node due to dense socio-economic investment that sees the growth of public and private enterprise that's already thriving within the node.

The overall purpose of the transportation system and road network classification is that, by understanding the general purpose of various road types that categorise Julius Nyerere /R102, we can then determine the functional efficiency to harness traffic pressure from pedestrians and vehicles. The spatial template we hope to formulate is said to exploit accessibility roads as well as mobility spaces alongside busy arterial roads (2013; 31), that circulate the whole metropolitan area or city. However we also need to be aware of the provincial and regional role of the road, to serve important economic activity centres such as international airports, taxi ranks, train stations and harbours. Once this template of an active pavement mobility corridor is executed in an operational setting in one node alone, then a precedent would have been set for how to implement active pavement systems across any hierarchy of streets within African economic hubs or transportation interchange zones.

### 2.1.4.2 THE MOVEMENT SYSTEM

Having introduced the concept of 'urban movement' above and the potential of movement systems and technologies we can now consider which of these technologies would be suitable if we were to execute an integrated energy-harnessing pavement system for the Warwick precinct. The movement system is a key structuring element within the municipal area (Red Book Vol.2, 2009) as it directs and dictates the growth of the urban form, this is due to the movement system being the lifeline to economically thriving centres. Cities are, to a large extent, movement economies and the efficiency of the urban system is directly related to the efficiency of the present movement system (eThekweni SDF 2014/2015:123). If this movement was to be catered for within a spatial framework that seeks to integrate various modes of transportation, mainly pedestrian NMT, then we could be able to secure a reliable energy source from the present pedestrian traffic within the parameters of a mixed-use economic node that's surrounded by transportation interchange zones (Berea train station, multiple local and regional mini-bus taxi ranks, multiple local and regional bus liner ranks, ETA bus depot).

### 2.1.4.3 THE ROLE OF R102 INTO JULIUS NYERERE ROAD

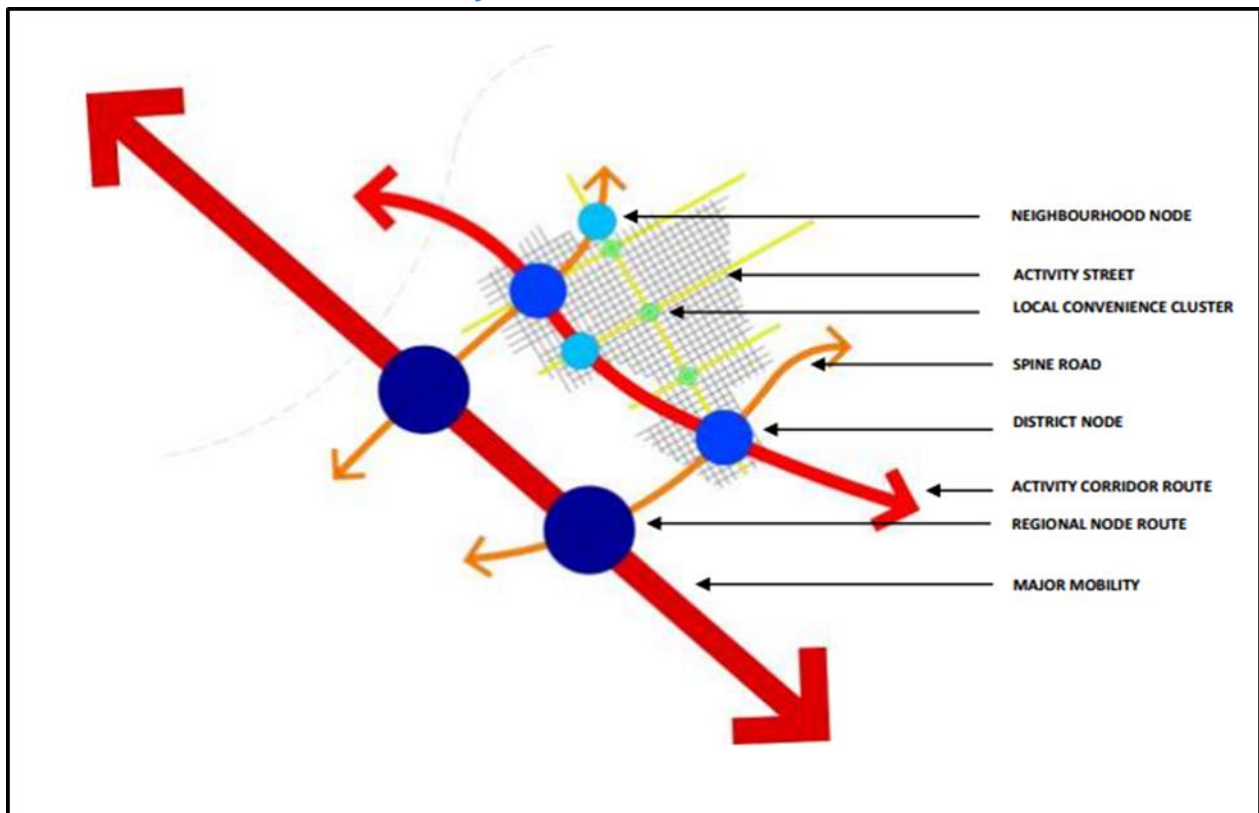


Diagram 4: Road hierarchy and classification (Source: Logan, S, 2012:23)

At the provincial level, the **R102** is a regional (within KZN boundary, Port Shepstone to Empangeni) and inter-provincial major mobility corridor (from the Western Cape Province to Kwa-Zulu Natal) that has been able to link up small towns with cities and also carries regional commuters towards greater opportunities of socio-economic progression. The major mobility corridor is a reserve route, to the national roads e.g. **N3 or N2**, since having no toll fees, and links small towns to cities. Within the eThekweni Municipality and the Durban CBD, the R102 becomes Julius Nyerere Road/ Warwick Market Avenue. At the local level, the role of Julius Nyerere Road, is drawn from the regional context of the **R102** major mobility corridor into an activity corridor route that acts as a major transportation connector for many district nodes and regional nodes within municipal boundaries. There are traders from all corners of the province who occupy Warwick Junction pavements and as a national route from Cape Town to Empangeni, parallel to the **N2**, it also solicits the trade of goods and people from surrounding local areas and those from abroad. Taking a look at the social make-up of the research area, it is true that the Warwick Market is an African bazaar. The Warwick Precinct is a transportation hub and socio-economic network where various economic activities take place. It cannot be ignored, since the area attracts a very large footfall and the concentration of vehicular traffic is extremely attractive to traders and commuters from across the province and the municipality. Old towns such as Kwa-Dukuza and Port Shepstone, for example, tend to expand with growing transportation demands, yet with limited service delivery in terms of energy and infrastructure provision. These constrained municipalities tend to have a number of negative factors that are discouraging to traders, and thus the majority of the regional public trade and public transportation usually heads towards the Warwick Junction Precinct.

Wherever there is an intersection along the Julius Nyerere Road we find public transport intensification and pavement densification by public traders and pedestrians. The by-product of such densification is that the urban landscape of formal and/or informal transportation nodes is channelized by public traders and footfall at strategic points and if sourced correctly could be captured as renewable energy via piezoelectric pavements.

#### **2.1.4.4 TRANSIT-ORIENTED DEVELOPMENT**

Transit-Oriented Development (TOD) according to Pretorius (2000: 3), can be defined as “*a unique mix of land uses located at a high density within a 400m walking radius of a railway station*”. TODs are purposely designed to facilitate access to the transit stations and to increase the use of the public transportation systems. The TOD concept is the underlining feature of most 21st century transportation developments, and this is due to the presence of worldwide support and backing for such a sustainable form of urbanism and transport planning development (Cervero and Sullivan, 2011). TOD offers features of compact and mixed-use activities configured around light or heavy rail stations, motorised transit interchange zones interlaced with pedestrian amenities (Cervero and Sullivan, 2011). The design specifications imply that high economic density areas need to be specifically designed to fulfil their local area functions and needs such as pedestrian-orientated mobility and people-friendly urban spaces (Pretorius, 2000). The overarching principle of TOD has been successful in addressing the need for transportation that is human-centred, resource-efficient and is consolidated by compact urban developments (Pretorius, 2000 & Cervero and Sullivan, 2011). If such principles in urban development were to be followed, then this would result in restricting urban sprawl and the utilisation of multiple modes of transportation. An added advantage would be that TOD complements the promotion of the urban spatial context necessary for the green roads concepts.

TOD also supports interrelated approaches and concepts that can be integrated into smart urbanism, with a major emphasis on green urban developments and better urban functionality. Green TODs could produce future solutions to public transportation facility design. The greater picture would be urban regeneration projects that are 35 percent less taxing on the ecological footprint left by development (Cervero and Sullivan, 2011) in urban areas. In combination, the co-benefits of TOD and Green Urbanism can deliver energy self-sufficiency, zero-waste living and sustainable mobility. It all depends on the proper evaluation of spatial variations, in terms of suitable catchment areas to inform transportation planners about the available energy potential within the pavements of the most frequently utilised routes.

#### 2.1.4.5 GREEN URBANISM

Green Urbanism is an approach to urban design that can incorporate a complex equilibrium of innovative technology, sustainable development approach and green practice to create a future-city or eco-city paradigm in the present day. The balance sees a sustainable urban form that is dictated by social needs so as to maximise access to limited infrastructure resources and public facilities (Lehmann, 2009, 2010). The urban form has taken on a living form that sees mobility corridors become a nervous system, commuting goods and passengers, while also communicating a message of growth to central nodes. These nodes are the compact precincts that have specialised uses, such as Warwick Junction, serving as a node for public trade and transportation. However the approach argues for us to look deeper into the urban network and seek innovative means of solving urban problems (Lehmann, 2010). The issue of energy demand within urban precincts, locally and nationally, has resulted in the researcher looking at the correlation that exists between node densification and wasted footfall/ kinetic-energy within the nodes. By understanding this link, the purpose of the pavement is highlighted as a universal surface that is a means to commute pedestrian and vehicular traffic and also to a socio-economic end, as an easy-access platform for public traders.

An active pavement spatial template for such densely populated precincts would be able to assist the municipality and any other entity that wishes to undertake renewable energy production from transportation interchange zones. The urban spatial planning tool or framework that would be produced, would be able to quantify the traffic flows collected at catchment areas, project traffic-flow distribution and monitor the local catalogue of renewable energy sources that would be embedded within the pavement surface. If we are to develop in accordance to green urbanism development principles, as stated by Lehmann in *Green Urbanism: Formulating a Series of Holistic Principles* (2010), then we need to believe in localised solutions that are based on urban districts' ability to exploit their competitive advantage in renewable energy generation. Lehmann adds that, when it comes to area function and renewable energy generation, priority precincts like Warwick Junction could be seen as plus-energy districts, as the local generation would, in the long run, off-set local energy consumption (2009;191). A decentralised system of energy harnessing pavements could be able to promote

sustainable and walkable precincts that focus on concentrated interconnected features which improve the energy-efficiency of urban socio-economic development.

Green Urbanism reduces emissions and waste from stationary sources in the form of green architecture and sustainable community designs can deliver energy self-sufficiency and sustainable mobility (Cervero and Sullivan2011). Renewable energy might come from traditional sources such as solar and wind, as well as bio-fuels, however, with the growing amount of tools to fill the sustainability catalogue, urban area development should be area specific and so should options for solutions be endemic to the problem they are attempting to solve. Recycling and reusing of low-impact building materials and rearranging public spaces to meet the immediate needs of the local constituency, while reducing the urban ecological footprint of Green TODs, we can see how Green Urbanism has multiple knock-on benefits to urban growth (Cervero and Sullivan2011). In the present context of urban development within the third world relating to the African city, such an approach warrants the exploration and exploitation of micro-renewable energy sources that could see the proliferation of a recycled energy mix consisting of solar from TIZ canopies and piezoelectricity from active pavements. The purpose for pursuing this logic is that, with power, the urban constituency would be able to sustainably diversify within a conducive environment if it has public infrastructure that could result in greater growth strides being made by the municipality as a whole.



Diagram 5: The three pillars of Green Urbanism  
 (Source: <http://sapiens.revues.org/docannexe/image/1057/img-1.jpg>)

The table presented above illustrates how the three pillars and the interaction between them contribute to Green Urbanism. For the sake of this research, the left pillar on *Energy and Materials* and the right pillar on *Urban Planning and Transportation* are of importance. To frame this in the present context of the research, intensified land use occurs at transport nodes, where we find that there is a high amount of pedestrian traffic due to the wide array of economic activities that exist on the pavements. With an approach based on the values of Green Urbanism, integrating a renewable energy-active pavement corridor into a precinct plan would be a new strategic approach to how urban areas are able to generate a large amount of electric energy (Lehmann, 2009 and 2010), in a pedestrian traffic zone that is channelled and can be managed in an efficient manner. Sustainable mobility does not only advocate Transit Orientated Development (TOD) in the sense of having efficient transport modes within a certain



radius at a certain threshold, but also speaks to how people access these nodes and modes of transportation (Lehmann, 2009; Cervero and Sullivan, 2011). Green TOD, in the practical sense, would look at the quality of the journey and the efficiency of transition zones to exchange passengers from one mode to the next or while the commuter is still making his/her way through the market mobility spaces. What the research hopes to achieve by utilising the Green Urbanism approach is to improve the quality of the urban layout, to accommodate public traders in an equitable manner, while improving the efficiency of public mobility within well designed/arranged public spaces.

Energy planning integration strategies and solutions are successful if strategies meet immediate needs, while acquiring the power to sustain long-term objectives to TIZ growth. These solutions must have integrated ends/outcomes and should thus prove to be holistic in the sense of taking into cognisance the interdisciplinary elements that lead to the formulation of a comprehensive precinct plan that speaks to transportation planning and energy planning. The solutions presented should see the manifestation of alternatives that promote local efficiency of urban systems and also allow stakeholders to be equal participants throughout the planning and implementation process (Wheeler, 1998: 487-490).

#### **2.1.4.6 PAVEMENT SYNERGIES**

By pursuing the synergies of Green TOD and Green Urbanism, we could compactly quantify the local environmental footprint and energy needs of a high priority TIZ node, like the Warwick Junction. Sustainable communities that promote renewable energy and recycle traffic waste (pedestrian and vehicle) could increase the potential efficiency of urban public transit services and facilities. The efficiency of public transit services looks at the commuter experience from point of embarkation to destination and the engagement commuters have with public traders along their mobility route.

The presence of green technology within the Warwick Junction would be able to offset, to a degree, the cost of such technological implementations, and also promote the socio-economic rejuvenation within the node which would highlight the importance of pedestrians and public trade within the market area. The way that specific social and technical practices are embedded

within a wider facilitating infrastructure, which subsequently restricts opportunities for alternatives, needs to be set free by changing the energy paradigm for public trade. With regard to urban infrastructure and public facilities, it's of importance to note that a street is not a road in terms of it being a traffic carriageway, but is more complex, supports multiple uses and users and is a place of coexistence of formal methods and informal techniques of commercial exchange. In terms of function, it plays a particular structuring role for mobility paths in the urban area.

Within this research study, it is the synergy of the TOD principle via NMT and MT utilising the Green Road concept as a vehicle that is incorporated with Green Urbanism to create an element of sustainability that will promote effective movement systems that are crucial for the active pavement template to service the people. TIZ's active pavement developments may cater for dense nodes which are of priority to local municipal transportation developments, however, the greater picture calls for us to forecast the expanding urban network of NMT routes and to suggest how to consolidate such into functional transportation plans like the *GO! Durban* IRPTN. The pavement ecology that's to be produced is one that is founded on Green Urbanism employing Green Road technology. The green road concept is there to introduce the variety of technologies available which can be integrated into the pavement structure/ reserve beneath the pavement surface. In this way, it may be possible to steer the inner-city economic drive towards the green sector of renewable energies. The combined energy produced by both pedestrian and vehicular commuter traffic, could produce a charge large enough to make a valuable contribution to the robust energy mix that already exists and could generate 7,5 MW of green energy (ETA SDF 2014/2015:116).

<p style="text-align: center;"><b>Green TOD</b></p> <p style="text-align: center;"><i>Sustainable Mobility Sources</i></p>	<p style="text-align: center;"><b>Green Urbanism</b></p> <p style="text-align: center;"><i>Sustainable Stationary Sources</i></p>
<ul style="list-style-type: none"> <li>• Transit Design World-class transit system (trunk &amp; distribution) – IRPTN</li> <li>• Pavement embedded technology resulting in energy transformation from pavement surfaces.</li> <li>• Transit Station as commuter hub</li> <li>• Non-motorized access (side-walks, bike pathways)</li> <li>• Compact, Mixed Land Uses</li> </ul>	<ul style="list-style-type: none"> <li>• Energy self-sufficient ; (renewably powered – solar, wind turbines, piezoelectric pavements)</li> <li>• Zero-waste (recycle/ convert wasted kinetic energy into energy, rainwater collection for grey-water use)</li> <li>• Mobility Spaces ( TIZ canopies and TIZ pavements)</li> <li>• Green Infrastructure; Green Roofs, Materials (recycled; low impact), Smart street furniture</li> </ul>

Table 1: Theory Synergy for Pavement Ecology (Cervero & Sullivan, 2011:177-178)

From the functional correlation stated in the above table from Cervero and Sullivan (2011), serving TOD (Transit-Oriented Development), looks at how mobility spaces could be utilised as a strategic feature tool to harness energy along mobility corridors. The latter, serving Green Urbanism, looks at how public facilities (transportation interchange zones) could be designed in ways that assist the orientation and functional purpose of the land feature such as a multi-transit mode precinct like the Warwick Junction node. The researcher believes that TOD is the foundation upon which to base successful green road developments, which are an outcome of green urbanism. The alignment of such dynamic sources is crucial if we are to offset the negative socio-economic impact on those who are marginalised on pavement sidelines, however it would all be based on transit-oriented development and how it caters for those who occupy its routes.

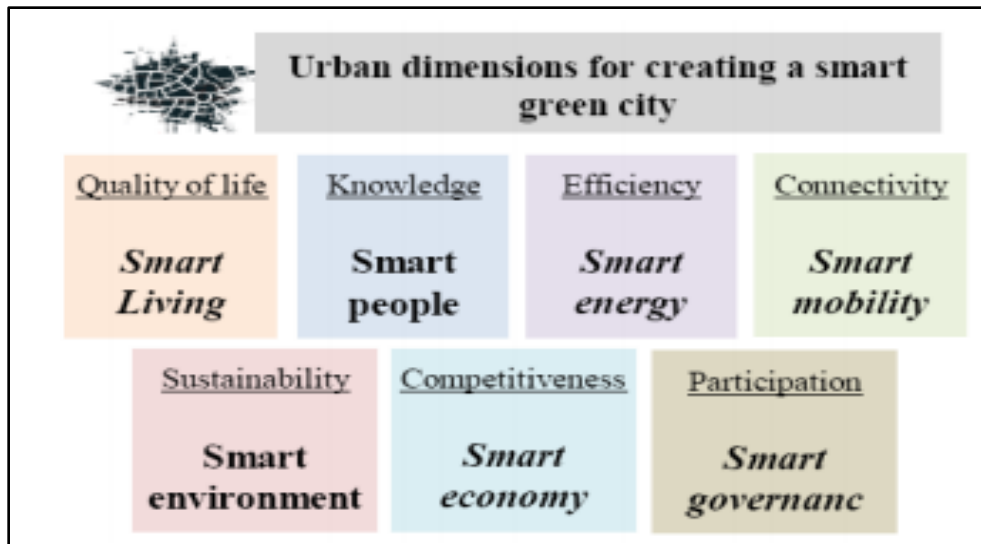


Diagram 6: Main urban dimensions for creating a smart green city (Nassar, U, and 2013: 340)

Green Urbanism and TOD have been utilised in a synergistic approach that has the following characteristics: increased density, promotes transit usage by having mixed land uses resulting in NMT networks and curbs urban sprawl, conserving energy expenses by supplying public facilities and services with a resilient energy mix which draws from solar power or from TIZ canopies (as is being done by eThekweni Municipality currently) and piezoelectric power from TIZ mobility spaces (Cervero and Sullivan, 2011). The synergy described above would lead to the manifestation of a smart eco-city that is resilient and progressive and able to meet the immediate needs within the energy crisis within the country. If we were to rubber stamp this template according to the local needs of every TIZ, then we would be able to justify the compulsory action of implementing such pavements in other precincts enjoying the same functional characteristics as Warwick Junction.

### 2.1.5 GREEN ROAD CONCEPT

At a central transportation interchange node, like Warwick Junction, the supporting infrastructure provides a basis for economic activities to prevail robustly (*New Road Construction Concepts (NRC) – EU 2040 Vision, 2008*). Even at present levels of economic activity, the commuter is forced to engage with a variety of public traders while heading to a destination, or when switching a mode of transportation (*Markets at Warwick, 2010*). Within these canals of constant mobility and economic engagement, we find that a reliable energy supply is found wanting by the street vendors. According to the Department of Science & Technology, to ensure accelerated and sustainable growth, energy supply infrastructure must be increased (2007:18), and this therefore calls for an innovative means to reach that end. This development would be supported by the National Development Plan and other national growth strategies to combat our nation's fossil fuel intensive development (*2030 NDP, 2012*). Since urban development and growth are two sides of the same coin, we need to find approaches like *The Green Road* approach which is proving to be a sustainable way of constructing roads, while also being able to extract a considerable amount of renewable energy for commercial use within urban precincts.

According to Coetzee et al. (2014), in South Africa, infrastructure development should follow spatial trends so as to increase public access and equity to efficient services to reduce social disparities that are the remnants of apartheid planning. The researcher advocates energy harnessing pavements, but acknowledges that the Green Road Approach requires a synchronisation of complimentary policy elements such as greater community participatory action by public traders and a decentralised approach to energy generation and distribution. The optimum utilisation of local resources and abundant public spaces that are vulnerable to high footfall statistics could produce a new wave of inspiration and positive attitudes towards the node as a potential renewable energy node. The integration of energy harnessing pavement infrastructure to simple technologies is the key to unlocking local resiliency and grass-roots innovation. The local skill-pool capacity that would entrench the self-help efforts could be justified and aligned to local spatial frameworks. The progress along the sustainable road of development in the 21<sup>st</sup> century has a green ethos, and we need not fear novel ideas in the way

we approach the construction of roads. One should caution that infrastructure development has a lasting effort when it adds value to the lives of those who are to make use of it. The existing footfall pathway calls for us to exploit the road reserve and the immediate traffic lanes collecting the reserve overspill of footfall.

Since funding for roads is limited, when considering the objectives that the planning council would have to cater for it's imperative to motivate for greater access management to the active pavements, as the template layout caters for all mobility spaces. Municipalities should, therefore, rather concentrate their funding on upgrading existing road infrastructure, enabling the demand for denser developments to be met, rather than building new roads (*SA Road Classification and Access Manual, 2013*). This provides the scope and justification to take advantage of the already existing infrastructure rather than waiting for new developments to implement such strategies. Existing regional transportation nodes already have the threshold that would make such an explorative research viable, and therefore they could provide viable insight into how the already existing pavement infrastructure can serve as a tool to meet delivery needs. The green road concept, in terms of economic viability of road infrastructure developments, insists that road infrastructure developments should do more than just fulfil the mandate of access and mobility when thinking of transportation planning. The concept lends itself to meeting the 'green development' agenda of the 21<sup>st</sup> century by pushing for more sustainable methods and techniques, which would see the sustainable utilisation of suitable resources to meet an array of objectives set out for road infrastructure developments (*New Road Construction Concepts (NRC) – EU 2040 Vision, 2008*). The array spectrum, set out by the green roads concept, is able to accommodate the possibility of harnessing renewable energy from "green pavements" or active pavements within the appropriate technology, since some locations are exposed to abundant sunlight and capital footfall (*New Road Construction Concepts (NRC) – EU 2040 Vision, 2008*).

A country's road network has an important role to play in economic and social activities. Road reserves take up a large portion of land and the multi-use of the road reserves represents a more efficient land use. The table below showcases the pillars of the Green Road Concept,

which are *Reliable Infrastructure*, *Green Infrastructure*, *Safe & Smart Infrastructure* and *Human Infrastructure*. These pillars are meant to guide the implementation of micro-renewable energy sources such as asphalt solar collectors, piezoelectric pavements and electro-kinetic road ramps.

<b>GREEN ROAD CONCEPT</b>		
<b>Construction Concepts (components)</b>	<b>Characteristics</b>	<b>Directions for solutions</b>
<b>Reliable Infrastructure</b>	Available Durable Reliable	<ul style="list-style-type: none"> <li>• Lifetime engineering</li> <li>• Fast, hindrance free maintenance</li> <li>• Balancing demand and capacity</li> <li>• Asset management tools</li> </ul>
<b>Green Infrastructure</b>	Energy efficient Sustainable Environment	<ul style="list-style-type: none"> <li>• Saving natural resources</li> <li>• Emission Control</li> </ul>
<b>Safe &amp; Smart Infrastructure</b>	Accessible Smart Safe	<ul style="list-style-type: none"> <li>• Safe design</li> <li>• Smart design</li> <li>• Smart communication</li> <li>• Smart monitoring</li> </ul>
<b>Human Infrastructure</b>	Multi-functional Multi-usable Public security	<ul style="list-style-type: none"> <li>• Public security</li> <li>• Multi-functional use</li> <li>• Human design</li> </ul>

Table 2: New Road Construction Concepts (NR2C) – EU 2040 Vision (2008:33)

*New Road Construction Concepts (NR2C)* is a European Commission co-funded with private enterprise to facilitate a research project, designed to give insight into vital questions relating to how urban practitioners could anticipate social, economic and technical developments and provide innovative solutions to shape the roads of the future (2008:12). The South African equivalent has been the formation of the *Green Road Council of South Africa (GRCSA)* in 2012. The chairman of, what was at the time, the technical and development committee was Mr Flint, who saw it as imperative that the South African chapter of the Green Road Council worldwide should contribute uniquely by adding a Ratings Tool to the operation. According to Mr Flint, as recorded in an article in *Engineering News* (Vol. No. DATE, Page reference, MISSING), the Rating's Tool would calculate the socioeconomic offset that road infrastructure developments should meet, owing to the country's lack of skills development and increasing demand for job

creation (Venter, 2012). The way in which a road, bridge, sidewalk or island is developed and built, can either be environmentally friendly and conducive to socio-economic activities, or not. Mr Flint believed that a 5-Star Rating Tool for roads built or rehabilitated in South Africa would stimulate innovation in road construction and also add value to the urban environment. He was fully aware of the obvious argument against innovative strides, that being the financial constraints, but the article argued that Green developments do not necessarily have to be expensive with inflated project prices. All relevant stakeholders need to be on board and government support is fundamental, since most roads fall under Public Sector Developments (Venter, 2012).

By integrating the ratings tool into the green road concept, the research has been able to formulate a method that would be able to meet the needs and functions of these approaches. The active template proposed would be able to be integrated into the IRPTN framework and within the transportation hub that is Warwick Junction, a spatial template of active pavements, would have to incorporate the appropriate micro-renewable energy source within the catchment area. The primary objectives of the research are to advocate for harnessing of the renewable energy from footfall pressure. The spatial template can, however, suggest how other sources could be integrated into the plan in future.



## 2.1.5.1 MICRO-RENEWABLE ENERGY SOURCES

### i. ASPHALT SOLAR COLLECTOR

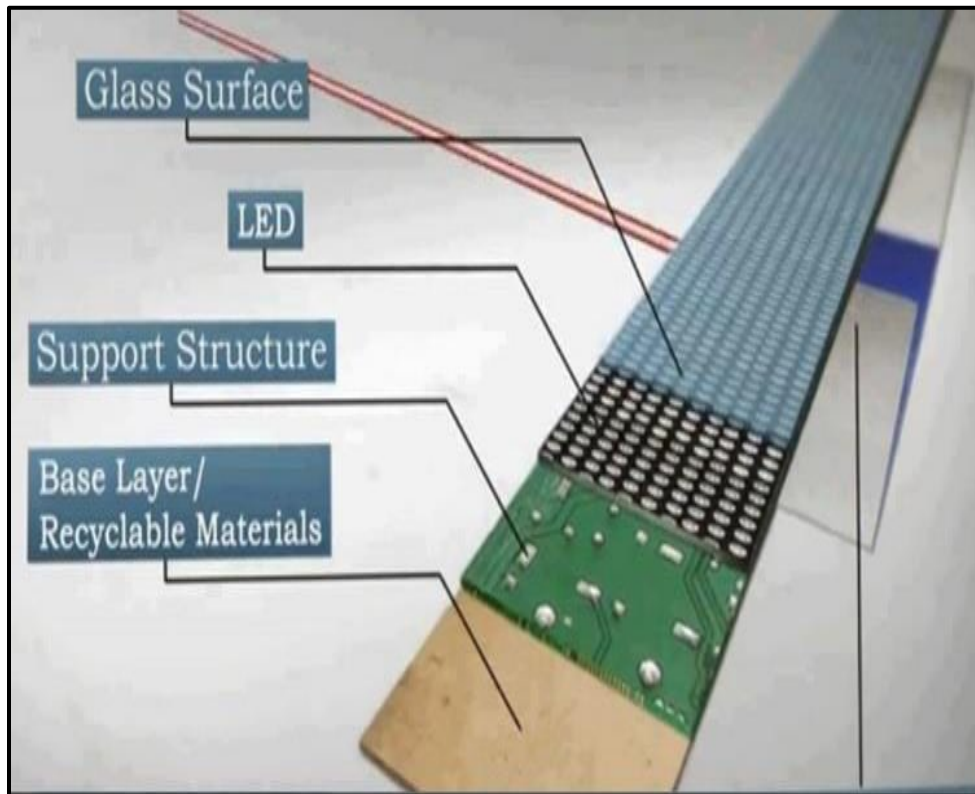


Diagram 6: Asphalt Solar Collector (Source: Solar Roadways,2012)

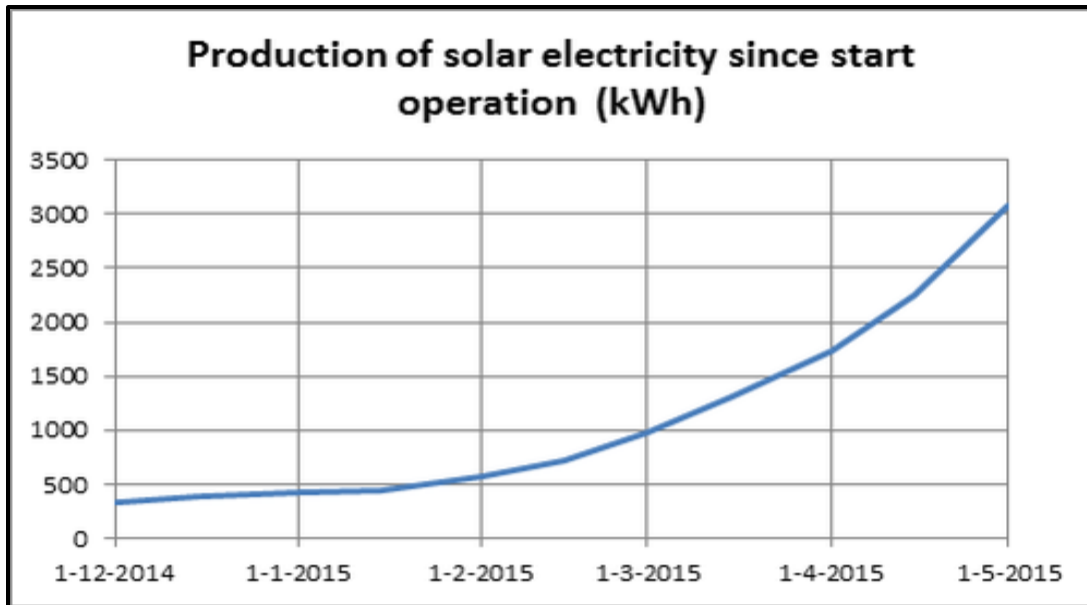
The asphalt solar collector was an idea that was conceptualised in the mid-1990s, however it has only been contemplated in the present day as a viable component in a diverse energy mix. The vast road pavement surface is exposed to natural light for most of the day and so the question is: How can modern technology be used to exploit this energy resource? (*New Road Construction Concepts (NRC) – EU 2040 Vision, 2008*).

In 2010 a Korean institute headed up research to investigate several approaches to harvesting solar energy from asphalt pavements. The investigation would also gave the research team an opportunity to identify what feasible technology options could be utilised, between solar cells that would be in pavement modules/tiles or photovoltaic technology that would be along the road. The former was found to be most commercially viable and the approach to utilising solar cells involved the development of a multi-layered system or modules/tiles, consisting of a transparent surface and a complicated layer of electronics that are supported by a solar

collecting sub-base. The embedded solar tiles would also be able to illuminate message boards and billboards, traffic lights, street lights, road markings and any other street installations (Kang-Won & Correia, 2010 and Wayne, 2013).

From the first experiments, a lot of progress has been made in trying to improve the technology and its performance outputs. However there are still some sceptics who question the feasibility of the solar road tiles. In the United States of America, the commercial viability of such green technologies has been realised and now most manufacturers and road engineers have started to develop heavy-duty solar road panels to handle the mechanical stress exerted by high frequency traffic areas with varying loads commuting above it (Wayne, 2013). There are two major hurdles thus far for solar roads; the first is cost and the second is safety. The cost is tied closely to the lifespan of the technology, since an average road would have to have a lifespan of 20-30 years. The matter of safety considers the solar tiles' rigidity. Can the tiles handle the heavy duty load without breaking up in a way that would be harmful to vehicles and pedestrians? (Kang-Won & Correia, 2010 and Sasitorn, 2015 ). The research study area involved an arterial Class 1 road, which enjoys abundant exposure to natural solar rays. The problem lies with the vehicle loads.

Despite the above concern, in the Netherlands, in November 2014, in the province of Noord-Holland, the world's first solar road was opened and it performed better than had been anticipated by the research team. In its maiden 6 months, the SolaRoad project produced over 3,000 kilowatt-hours (kWh) of renewable electric energy, as reflected in the table below. The current energy can supply three hours of full power (Sasitorn, 2015).



Graph 1: Annual production of solar electricity from SolaRoad project (Source: Energy Production, 2015 : <https://twitter.com/zepenexis/status/596979432142675968/photo/1>).

This first feat of official commercialisation of solar roads was based on the use of such roads by cyclists and pedestrians. The pilot involved the embedding of solar modules in a 70 metre pathway with the modules protected by two layers of safety glass. Developers claim that heavier loads could be accommodated (Sasitorn, 2015).

ii. **PIEZOELECTRIC PAVEMENTS**

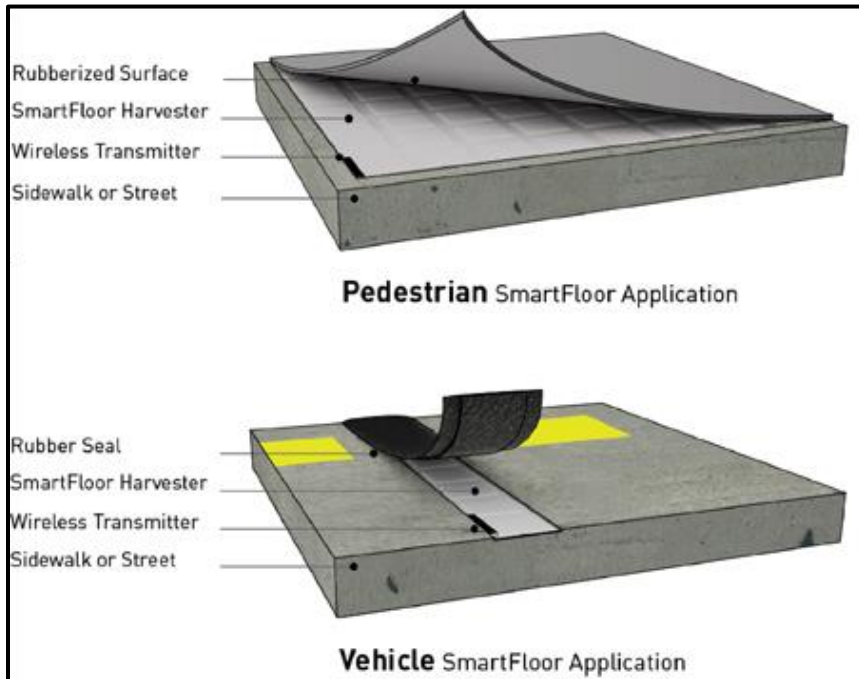


Diagram 7: Piezoelectric pavements (Source: Kinetic Tiles, 2015)

The application of piezoelectric devices or sensors in the pavement infrastructure has become a revolutionary step in approaching how we use and view mobility spaces and mobility corridors. The current leaders in the field of producing commercially viable piezoelectric generators are *Innowattech* and *Pavegen* (Innowattech Energy Harvesting Systems, 2012 and Kinetic Tiles, 2015). These systems, when implemented, can generate an electric voltage when mechanical pressure/ stress or vibration is applied (Kinetic Tiles, 2015). Piezoelectric materials are widely available in many forms, for example as: single crystal (quartz), single and stacked piezo ceramics (lead zirconate titanate or PZT), thin film (sputtered zinc oxide), screen printable thick-films based upon piezo ceramic powders and other polymeric materials (Innowattech Energy Harvesting Systems, 2012; Roshani and Dessouky, 2015 and Kinetic Tiles, 2015).

In the present day, the scope for research within the field of piezoelectricity is broad, but for this research we focus on producing power from small-scale vibrations like those from footsteps and other NMT modes. Piezo materials offer the desired functionality that can be incorporated easily into existing pavement infrastructures, thereby resulting in the ability to produce a diverse range of power voltages depending on the type and magnitude of the applied

stimulus and the energy generating system (Gkoumus, Petrini and Bontempi, 2013 and Roshani and Dessouky, 2015). They can respond to a variety of physical stimulus (tensile force, torsion, pressure) and they don't have a minimum requirement for producing power, just an applied mechanical force (*Kinetic Tiles*, 2015). To achieve the best results of electric power yield, we would have to focus on the sensitivity of the pavement interface, the type of piezoelectric transducer and any other naturally occurring, yet contributing variable (vehicular load, expansion and contraction of the pavement) etc. (Gkoumus, Petrini and Bontempi, 2013). The harvested energy can, however, be used for small scale road applications where the installation and maintenance costs are low. To increase the electric output from the mechanical strain applied, the PZT surface area must be increased in diameter and thickness, however this can also increase cost. When piezo materials are applied to roads, the life cycle of the system is compromised, as the heavy loads would call for regular and constant inspections and maintenance (Innowattech Energy Harvesting Systems, 2012; Gkoumus, Petrini and Bontempi, 2013 and Kinetic Tiles, 2015).

The Innowattech system is designed to harvest and convert mechanical strain into electrical current through Piezoelectric Generators (IPEG) (*Innowattech Energy Harvesting Systems*, 2012). The mechanical energy is derived from various sources such as compression stress on pavements when vehicles or pedestrians travel on an embedded pavement surface. The accumulated electric energy is transferred and stored in batteries for immediate on-site power needs and can also be used later or routed to the grid (Gkoumus, Petrini and Bontempi, 2013 and Kinetic Tiles, 2015). IPEGs' implementation into the road layers can be done via electronic cards, so as to store traffic-generated energy and these are covered with a layer of asphalt, either concrete or composite concrete if on roads, and if on pavements, then they can be embedded into modular pavements (Innowattech Energy Harvesting Systems, 2012 and Kinetic Tiles, 2015). For the sake of extrapolating figures to conduct a desktop feasibility study, I choose the *Innowattech* Piezoelectric Energy Generators, which can produce 1Kwh of electrical energy from a 100m passage that has an average of three thousand people walking past it (Innowattech Energy Harvesting Systems, 2012).

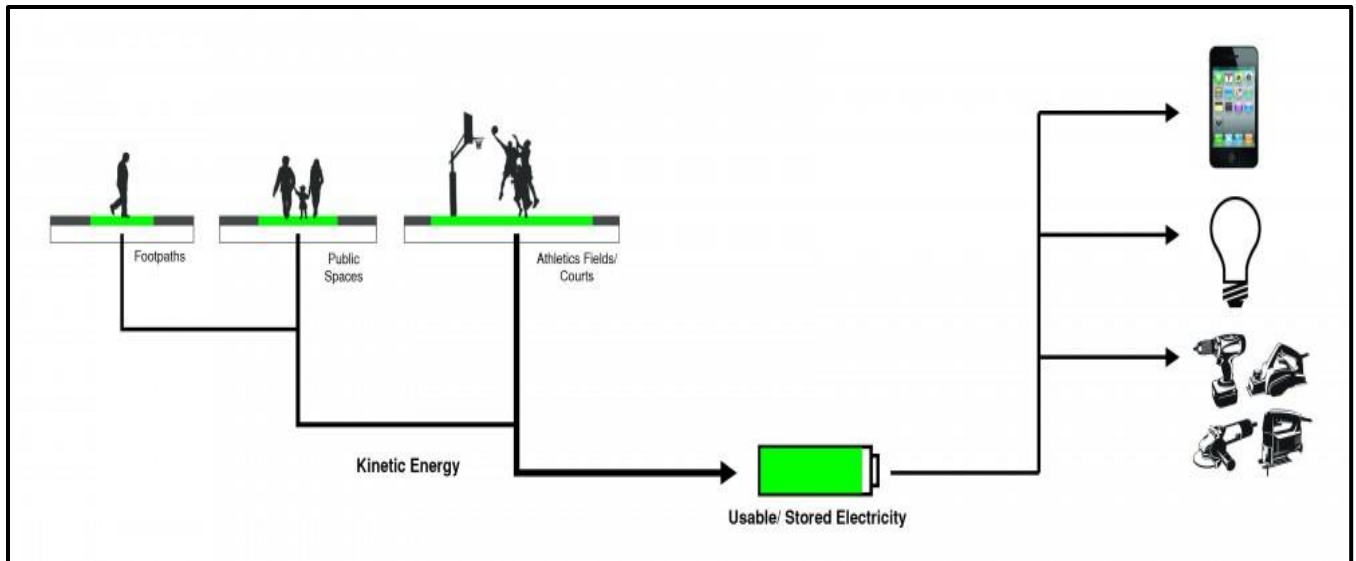


Diagram 8: Application and uses of piezoelectric pavements (Source: Kinetic Tiles, 2015)

*iii. Electro-kinetic road ramp*

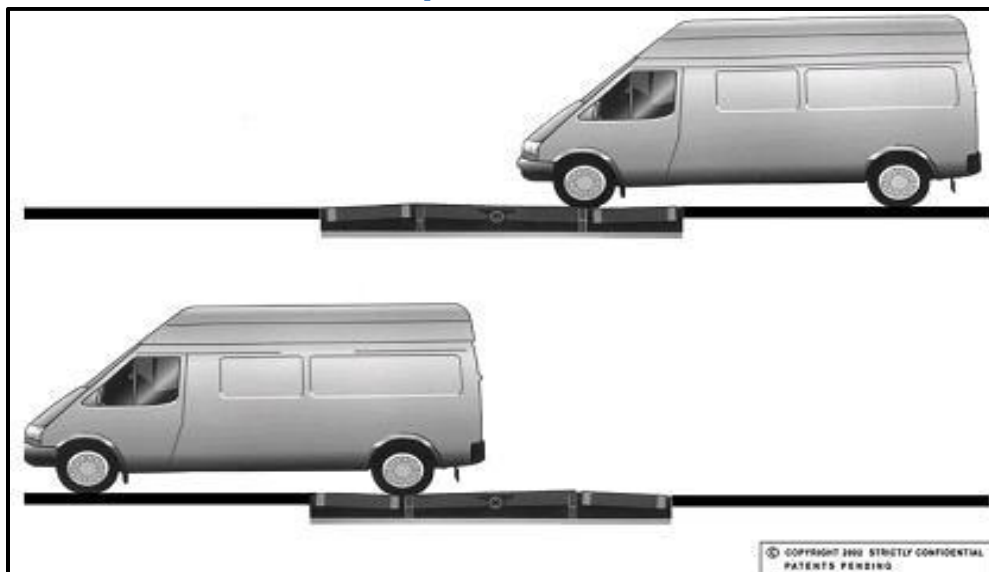


Diagram 9 : Electro-kinetic ramp for road use ( Source: Phillips, 2009)

The Electro-kinetic road ramp or ‘Green’ speed bumps are able to generate electricity as cars drive over them. These electro-kinetic road ramps will be able to power street lights, traffic lights and road signs. Speed bumps are ideal speed control mechanisms which have proved to be able to capture the kinetic energy of slow passing vehicles. They are silent, comfortable and don’t damage the vehicle or waste any petrol when driving over them since they are embedded into the pavement surface (Roshani and Dessouky, 2015). They are also adaptable; ramps can be raised to act as a speed bump or can be laid flat. Underground cogs and an energy storage

system can be linked to the local network. The pilot for these ramps was proposed for London, UK in 2009 (energy price and rand conversions done to 2015/05/20) and the cost for 4 ramps covering 1.6km would be between R360 000 and R990 000 (BHP 20 000 – 55 000). The series of panels would be integrated into the existing pavement structure. The method of operation is that, as vehicular traffic passes over it, the panel goes up and down, setting a cog in motion under the road. This then turns a motor, which produces mechanical energy. A steady stream of traffic passing over the ramp can generate 10 – 36 kWh of power. Energy not used immediately can be stored or fed into the national grid (Phillips, 2009). Annually, the electro-kinetic road ramp project hopes to generate between 37,80MWh (R 64 240) and 136MWh (R231 264) worth of energy per year; the figures were converted using the *Eskom Schedule of Standard Prices 2014/2015*. This means that it would take about four to six years to repay the cost of the infrastructure, but once the capital costs had been paid for, the energy produced would be cheaper. Ten ramps equate to the same price as a single wind turbine in terms of power generation (Phillips, 2009). However, for Julius Nyerere Avenue, these would be ideal at the entrance and exit of TIZs and also in the slow lane as manual hauling of goods is predominant.

#### **2.1.6 CONCLUSION TO THEORETICAL FRAMEWORK**

In an attempt to create an innovative and resilient city, our urban sustainability goals could be met when strategically approaching the development agenda of an African city. At the local and intermediate level where we need integrated planning measures that create urban spaces and systems that are responsive to the urban challenges which hinder the progressive development of socio-economic ventures.

The implementation of a piezoelectric pavement system is meant to improve the present and future growth of the Warwick Junction precinct by providing an on-site renewable energy source in close proximity to public traders. It has been shown through this body of literature that the urban management aspect in terms of novel technology roll-out is really important, and thus we have to integrate all government and municipality governance functions before we can realise our development goals stated in the National Development Plan for 2030. When we look at the infrastructure and function of cities over the past decades, it needs to be formally acknowledged that, innovation and resiliency are the intrinsic features of an African city. The

prevalent presence of public traders makes us see the need to implement a sense of green urbanism and sustainable TOD, and to make sure that we are able to link up urban design to urban mobility efficiency. Mobility spaces offer urban practitioners a vibrant space that connects people and places whilst also serving a common good as a public space for trade.

The pavement ecology and its densely occupied nature, could be exploited for renewable energy and the potential that would have been lost within mobility spaces as pedestrian commuters make their way serve as a lighting source for many traders.



## 2.2 LITERATURE REVIEW

### 2.2.1 INTRODUCTION

In order to secure a reliable alternate energy source for informal traders within transport precincts, it is important to understand the pavement ecology that exists within those high priority, transport node perimeters (Markets of Warwick, 2010 and Open City Projects, 2012). The second objective of this research is to guide the investigation through the question: *Can proactive precinct planning of transport nodes be able to maximise energy access to meet energy demands by public (informal) traders within the Warwick Junction mobility spaces?* With this question in mind, it becomes imperative to investigate and substantiate the necessity of having a proper urban design strategy informed by the resource needs of public traders. Such an urban design should be a contributing agent to the urban rejuvenation initiative that is already being implemented by the eThekweni Municipality (eThekweni IDP 2015/2016, 2014).

The literature review will involve critical engagement with academic views from various disciplines and institutions on sustainable local area planning, energy planning and its policy framework, encompassing municipal by-laws concerning energy regulations for informal pavement trading, smart growth strategies for innovative cities and transport node development, in relation to *eThekweni Transportation Authority goals (2012)*, in rolling out its *Integrated Rapid Public Transportation Network Strategy*.

### 2.2.2 INFORMAL ECONOMIES AND RENEWABLE LIVELIHOODS

The purpose of the literature review is not to seek the truth or narrative of the history and discourse till present within Warwick Junction, however, the purpose of this research is to formulate the best approach to implementing a spatial template that could be a vehicle for integrated urban sustainability that is part and parcel of urban rejuvenation within a predominant public transport node/hub. The Warwick Junction has had a controversial history with multiple transformations that have supported the informal sector being considered within policy formulation, and is also inspirational for world renowned area-based management projects. It is still an area with contested notions of equality and right of access to public space and resources for those who eke out a living on the pavements of the transportation hub (van Schilfgaarde, 2013).

Even though the Warwick Junction and its market components are dualistic in nature; formal and informally structured, the precinct is still in a functional condition to continuously sustain and service the street-trading activities and the various transport nodes that attract large volumes of pedestrian traffic (Open City Projects,2012). As an entry port for commuters to the city centre, it becomes a hive for street traders who eke out a living on Warwick Junction pavements, awaiting hundreds of buses, taxis and trains that bring in commuters to and from the CBD or from surrounding and regional areas (Markets of Warwick, 2010 and Open City Projects, 2012). The area serves commuters from rural areas, townships, informal settlements and those from the inner-city (SARPN, 2003: 6 and Markets of Warwick, 2010). Commuters are dropped off and make their way through various routes towards their destinations. Most of these routes begin and end at the Junction due to its central transportation interchange role within the CBD (Nomico and Sanders, 2003:7).

In trying to link the global view once held by Bromley (2000), of the global *status-quo* as to what is necessary for street-trading, with contemporary views by Marlene Laros, Chen et al. (2012) and Skinner (2009), it is necessary to acknowledge that informal trading on pavements is an ancient and important occupation found in virtually every country and major city around the world, however, nowhere in the world does it predominantly shape the urban form and then develop cities (Nomico and Sanders, 2003; Chen, M, Bonner, C., Chetty, M., Fernandez, L., Pape, K., Parra, F., Singh, A. and Skinner, C., 2012 and van Schilfgaarde, 2013). The informality that has persisted in Southern African cities can be categorised as “quiet encroachment”, which is un-politicised encroachment upon urban space, infrastructure and services, resulting in major infrastructure and service delivery backlogs. The urban poor are forced to compete for limited urban space, infrastructure and service provision to survive and sustain their livelihoods (UN-HABITAT, 2014: 251). Informal trading adds greater value and vitality to local enterprise. It contributes to pavement ecosystems in a manner that is dynamic and diverse in its economic activity, while demanding service provision within formally ignored urban spaces (Skinner, 2009 and van Schilfgaarde, 2013).

The development and planning objectives for the Warwick Junction urban renewal programme, under *ITRUMP* are aimed at holistic and integrated development of the area in order to improve the overall quality of the urban environment in terms of safety, security, cleanliness, functionality, efficient public transport usage and facilitation of economic opportunities (SARPN, 2003:8 and eThekweni Municipality IDP 2015/2016, 2014). What makes Warwick Junction a relevant local site for research is that it offers the opportunity to demonstrate how the informal trading space, this being pavements (pedestrian spaces), could be successfully integrated into a strategic spatial template for transport interchange nodes (taxi ranks), in an attempt to create a public-space that has a self-sufficient energy system that meets local trader needs (Chen et al., 2012 and UN-Habitat, 2014).

From the World Bank Report (Chen et al., 2012), which focused on *Urban Informal Workers: Representative Voice & Economic Rights*, the rich contrast between developing cities in the global south and their informal trader rights, highlights the need for the effective management of the informal economy, especially street trading and retail markets. The 2015/2016 eThekweni IDP, dictates that the effective management of such public spaces is a demanding task involving the demarcation of trading areas, the issuing of permits, organising traders into area committees that feed into a citywide forum and the ongoing collection of rentals (2014). The necessary enforcement of operational regulations and by-laws in conjunction with the Metro Police, as well as negotiations with civil society and also the community of public traders within the CBD, would be the necessary catalyst to creating an urban environment that is meant to serve the needs of the many who are poor (eThekweni Municipality IDP 2015/2016, 2014:95).

### **2.2.2.1 PUBLIC TRADERS**

If we are to change the perception of the informal economy and its impact on spatial developments, then we have to start at changing the terminology that exists around the informal traders, and also around the spaces from which they practice their business. In order to project such a positive image, it is important to engage with the nature of public space enterprises. These are: numerous forms of informal trading activities that offer goods and services along public spaces; and public facilities that are accessed by the general public, such

as the multiple public transport interchange nodes or taxi ranks that exist within the Warwick Junction public transportation precinct and the rest of the African city.

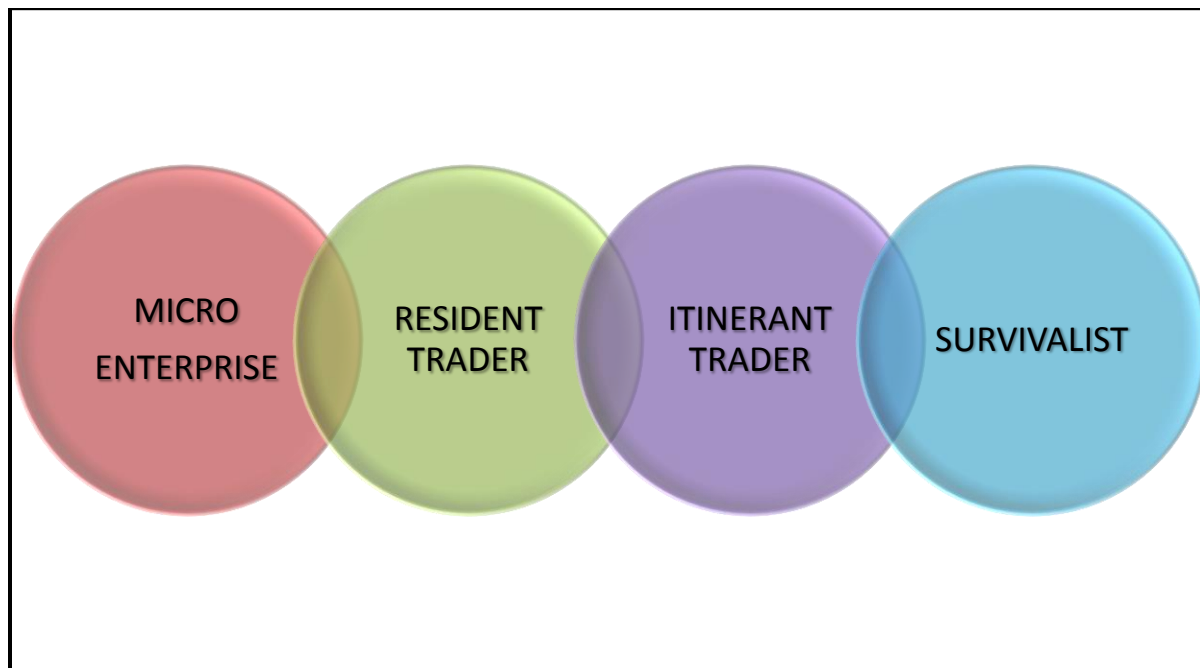


Diagram 1: Multiple layers of a “public trade”<sup>11</sup> (Source: Researcher, 2015)

What makes it harder to draw the line between legal and illegal trading activities within public spaces that are in range of public facilities, is that the criteria for suitability of an area for public trade rests on the size of the area and its functional capacity, as well as what sort of amenities it offers and the sort of clientele available, secondly, one must consider pedestrian traffic flows (how busy the area is) that exist within the area and those commuting through the area (Itinerant Policy, 2012). Since formal and informal traders in public spaces have become one and the same as they compete for profit within the very limited road reserve for pedestrian commuters, the operational characteristics of the Warwick Junction precinct make them both dependent on the bustling public transportation hub and its markets that receive an average of 500 000 pedestrians a day (Open City Project, 2012). What is evident along Julius Nyerere Road is that franchises such as Pie City, and big businesses such as cellular networks, have realised that commuters within a public transportation precinct don’t usually have the time to go into a store and buy a pie or even walk into a store to purchase a SIM card or airtime, and so they rely

---

<sup>11</sup> The interchangeable terms that describe the prevalent agents of public trade that exist within the public transportation precinct of the Warwick Junction

on itinerant traders to sell these products on a commission basis. What has also become evident is that some informal catering traders prepare the food and then hire a person to walk around with a container full of polystyrene food parcels ready for sale and consumption.

Traders have become smarter as their permits only allow for one business within a fixed space, however, in order to maximise their spatial range for interacting with clientele, they have runners who deliver and sell within the spatial perimeters of their transportation precinct. Census findings also show how hard it is to pinpoint the actual number of traders, as only 66.2 percent are resident traders or have a fixed location for trade, and 33.8 percent said that they were mobile (Census of Street Vendors in eThekweni Municipality, 2010). From the sample who were willing to collaborate, only 43.6 percent said that they were operating via a permit issued by the Municipality. Traders weren't always operating from a fixed location, and even more alarming is the fact that many do not have permits to operate their trade in public spaces. This leads to their business activities being labelled as criminal and a nuisance to the city officials. The term 'public trader' is meant to be a universal platform for all those micro-enterprises which operate within public spaces and utilise the public domain as their main point of access to their clients and consumers (Census of Street Vendors in eThekweni Municipality, 2010).

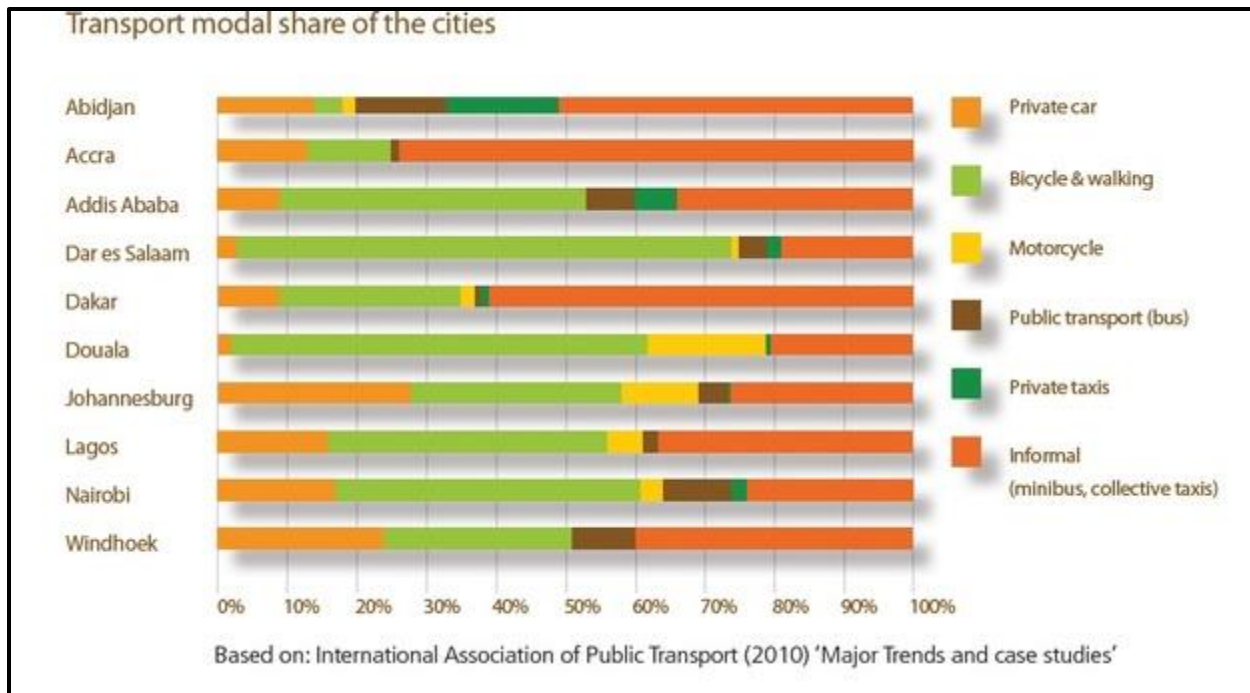
The eThekweni municipality has done a great deal to formalise and assist the informal economy as it acknowledges that the sector plays an important role in the economic and social development of a city. The African city's resilience rests on this sector, as it is an important force to generate employment and income that also contributes to the municipal GDP. It also has the potential to be a catalyst towards activating local economic competition within or between precincts within the CBD or within the municipality and providing goods and services at a competitive price to meet the needs of a larger niche market of customers and consumers. It could also enhance technical change and local innovation to meet infrastructure shortfalls, and stimulate local economic developments that could be the generator for public sector investments (Improved Management and Control of Itinerant Traders - Policy Framework, 2012).

However, even though the city has done so much in an attempt to formalise and assist this sector, there are numerous constraints that relate to the legal and regulatory environment of

public trading, equitable distribution of public infrastructure and access to appropriate technology for all public traders according to their trading activity needs. The issue of storage premises with affordable rentals needs to be addressed along with the provision of water and electricity (Itinerant Traders - Policy Framework,2012). To counter these constraints to public trade, the Municipality has taken it upon itself to review its spatial development principles in order to cater for all public traders and to promote the informal sector only in areas that have large flows of pedestrian traffic, specific demarcation of public trading spaces, trading bays and zones located along major pedestrian traffic routes, supported by the broad idea of following the Spatial Planning Framework of the eThekweni Municipality (Itinerant Traders - Policy Framework, 2012; Durban's Informal Trader Policy, 2001; Open City Project, 2012). Furthermore, the City aims to assist 10 percent of approximately 150 000 public traders, to graduate and become commercially viable and dynamic players who are capable of contributing meaningfully to the economic growth of the City and the quality of life of its citizens (Improved Management and Control of Itinerant Traders - Policy Framework,2012), however, this can only be effective if carried out according to the terms of the public traders, and not under the 'dictatorship' of municipal officials, as this, in the past, has led to counterproductive clashes between officials and traders.

#### **2.2.2.2 URBAN PAVEMENT FUNCTION**

The utilization or occupation of pavement spaces within precinct mobility corridors, could determine the maximum space for potential piezoelectricity harvesting catchment areas, which could source renewable energy from the commuting pedestrian traffic footfall. By securing and enhancing a thriving environment, the informal economy activities could be seen as the main beneficiary of renewable energy strategies that could intensify the presence of diverse traders throughout the working day.



Graph 2: Transport modal share of 3<sup>rd</sup> World Cities (Source: City Lab .Sturgis, 2015)

The table showcases the various transportation modes for various African cities and what is evident is that public transportation modes and NMT modes across the continent's bustling cities are predominant over private transport. If the population growth of the urban areas is factored in, which is said to triple between 2020 and 2050, we start to see the bigger picture of how African mobility spaces will become incrementally denser as a by-product of urbanisation. The piezoelectric pavement system could leverage off the growing presence of footsteps in urban areas. The image of the public traders who are the main beneficiaries of the cheaper renewable energy source could also change in the public perception. (Sturgis, 2015).

Before engaging with the presence and location of the mobility spaces of opportunity, we need to understand the nature of the urban form that would be most conducive to the progressive implementation of piezoelectric pavement systems. The ideal setting for the implementation of the pavement strategic tool would be a transportation interchange zone that is coupled with a 'market' ethos, which is described by the *eThekweni Municipality Retailer's Market Policy (2003)*

as being a grouping (formal or informally) of specific traders operating from open stalls, within a defined or enclosed public space, who are engaged in the exchange of goods and services.

Taking into account the points mentioned in the *Open City Project* article (Web.10), the researcher concurs that suitable area-based urban management practices could motivate an energy-spatial template that is able to leverage from the concentration of market activities in spatial forms, to draw pedestrians and micro-enterprises to energy harvesting catchment zones within the CBD ( Eberhard, et al., 2011). If informal traders are made equal partners in such an initiative then the strategic pavements could have capable custodians to maintain the infrastructure throughout the project life cycle (Web.10). Technology is only reliable if it is well taken care of, as the maintenance issues that plague Eskom bear testimony to (Gkoumus, Petrini and Bontempi, 2013 and Web.11, Web.12, Web.14). Smart growth strategies and strategic technological tools, embodied as strategic infrastructure could be integrated into urban renewal approaches, as a means to aid innovative micro-enterprise. Urban markets and transportation precincts are the potential sites for economic stimulation within the formally marginalised spaces that offer so much to informal traders.

### **2.2.2.3 INFORMAL INNOVATION**

If area-based development is going to be successful in executing energy harvesting projects in fixed urban zones, then potential opportunities within mobility spaces need to be recognised when trying to consolidate the informal trading space, including pavements, in the context of the innovative city paradigm which can spearhead smart growth development This should also allow innovative diversification by informal traders to acquire a sustainable livelihood in a physically responsive atmosphere. This premise is based on the ideas presented within the *Integrated Development Plans and Spatial Development Frameworks* by Cameron et al. (2004; 1) and Coetzee et al. (2014), relating to how we could find the key to unlocking the potential of urban spaces which could initiate innovative approaches that promote integration and sustainability, while linking municipal planning goals that try to promote integrated area development projects (Durban Informal Economy Policy, 2001).



The human development approach to planning as a strategic tool could result in the promotion of Local Economic Development (LED) and could provide a meaningful impetus to micro-enterprise growth which is predominantly informal. Innovation is context-based, and to draw that innovation into urban plans we have to empower the will of the people who occupy these informal spaces. With the basic provision of electricity to these compact transport nodes, the Municipality could see the birth of a new purpose to the Warwick Junction precinct. Already in the literature (van Schilfgaarde, 2013) previous studies have pointed out that the micro-enterprise sector, both informal and formal, has major obstacles to surmount, since the diversification of operational processes by traders is dependent on fully serviced public spaces. Such limitations cannot be ignored if we are to address the issue of trade and growth in future smart cities.

Infrastructure and resource provision (energy provision) to the micro-enterprise industry could sustain the expansion of the pedestrian spaces in public transport dense urban precincts such as those within the research study area, which has a wide variety of public transport modes available to all commuters.



**Image 4. Pavement kebab grill**



**Image 5. Mealie cookers**

Source: Open City Projects (2012)

The strategic active pavement system could provide the infrastructure to facilitate economic activity that is conducive to sustainable socio-economic growth, urban development and job creation within the municipal area.

The purpose of this study is to evaluate the extent to which the pavement spaces, occupied by traders and pedestrians, could play a possible role in being a renewable energy source for the informal traders and also for the Warwick Precinct as a whole. This does not mean, however, that the research sees the piezoelectric technology as a panacea for all the energy needs of urban spaces. The research acts as a platform to suggest how a proactive approach towards spatial planning could provide on-site energy, functioning as off-grid mini-grids, enhanced by the right mix of technology and stakeholder participation. Transport precincts are the main focus area for the research study and the informal catering sector is the main end-user in mind for the renewable energy that is to be provided by the strategic active pavement system. On a larger scale, an attempt will be made to produce a spatial template that could be duplicated elsewhere.

The highlight of such an integrated strategy is that it could help formulate a sustainable spatial template for piezoelectric pavement lay-outs within the perimeter of a transport node. By making use of piezoelectric material within pavements and following spatial planning principles

of concentration, we can integrate the pavement ecology factors (informal traders, pedestrians, public transport modes, and potential piezoelectric pavement surface area) into a regulated framework that could assist in monitoring the overall functional capacity of the spatial template. The end result could be the provision of a catalyst to urban economic growth, while also being able to provide a much desired service to the mini-enterprise sector. Job creation could be fuelled by the innovative spirit to earn a sustainable living that not only sees personal economic gains for the trader, but in the context of a larger picture, secures a mini-grid that is able to serve the immediate transport interchange precinct. The redistribution of electrical power within such an environment could spell new avenues for earning a living for informal traders.

As the national development and growth path rests on our ability to access reliable power, the optimisation of a renewable energy mix could ensure energy security:

*the race is on for safe, clean, affordable and reliable energy supply, and South Africa must meet its medium-term energy supply requirements while innovating for the long term in clean coal technologies, nuclear energy, renewable energy”* and also to secure the promise of a diverse green economy.

(RSA10 Year Innovation Plan (2008-2018) 2007: 6)

#### **2.2.2.4 THE GREEN ECONOMY AND INFORMALITY**

The United Nations Environmental Programme (UNEP) defines the Green Economy (GE) as a pro-growth strategy that encompasses a system of activities that instrumentally sees to the *“improvement of human well-being and social equity while significantly reducing environmental risks and ecological scarcities”* (UNEP, 2010:4). In South Africa, the GE agenda was first adopted at the Green Economy Summit held in May 2010, by various government, private and public stakeholders who were to be instrumental in the application of the green projects and programmes to accelerate the entrenchment of the national grassroots strategy. Presented as a suite of progressive macro-economic policies within the *National Sustainable Development Strategy and Action Plan* that were meant to align the short to long-term strategy for action and development, this attempt sought to eliminate unsustainable consumption and production

methods within developing regions (DEA, 2011). The framework documents sector-specific policy reforms aimed at assisting the transition to a resource-efficient, low carbon and pro-employment growth path. This was designed to guide the green growth measures that could be taken in integrating environmental goals and to promote sustainable development in a manner which compliments the national commitment to the green economy transition, as stated in the UNEP guide to the GE (DEA, 2011 and Allen and Clouth, 2012). The international message to developing countries is that governments need to be creative and resourceful when carrying out catalytic projects and programmes which would support developing countries like South Africa towards achieving their 2030 national development goals, while fulfilling their integrated national development framework recommendations to accommodate green economy transition action plans (Allen and Clouth, 2012). The transition is meant to direct developing countries away from carbon-intensive activities within key economic sectors such as energy, agriculture and manufacturing, while looking at pro-growth and pro-employment strategies that seek to uplift social capital and to secure the socio-economic development of those who are marginalised or indigent (DEA,2011; Allen and Clouth,2012 and UN-Habitat, 2014).

The Green Economy also refers to two inter-linked developmental outcomes for the South African economy as it embarks on a sustainable development growth path. In an accord commissioned by UNED during the global economic crisis of 2008, it called for the Global Green New Deal (GGND) whereby governments had to find new and innovative economic activities that would usher in a new system of development that relied on green technologies and industries (2011: 24-25). This is why the overarching theme of the Green Economy Summit in South Africa, in relation to the UNEP accord, was focused on a resource-efficient, low-carbon and pro-employment growth path. (6:2010). As per the GGND accord, these two developmental outcomes for SA's green economy are aligned with the global economic transition to a greener economy that creates green jobs, promotes sustainable and inclusive economic growth and is linked to the Millennium Development Goals and their revised date of 2018 (2010: 5 and 2011: 25).

With its *2030 National Development Plan*, the South African government has aimed to have 36 percent of its energy emanate from renewable energies by that date. The government has further launched a range of programmes, catalytic projects and reform policies that were outlined in the *National Strategy for Sustainable Development (NSSD1)*, which was presented in 2011 and, like every other strategy, it had a five-year horizon before being reviewed again, and so, from 2015 – 2020 there would be a new *NSSD* in place (2011: 23).

The global economic system in the 21<sup>st</sup> century has had to be robust enough to be able to grapple with climate change, unemployment and growing levels of inequality in terms of access to basic services (Allen and Clouth, 2012). Since South Africa has been a hot-bed of service delivery protests, coupled with a load-shedding crisis said to last for at least two to five years (Muller, 2014 ), the calls that echoed from the 2015 State of the Nation Address, were that the government, with its stakeholders, would now invest greatly in finding sustainable alternative methods and measures to provide essential basic services such as energy (SA News, 2015).

This brings into question the ability of the national energy provider, Eskom, to be the champion for decentralisation of renewable energy power production and distribution, since their monopoly affects the fair pricing of production and distribution of renewable energy and whether it could actually meet this global economic transformation that's occurring globally (Muller, 2014). Besides the decentralisation of the means to acquire power, there is also the consolidation of mini-off-grids and/or other remuneration programmes such as the *Urban Improvement Programme (UIP)* for the benefit of 'public traders' (a new term that removes the negative connotation from 'informal traders') (Allen and Clouth, 2012, Muller, 2014 and SA News, 2015).

Carrying this through towards the year 2020 and to 2030 and beyond, how can active pavements leverage the ability to provide power from the growing figure of urban footfall pressure in priority nodes such as the Warwick Junction? And, by utilising the green economy as a platform, how do we integrate a diverse sets of socio-economic objectives that are interlinked to the advantage of all who operate within the perimeters of the Warwick Junction?

The following tables below are meant to speak to the questions that were raised above by identifying the three main pillars in each table that play a role in making the green economy work for the people who occupy these densely populated spaces that could offer a viable alternative energy source to power urban street infrastructure, provide an alternative energy source to public traders and also be a contributor to the grid (UNEP, 2010; DEA, 2011, 2030; National Development Plan, 2012 and Allen and Clouth, 2012).

#### **LAND-USE DEVELOPMENT**

- Green cities and towns integrate land-uses with socio-economic gains resulting in a smart city.
- Green building designs create a resilient built environment ecosystem.
- Sustainable transportation and integrated infrastructure.

#### **POLICY FRAMEWORK**

- Sustainable urban management and expanding public works programmes and policies, to express the green economy in practice.
- Socio-economic technological proliferation, best practice in development and application of science and technology.
- Green infrastructure being a social capital catalyst in providing green jobs and impetus to public trader innovation within urban mobility spaces.

#### **GREEN INFRASTRUCTURE & THE GREEN ECONOMY**

- A generic growth strategy that justifies and promotes the localisation of competitive renewable energy technologies.
- Energy security, clean energy and energy efficiency being the outcomes of a well-formulated energy mix.
- Sustainable heating or illuminating resource. Its production and consumption is carried out with a sense of environmental consideration.

Three components for the success of the Green Economy at Warwick Junction utilizing piezoelectric pavements (UNEP, 2010, DEA, 2011, 2030 National Development Plan, 2012 and Allen and Clouth, 2012).

The table below is meant to show how the three pillars of sustainability: the social, the economic and the environmental, integrate and manifest themselves within the scope of the Green Economy and Green Growth. This table speaks to the latter question that sought to find a way of utilising the green economy as a platform that would allow us to integrate a diverse set of socio-economic objectives that are interlinked, to create a strategy that would be sustainable and beneficial to all, including the Municipality, public traders and the urban form, in terms of green infrastructure (*Economic Development & Job Creation, 2013, UNDESA - Allen and Clouth, 2012 and UN-Habitat, 2014*).

From a larger perspective moving from a carbon intensive environment to a green growth trend would see the following advantages:

- Collection and recycling of waste material from urban areas such as tires for piezoelectric pavement modules;
- Active mobility spaces being an asset within a spatial economy framework that looks at renewable energy pavement real-estate;
- Diversification of the job market should open up social development and it should encourage resilient urban growth;
- Public traders would be able to present their products/services and entertainment content on a digital platform; and
- Proliferation of ICT development, telecommunication networks and mobile banking services would add to the facilities of the area.

<b>Dimension</b>	<b>GREEN ECONOMY</b>	<b>GREEN GROWTH</b>
<b>SOCIAL</b>	Human well-being; social equity; socially inclusive; reduced inequalities; better quality of life; social development; equitable access; addressing needs of women and youth.	Well-being, socially inclusive, access to basic commodities for the impoverished; meeting demands for food production, transport, construction, housing and energy.
<b>ECONOMIC</b>	Growth in income and employment; public and private investments; resilient economy; economic growth; new economic activity.	Economic growth and development; technology and innovation; environmentally sustainable economic progress; more resilient; sustained economic growth; driver for economic growth; new growth engines; green technology; new job opportunities; qualitative growth rather than simply increasing GDP; job creation or GDP growth.
<b>ENVIRONMENTAL</b>	Reducing environmental risks and ecological scarcities; low carbon; resource efficient; reduce carbon emissions and pollution; enhance energy and resource efficiency; prevent loss of biodiversity and ecosystem services; within ecological limits of the planet; environmental responsibility; finite carrying capacity.	Protection and maintenance of natural assets and environmental services; provision of resources and services; low carbon; using fewer resources and generating fewer emissions; resource efficient; cleaner; climatic and environmental sustainability; energy and resource efficient; minimises pollution and environmental impacts; resilient to hazards; harmony between the economy and the environment; environmental protection; reduce GHG.

Table 3: Keywords and definitions of Green Economy and Green Growth (UNDESA- Allen and Clouth, 2012:60 and UN-Habitat, 2014).

The eThekweni Municipality had, in its IDP as its first strategic priority, the creation of sustainable livelihoods with a tagged value statement that read:



*“Ensure that initiatives undertaken by the Municipality contribute to strong economic growth, sustainable job creation, poverty alleviation, improved skills and promotes a Green Economy”* (eThekweni IDP 2015/2016, 2014).

*The eThekweni Municipality’s Economic Development and Growth Strategy for 2013* was clearly proactively aligning itself with the green economy objectives of the 2030 NDP. In terms of increasing the social capital within the municipal area, the green economy involves largely new economic activities and must provide an important entry-point for broad-based black economic empowerment (NDP, 2012). It must address the needs of women and youthful entrepreneurs and must offer opportunities for enterprises in the social economy (Economic Development & Job Creation, 2013 and UN-Habitat, 2014).

In terms of trying to empower micro-industry growth, green technologies, at the forefront of energy security, should cater for a wider range of micro-energy generation applications that would supplement public trader enterprises within the Warwick Junction with a cheaper and cleaner alternative source of energy and which would also provide the Municipality with a large GDP contribution from the sale of renewable energy (*Economic Development & Job Creation, 2013*). A regulatory framework, inclusive of all stakeholders, should have the foresight to forecast expanding public trader presence and their growing needs for suitable infrastructure and sufficient energy.

When we consider the multifaceted growth that is to be set in motion by the Green Economy, then we need to understand the spirit of innovation that truly exists within the confines of the Warwick Market. The implementation of renewable energy technologies would be able to sustain the innovative spirit that exists to sustain the livelihoods of more than 2000 public traders and thousands more commuters. The acquired renewable energy would allow greater diversification of economic activities for traders, but would also mean an additional source of revenue for the eThekweni Municipality. When we start to align infrastructure projects and their implementation, we need to consider the existing social upliftment programmes such as *iTRUMP* and the urban regeneration policy such as the *Urban Improvement Plan (UIPs)*. The social upliftment programmes could be promoted by green infrastructure in the form of

servicing and electrifying of urban nodes with cheap and sustainable energy. The UIPs could also leverage the traders as they would be part custodians and beneficiaries from the sale of the renewable energy. The city would be able to provide other public services from the profits of the energy sales. With this short scenario of what green infrastructure would mean for urban growth, this illustrates that there would be multiple beneficiaries. However, the infrastructure alone is not the panacea for urban energy security.

### **2.2.3 PIEZOELECTRIC TECHNOLOGY**

The technical debate from the electrical engineering perspective argues that piezoelectric pavements have the potential to harness electrical energy from pedestrian kinetic energy exerted on pavements (Web.5, Pramathesh and Ankur, 2013 & United States Department of Transport, 2013), however, the potential for large scale implementation and use of energy besides conventional lightning, is still being experimented on by various state institutions around the world (United States Department of Transport, 2013). Leading developers have been those private institutions, such as Pavegen (Web.6) and Innowattech (Web.5), which have managed to produce an operational prototype of piezoelectric generating pavements that is already being used throughout the world to meet the growing energy demands of compact spaces. The installation of piezoelectric pavements has been effected in a variety of ways around the world, ranging from being installed on surfaces such as highways to primary school corridors and at musical and sporting events (Web.5; Web.6; United States Department of Transport, 2013). The potential of harnessing lost kinetic energy has been recognised and acknowledged by the urban development industry universally, but the majority of the research and application has been first-world based. The researcher believes that the application in the chosen study area could be used as a precedent for the implementation of such renewable energy technology within South Africa and in Africa as a whole.

Within the African context (Nomico and Sanders, 2003, Todes, 2012), we, in South Africa, have a large volume of commuters within transportation nodes that could be utilised in harnessing renewable energy from piezoelectric technology implementation in transport precincts. Non-motorized modes of transportation such as walking and bicycles are commonly utilized in Africa

and when South Africa is compared to various other countries within Africa, we find that NMTs have a large stake in commuter modal choice for transportation, with Kenya having 45 percent, Nigeria having 40 percent and South Africa having 30 percent (Sturgis, 2015). The question now is whether or not the level of efficiency would be high enough to provide enough energy for the illumination or heating needs of informal traders within the Warwick Junction area. Can pedestrian traffic and informal trade, on pavements alongside Julius Nyerere Road, be seen as sufficient to power an active pavement energy system, and can we provide a cleaner energy source than is currently utilised by informal traders?

### **2.2.3.1 STRATEGIC APPLICATION OF PIEZOELECTRIC TECHNOLOGY WITHIN TRANSPORTATION PLANNING AND URBAN PLANNING**

Besides piezoelectric pavements being a technological tool that can be utilised in a strategic application (US Department of Transport, 2013), the researcher proposes that they could be a strategic tool that could also lend itself to the sustainability design agenda of Smart Growth, Green Urbanism and Innovative Cities (Kinetic Tiles, 2015). The discourse around urban development is such that it no longer settles on the blanket approach that New Urbanism may offer to all urban developments. Town planning, at its most detailed level, which is precinct planning, also needs to integrate Transit-Oriented Development (TOD) principles so as to develop the urban transportation network in such a way as to take account of the need for pedestrian walkways. The current discourse now needs to venture further into New Pedestrianisation (Iranmanesh, 2008) with TOD (Lehmann, 2010 & CNU, 2012), where urban projects are spearheaded towards integrated public transport network planning and sustainable energy planning (Litman, 2011).

Within an African context, non-motorised public transit development faces challenges in urban precinct planning, since there is a lack of understanding of the unpredictable nature of pedestrian traffic (Iranmanesh, 2008 and Web.4). Framing the urban context is a lengthy task. However, the *Land Use Draft Report (2014) on the Greater Warwick Needs Assessment for the Socio-Economic Development Framework*, gave greater insight into the nature and urban form of the study area by identifying fixed points, such as nodes and precincts, with specific functions such as transportation and/or economic trade. This is important since there is a significant potential to channel the high volume of pedestrians who use the sidewalk pavements to

harness kinetic energy. This report also explored how diversification of service delivery and infrastructures through decentralised governance systems and technologies could be a vital catalyst in trying to implement any energy strategy. This ties in with the call from UN-Habitat to seek green energy solutions so as to solve the energy security issue that plagues African development and GDP growth. The realisation of an independent renewable energy mix (e.g. solar, wind and any other progressive technologies) holds significant potential for Southern African cities (UN-Habitat 2014:241).

#### **2.2.3.2 CO-EXISTANCE TO DRIVE THE GREEN PAVEMENT ECOLOGY**

Mounting pressure on the electricity grid has had some negative effects on the development of priority areas or precincts of economic densification. However, the unstable energy supply has led private companies like Deloitte, who are a worldwide leading professional services firm that provides various services to private and state institutions (such as, Audit, Consulting, Corporate Finance, Taxation Services and Risk Advisory services), to suggest that smart planning of urban developments could create urban areas that are more resource efficient. Using less water and electricity could improve the operational capacity of emerging markets, and could also result in a knock-on effect of accelerating economic growth in priority areas (Deloitte, 2015).

The solution to service energy-deficient priority nodes needs to incorporate numerous urban integration and rejuvenation strategies between all sectors if there is to be sustainable urban growth that is smart and produces resilient urban pockets (Kinetic Tiles, 2015). The following have been noted as key national, provincial and local sectors that could master the will to be agents of change in service delivery: the private sector in terms of renewable energy industry capacity; and directly involved built-environment professionals such as planners and architects and developers who can dictate the course of spatial development (Todes, 2012; UN-Habitat, 2014). According to the recommendations by the Master Builders' Association, as stated in the Deloitte (2015) article, the built environment consumes 40 percent of generated energy. However, it is still one of the most obvious and potentially fruitful places to embark on energy savings and energy development. By following the best practices of Smart Growth and the Green Road Concept, the development of urban spaces and economic precincts such as those in the research study area should be encouraged to be more densely populated, so as to

leverage the solar exposure of roof-top canopies within the transport interchange zones (EU 2040 Vision, 2008 and Lehman, 2010), as well as the potential to harness the footfall pressure of pedestrians commuting through an urban corridor that is further channelised onto its pavements by the presence of informal traders.

#### **2.2.4 SUSTAINABLE ENERGY TO POWER AND EMPOWER URBAN DEVELOPMENT**

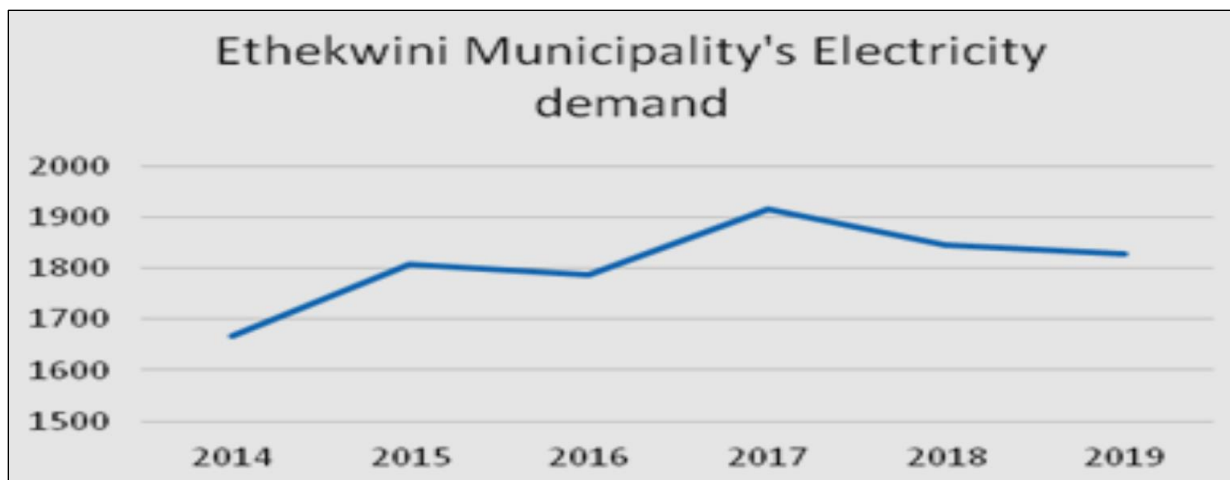
The global, regional and local energy discourse has been one that is focused on a disjuncture between sustainable and renewable energy sources and the carbon-intensive norm that has powered the development of so many nations for the past century (EU 2040 Vision, 2008; UNEP, 2010). Even though the calls for renewable energy sources to power and empower urban development for developing nations around the world have been seen as being relevant and sustainable, there is still a huge gap in trying to maintain a regular supply of energy to meet functional capacity needs for economic production in urban centres for many nations (Bekker, et al., 2008; International Atomic Energy Agency (IAEA), 2009; Eberhand et al., 2011 and South African National Energy Development Institution, 2011). From Lagos to Durban, urban African economic centres are plagued by an inconsistent energy supply and, in South Africa, the national energy strategy to implement load-shedding (*scheduled power outages performed by the national energy producer and distributor Eskom, to conserve energy*) has crippled the development of micro-industries as production is halted when power is out (2030 National Development Plan, 2011 and Chen et al., 2012). Illegal electrical cable connections have also been another compounding factor in the energy crisis that plagues our country, as Municipalities like eThekweni lose millions of rand in revenue due to such activities (Durban Informal Economy Policy, 2001).

This then justifies the reason for the application of piezoelectric pavements as an approach towards transit-interchange zone development, since it makes use of case study comparative advantage, such as the high volume of footfall from dense pedestrian areas in the Warwick Junction Precinct. Therefore, to ensure successive integration of an energy system to be utilised on-site by a network of informal traders, we would also have to look at the existing building regulations and standards. According to the *Red Book* Vol.2 in Chapter 5.2, “*appropriate nodes*

*and technology should be selected to provide cost-effective services at predefined service levels, based on principles of efficiency” (2000: 7),* therefore, it becomes a developmental imperative to encourage a dense pedestrian presence in transport precincts such as the Warwick Junction. The possible outcome is the creation of self-sustaining CBD districts operating at a functional capacity for economic production within a given space. To assure effective adoption of technology within an African context, it needs to be integrated according to Municipal planning measures from a precinct level, e.g. *eThekweni Municipality Local Area Plans and Urban Improvement/ Rejuvenation strategies*.

#### **2.2.4.1 ENERGY HARNESSING SPATIAL TEMPLATES DEVELOPING URBAN DISTRICTS**

Potential for renewable energy is high in Southern Africa, and it is important for cities to consider alternative energy strategies. Independent renewable energy producing companies can be established on a small (precinct) or medium (district) scale to manage the efficient production of energy from footprints through the integration of new technology appliances such as GIS, CCTV footage and piezoelectric pavements. The wider use and adoption of such technologies could also lead to further reduction in prices for renewable technologies and this would make renewable energy a viable option to service energy-starved communities within urban areas (UN-Habitat, 2014). Furthermore, implementing local-scale, smart-grid technologies can contribute to building long-term resilience within the national grid that has, since 2008, been unable to supply, sufficiently, the growing demand for power within our developing state. Off-grid technologies can alleviate demand pressures on the national grids. Every effort should be made to make use of the opportunities that new technologies offer to diversify and decentralise the energy market and infrastructure systems in Southern African cities (UN-Habitat, 2014 and SONA, 2015).



Graph 3: EThekwini Municipality Electricity Demand (Source: eThekwini IDP 2015/2016: 121) Five Year Demand Forecast.<sup>12</sup>

The bulk of electricity in South Africa is produced from coal, with generating stations situated in Mpumalanga, Limpopo and Gauteng. Electricity is generated at the City's landfill sites at Bisassar Road (6 MW) and Mariannahill (1 MW). In total, 500 kW of electricity is generated through photovoltaic cells in Hazelmere. EThekwini's electricity demand is presently 1.67 GW. Currently, there is a constraint on Eskom's generation and this has led to load-shedding. EThekwini's customers experience load-shedding in blocks of two hours. At present, new generating stations are being built with the first due to be commissioned in June 2015 (IDP 2015/2016: 120-121).

The mission to diversify our energy sources is usually caught short-handed as the true figures of externalities are never accounted for when measuring the cost of renewable energy against fossil fuels, or even the long-term effects of the gas emissions from using that source. The transmission and storage of energy is vital and the true figures of fossil fuel extraction and production are five times greater (or even more) than the estimates. In 2013, the IMF/WORLD BANK showed that the cost of fossil fuels including externalities were around \$ 5 trillion dollars. And so when we have to lobby for renewable energies, we need to factor in the externalities in relation to the socio-economic drive of an area and its immediate resources to acquire a sustainable energy supply. In South Africa, the NERSA has received a variety of bids to reduce

<sup>12</sup> Values on the Y-axis are MWh (megawatt-hour)

the cost of renewable energy to 81c/kWh from independent electricity producers in relation to the 80c/kWh from Eskom (NERSA, 2012). By the time the energy is transmitted and delivered to a city like Durban, it is 91c/kWh per unit (eThekweni Electricity Tariff 2015/2016). The World Bank has noted that, in the 20 years to come, there will be a 40 percent increase in the need for renewable energy. The International Energy Agency (IEA) states, in addition, that the current energy mix still relies for 80 percent of its energy from dirty fuels and the scales are predicted to tip over in 2035 when renewable energy might be the logical choice for big business and also political lobbyists. A green economy that is based on renewable energies and the spatial configuration of urban precincts requires urban development that needs to be entrenched in transparent policy measures (Aljazeera Interview, 2015/07/05, U.A.E, Al-Ain, Inside Story 3-4pm) Douglas Parr (GreenPeace UK) and Klaus Webber (Centre for sustainable energy, Australian National University were interviewed).

Even though the planning scope may be at the precinct level, a spatial template can be the blueprint for other areas beyond the research study area. This could provide an understanding of the bulk infrastructure (pavements) that is already provided, the pavement ecology (movement systems and traders) and also the cost to the Municipality of introducing the new technology. The growing threat of illegal connections, fossil fuel dependency and urban pollution by taxi-rank public traders at less favourable locations, sounds the call to have a much more immediate means of supplying electrical power to the people at a reasonable price (SANEDI, 2011, Electric Power Research Institute (EPRI), 2012). Since municipal by-laws in eThekweni call for a title deed to formal trading facilities to house an electric meter and thus to access energy (Skinner, 2009), the ironic point is that most of these traders may migrate or just connect from those who already have a meter from another part of the CBD following the migration of footsteps. The Municipality is already subsidising some areas with indigent electricity customers, to the tune of 65kWh of free electricity per month (eThekweni Electricity Tariffs 2015/2016, 2015: 7). The total cost, including VAT, for a single kilowatt hour is R1, 03 and when one has to compare the cost of energy exporting resident units via solar panels connected to the grid, it is 62 c/kWh (eThekweni Electricity Tariffs 2015/2016 , 2015:8-9).





Image 6: Ballito taxi rank and informal pedestrian side-

This point of having a mixed energy grid stems from the researcher's observations with taxi-ranks in urban precincts such as Ballito Compensation which is north of Durban.

Not all transportation interchange-market precincts in a CBD, or within urban municipal boundaries are serviced in a manner that has the best interest of all stakeholders at heart. From the image above it is evident that the public transport interchange that is located on the shoulder of a regional road M4 and also right behind the Ballito Compensation shopping centre, is informal in its establishment and thus hasn't even been paved. The pedestrian mobility space hasn't been provided with appropriate paving for the sidewalks. If the department of Roads and Storm-water were to dedicate itself to formalising the informal pavement routes then the energy department would be able to implement an active pavement template that could harness the lost renewable energy. Old spaces that were once considered as being invaded by unfavourable land-uses, such as taxi-ranks or public traders, could be seen in a new light as having the potential to contribute to the production of local energy at a cheaper price in the long term, when compared to just relying on the national power grid.

#### 2.2.4.2 SOUTH AFRICAN PRECEDENCE

Ever since the first sessions of load-shedding in January 2008, by the state-owned enterprise Eskom, a few years ago, it has become evident that we are now living in a dark age of energy innovation for our country (SANEDI, 2011, Electric Power Research Institute (EPRI), 2012). With the growing sweep of solar panel installation, hydro-powered and wind-energy renewable technologies, the landscape for urban development has tried to relate and provide stimulus to the growing need for energy innovation so as to source a reliable and secure supply of

affordable energy across the country (SANEDI, 2011; EPRI, 2012; Web.11, Web.12). The energy-planning mandate from the 2014 State of the Nation Address by the president of South Africa, called for radical transformation in the energy sector to jump-start the economy, as this would lend itself to objectives aimed at sustainable urban development. Having acknowledged that future energy sector plans see the establishment of new power plants (Medupi, Kusile & Ingula power stations) by the year 2030, the present climate requires short-term strategies that are able to ease the strain on national grid infrastructure from the high energy demand (Web.11, Web.12). Presently scheduled load shedding episodes, energy price hikes and growing demand can be combatted by innovative energy generation approaches that are renewable and which could fast-track short-term and locality-specific energy needs.

From the integration of global and local knowledge by the researcher, it's relevant to note that the global formulation of piezoelectric pavements hasn't found the appropriate end-user, but the figures from *Innowattech* substantiate the claim that the 660m stretch of Julius Nyerere could harness 6,6Kwh/ h with an average of 3000 pedestrians passing through at a steady flow per hour (Web.5). The evaluation of such strategic technological implementation could be appropriate to this golden era, in order to amend the current policy framework such as that reflected in the *Transport Node Precinct Plans, Pedestrian and Bicycle Guidelines, Integrated Energy Plans* and the *Energy Master Plans*, while still complying with the *National Development Plan* and the *Integrated Development Plan* for the Municipality. If well executed, the implementation at local level of renewable energy from piezoelectric pavements, could be integrated into a socio-economically sustainable plan that could hold out the prospect of prosperity for informal traders in third world market hubs such as the Warwick Junction.

With such a large cleavage between energy security and the spatial development of transportation interchange zones, the research could offer an alternative approach to how future transport precinct facility developments could benefit from piezoelectric pavement systems. Additionally, this could be a template coupled with the right energy mix that could provide a catalyst that encourages sustainable innovation in urban spaces.

The future development of transport interchange zones being informed by informal considerations and by the sourcing of alternative renewable energy resources, is already being implemented in Cape Town as reported by Preuss, a journalist for the *Business Day Live website* (Web. 13). He covered the commissioning by the Cape Town Municipality and its Transport Department, of the first ever off-grid taxi rank to be powered by solar energy and supplied by rain water, harvested on site. The taxi rank was built at a price of R25 million and designed to be self-sufficient and only to consume on-grid energy from Eskom when necessary. The energy recordings for the first month showed that 2 percent of power from Eskom was used, however, the overall powering of LED lights, electric gates and water boiling for informal trader kiosks was powered by the solar energy.

As Muller stated in his article (Web.14), the main objective for national development and sustainable growth is in establishing approaches in policy and international energy agreements that are able to inform the choice of selecting the most suitable options that will contribute to the prosperity of all South Africans, while improving the quality of public facilities to ensure a thriving green economy that feeds so many livelihoods.

In terms of institutional contributions to the fight to utilise a much more reliable energy source, we find that institutions around South Africa have been trying to research the most suitable alternatives to power for our urban precincts. In KZN, the University of KwaZulu-Natal (UKZN) has made progress in producing a solar-powered vehicle, better battery cells to store renewable energy, and Mangosuthu University of Technology (MUT) has been able to establish an in-house renewable energy department, headed by Prof.S.Malinga, which investigates novel ways to deal with our energy poverty. The advantage of being a University of Technology is that they are able to investigate in theory and then construct the technology that they need for their explorations into renewable energy. In terms of trying to link my research with existing work, the team from MUT have done work on an energy-harnessing road membrane that is able to collect the lost energy from vehicular pressure. This also goes to show that the local capacity to

investigate new solutions and to contribute to a better tomorrow is a working reality for the renewable energy industry within South Africa.

### **2.2.5 CONCLUSION TO LITERATURE REVIEW**

Since the second objective of this research is to guide the investigation through the question: *'Can proactive precinct planning of transport nodes enable the maximisation of energy access to meet energy demands by public (informal) traders within the Warwick Junction mobility spaces?'*, the literature review presented above was meant to show how the spatial template could be a success if only there was a greater synergy between infrastructure development and the proliferation of the green economy. The Warwick Junction perimeters demarcate a bustling hub for public traders and therefore we need to investigate how the spatial template that is being proposed could combat the energy security issue and also be a catalyst for public traders to be innovative in how they go about diversifying their trade.

The so-called informal activities, or trade, that take place within the Warwick Junction are synonymous with the public space development trend within many developing cities from Lagos to Cape Town, and all of these economic nodes are densely populated by pedestrians, public traders and also numerous public transport modes which all offer the opportunity to exploit formal and informal mobility spaces within transit interchange zones.

Piezoelectric pavements when seen as a strategic infrastructure tool, could provide the incentive to invest in mobility spaces so as to improve the quality of trade and also urban functionality, as load-shedding affects citizens and also our national GDP growth. It needs to be noted that the green infrastructure developments are the key to having efficient smart cities that are resilient and sustainable in their growth. In showing how a single unit of electricity (kWh) purchased from the grid is R1, 03 and the price for the same unit of energy exported from residential sources onto the grid is just 62 c/kWh, it is evident that there is some sort of reward for the use of renewable energy, and, since the Municipality has been making strides in building alternative energy power plants to supplement the Eskom demand, we could drive

down the tariff of energy as a whole and also be able to connect more residents and traders to a cleaner source of energy. Our country and nation demand a reliable energy source if we are to prosper and grow as a developing nation, and also as a regional economic hub. By taking advantage of our natural sources, we could have a robust energy mix that is not fossil fuel intensive and is also socio-economically responsive to the developmental needs of those who are marginalised in urban areas.

### **3. CHAPTER 3 - RESEARCH METHODOLOGY**

#### **3.1 INTRODUCTION**

Since the research aims to evaluate a spatial template of piezoelectric pavements within transportation precinct perimeters that involve the nature and pattern of pedestrian flow moving through intense mobility spaces that are formed by the pavement presence of public traders, alongside Julius Nyerere Road, which is an activity spine of the Warwick Junction, it would require primary and secondary sources of information. By identifying and quantifying the spaces intensely occupied by crowd movement, we can formulate a spatial template that meets the soft (public trader needs) issues and hard (access to cleaner energy) infrastructure issues facing the development of the precinct area.

If the research is also to attempt to propagate a socio-economic function for traders to access a secure energy service, then urban infrastructure should have enough capacity to overcome spatial parameters such as the informal pavement occupation. Therefore the research methodology will consist of the most suitable methods, matched with appropriate tools and adequate justification as to why such methods could maximise the potential of sourcing meaningful insight into what is being proposed for public transport interchange zones.

#### **3.2 RESEARCH METHODOLOGY APPROACH**

The methodology that was followed in the course of this research looked at the factors that are most suitable for the implementation of such spatial planning measures for transport nodes. The purpose of such a methodology was to create an environment that best suited the research objectives. According to the development regulations within the *CSIR Red Book*, the achievement of sustainable development within cities is impossible (The Red Book Vol. 1, 2000: 48), without the proper consultation, participation and considerate integration of all relevant stakeholder interests.

##### **3.2.1 RESEARCH PARADIGM**

The researcher will utilise a technique that is able to break down the evolutionary processes of the pavement ecosystem development. This could be done by carrying out research employing a mixed method enquiry, which interrogates both qualitative and quantitative data (Babbie,

1998; Teddlie and Yu, 2007 and Bandini et al., 2011). In the process of formulating the spatial template, it is the researcher's obligation to conduct an evaluation into the existing and future (under the IRPTN commission) potential of the urban form by unpacking the pavement ecosystem that exists (Babbie, 1998 and Marshall and Rossman, 2006). Since research data was going to be obtained in both quantitative and qualitative forms, it is imperative to state which forms were taken into account.

In trying to capture the essence of the research paradigm, a motive which was the cardinal point for the end result of the research that was informed by both quantitative and qualitative data was needed. The main objective was to carry out a deductive rationale for research that led from the general to the specific, in terms of energy and transport planning of spatial urban forms (Babbie, 1998). Since the template would act as an area-based strategy tool for the Warwick Junction precinct, the researcher needed to depart from an understanding of the expected development pattern, which was logical and theoretically sound, and move instead towards specific area-based observations that tested whether the expected pattern could actually occur within the spatial perimeters or not.

### **3.2.1.1 QUANTITATIVE DATA**

Quantitative data will be presented as primary and secondary data, in the form of surveillance footage (on-site photographs) of pedestrian traffic patterns through the activity spine. Interest was focused on pedestrian pavement segments and intersection points from University Avenue up to North Old Dutch Road intersection. And then, from observations, the piezoelectric pavement-template output was guided by use of graphs, statistical analyses and aggregates which were summarised into manageable secondary data (Babbie, 1998: 34). In terms of getting a pedestrians count, the researcher utilized figures from the Greater Warwick Junction Needs Assessment Report of 2014. The researcher had done a physical head count of public traders along Julius Nyerere Road .

Data extrapolation of quantified values (Babbie, 1998) from small scale prototype implementation of the piezoelectric technology was utilised as a secondary tool to evaluate the potential areas for maximum pedestrian footfall that could result in a greater yield of

piezoelectric energy than could be generated within the transport interchange perimeter. Evaluation of on-site implementation in an African city context such as Warwick Junction, could impact on how much influence research has for encouraging support for smarter public transport infrastructure.

### **3.2.1.2 QUALITATIVE DATA**

The qualitative data was obtained primarily from the in-depth interviews with all relevant stakeholders (trader committee head and NGO operating within the research area) and specific Municipal department officials (GO! Durban head and the Energy Office), who were concerned with the development of the Warwick Junction precinct. The secondary data was sourced from research journals, books, government and municipal laws, by-laws, policy and development framework documents, on-line and magazine articles covering the research topic. Since such a study within planning had not been undertaken previously, printed research material was limited. However, the research made good use of relevant material from existing publications in inter-disciplinary fields such as next-generation infrastructure, smart energy, green cities, and renewable / alternative energy. These are still emerging fields in urban development for African cities and so the research also hopefully contributes to the knowledge of integrated urban development.

The acquisition of qualitative data is more than just analytical engagement, but is seen as offering richer meaning than that which refers solely to the urban form (Babbie, 1998). This data provided a meaningful socio-economic gauge, to guide the researcher in understanding the functioning nature of pavements within African informal marketplaces which co-exist with transportation systems.

It is also important to state that for the qualitative data to be obtained, the focus group of public traders had requested that they stay anonymous, so pseudo names will be used and they were exempted from signing the consent form for such reasons. Due to their being an unhealthy relationship between public traders and city officials, in fear of being reprimanded or even having their goods confiscated, the researcher has utilized pseudonyms for most of the focus group informants.



### 3.3 RESEARCH DESIGN AND PURPOSE

The following section will set out the strategic process that was used to inquire more deeply into the exploration of the existing pavement ecosystem. The outcome of such a process was to identify the key variables and values to be reflected in the piezoelectric spatial template for transport interchange zones. The research method was a two-fold process. The first aspect looked at solving the problem that had been stated by the researcher and the second aspect looked at the feasibility of the opportunity that has been presented to solve the problem.

By taking on an explorative approach towards the research, it was the main purpose of the researcher to evaluate the applicability of new energy-harnessing technologies to the formation of a spatial template (Babbie, 1998: 90-91). Since pavement ecosystems within transportation and trading centers (market places) have not been identified as being potential catchment areas for energy produced by the footfall of pedestrian traffic, the researcher set out to explore the degree to which pavements, occupied by informal traders, could sustain active pavement segments.

From the on-site observations of the activity spine (Julius Nyerere), quantitative data was obtained and this provided proper spatial values of potential active pavement catchment areas. Pedestrian volume values and movement patterns informed the second aspect of the research process which looked into being able to channel pedestrians while benefiting pavement traders.

From conducting in-depth interviews, the researcher gathered qualitative data that assisted in identifying significant socio-economic variables for development (present and future), which could result in a deductive assumption of what future area-based development projects might need in order to develop a successful renewable energy strategy.

From the in-depth interview process along with the focus group, greater cross-sectorial integration within the research scope was reached, resulting in a progressive urban development approach that has an Afro-centric ethos when trying to plan for urban precincts such as Warwick Junction. By having understood the area-specific undertones, the application of such technology could be extrapolated and integrated in other area-based projects.

If the research was to be successful in meeting its main objectives, then the explorative nature of the research approach had to have social function and spatial capacity as caveats. By doing so, the researcher could, firstly, design a functional piezoelectric spatial template of potential catchment areas for pedestrian traffic. Secondly, it was important to solve the socio-economic problem of informal catering traders not having a secure energy source that is sustainable and renewable. By having this dual-system in existence, we can solve an energy issue that can tap into informal innovation that hasn't been empowered, while improving the quality of mobility and pavement infrastructure within activity spines and transport interchange zones.

### **3. 4 THE DUAL SYSTEM APPROACH**

The dual system complex, it was felt, could contribute with valuable insight for exploratory purposes to how the spatial capacity of active pavements could maximise informal trade and thus boost the green economy output of the municipality (200-202). The objectives of such a self-complimentary system are to create an urban form that is responsive to how pedestrians make use of the mobility spaces/ channels moulded by informal traders while the social function can only be preserved.

The spatial capacity, being an independent variable, refers, in this instance, to that of the activity corridor within Warwick Junction (Julius Nyerere Rd) and the adjoining intersection points or contributing streets that were selected via the judgemental sampling process. The process encompasses general comparative analysis of sampled pavement segments. The total spatial capacity of Warwick Junction precinct would prove too large for research, at this level, and so it was thought best to utilise a fixed segment from University Avenue, up to North Old Dutch Road. This segment is also the research sampling frame, as, in between these there would be contributing activity from adjoining streets, but the main focus was on the pavement ecology that manifested itself within the activity spine (2008: 195-197).

The social function of such technological application was best evaluated via an interview process, for which the judgmental sampling method was used as it was informed by the relevance of the chosen personnel. Hence the approach of the study was one that utilised

purposive sampling in the informant selection process. By identifying the informants of the study, a socio-economic value can be formulated for the technological application within the eThekweni Municipal Area. An additional and crucial opinion that had to be factored in was that of the informal traders, around whom the spatial template would be shaped. What can be assured about selective informant participation is that it can be utilised as the voice of the greater whole, as the views given would be taken as the objective consensus, since these views could be seen as the group experience and perception of the representative group. In the end, we could effectively quantify the qualitative value of the project because all informants (civil society or ABM NGO, municipal officials, informal traders and municipal officials) contributed to the facilitation of strategic infrastructure development while engaging with issues that could be constraints towards following the appropriate spatial planning framework, legislative guidance and feasibility of the project (2008:200-202).

	1	2	3
<b>SPATIAL FEATURE</b>	<i>SPACE</i>	<i>PAVEMENTS</i>	<i>ENERGY SOURCES</i>
<b>SOCIAL FUNCTION</b>	<i>PEDESTRIAN FOOTFALL ROUTES</i>	<i>INTENSE TRADING ACTIVITY</i>	<i>INFORMAL INGENUITY AND INNOVATION</i>

Table 3: Spatial Feature vs. Social Function for Research (Source: Researcher, 2015)

In an attempt to synthesise the above table into constructive input for an energy-harnessing spatial template for pavements within public transport precinct perimeters, the research was set up to understand, by observation, the nature and pattern of pedestrian traffic at intersections and within transport nodes, alongside Julius Nyerere Road. By identifying and quantifying the spaces intensely occupied by crowd movement, we can appropriately identify which segments to implement piezoelectric pavements, in a pedestrian traffic responsive setting (Babbie, 1998 and Bandini et al., 2011).

### **3. 5 RESEARCH SAMPLING METHOD**

A non-probability sampling method was used since such a method was most suitable for the dual-system approach of this research.

#### **3. 5.1 NON-PROBABILITY**

Purposive sampling techniques are primarily used in qualitative studies (Marshall and Rossman, 2006) and may be defined as selecting units (e.g. individuals, groups of individuals, institutions) based on specific purposes associated with answering a research study's questions (Teddlie and Yu, 2007). In relation to the research study area, it is the informal catering traders who occupy the Julius Nyerere mobility space who are of interest, since their food preparation methods are fossil-fuel intensive.

In terms of the officials selected, the researcher identified those working within the eThekweni Municipality, as stated in the interview schedule, and representatives of non-governmental organisations in energy. This allowed for a balanced response to the research inquiry.

### **3. 6 RESEARCH TOOLS AND METHODS**

The research tools and methods utilised were appropriate for the collection of quantitative and qualitative data sets. Since the research aim was to evaluate an application within a transportation precinct, it was necessary to: capture the spatial features in the form of quantitative data in the numerical form. The second aspect was the social function of piezoelectric pavements which was of non-numeric value, since this was a qualitative data set (1998:36). Presenting a dual system complex, the one set of data would arise from conducting the proxemics observation study and the other would be informed by interviews with identified stakeholders. Technological applications were judged for success, or otherwise, by their feasibility in implementation and social integration by having value-added purpose to the user's way of life.

### **3.6.1 PROXEMICS PARTICIPANT OBSERVATION STUDY**

The observation of pedestrian traffic flows was conducted along Julius Nyerere Road from the University intersection up to the Johannes Nkosi and Chris Ntuli intersection from city surveillance cameras. This is a 660m section of the Warwick Junction that the researcher focused on. The whole purpose was to observe and note the pattern of pedestrian flow and this was evaluated in relation to the informal trade that also plays a role in how people utilise mobility spaces.

A Proxemics Study refers to people's use of space in a manner that depicts routine pedestrian traffic behaviour within given perimeters (Babbie, 1998 and Bandini et al., 2011). This was used as an observation tool. From studying the way that pedestrians utilised mobility spaces, the pavement catchment area suitable for piezoelectric (strategic) pavement implementation could be ear-marked. Once there was a series of strategic pressure zones identified, a piezoelectric pavement network could be formulated into a template.

### **3.6.2 IN-DEPTH INTERVIEWS**

These were carried out according to the sampling method, in great depth, with the relevant stakeholders (Marshall and Rossman, 2006 and Teddlie and Yu, 2007) and also with urban practitioners such as transport planners, civil engineers, electrical engineers, urban development planners, non-governmental organisations and the street committee head for informal traders (catering). The in-depth interviews were a platform that allowed the respondent to give a much more detailed explanation of certain conditions that prevailed, and what they hoped for from the strategic development of the Warwick Junction precinct and its mobility spaces. Less structured interviews can be appropriate for field research when they are flexible, continuous and pose a reiteration of the sub-questions and, primarily, the main research question, aligned with the research aims and objectives. This form of interviewing process highlights the essence of qualitative interviewing (1998:290).

For this research a focus group method was utilised so as to gain a qualitative insight into issues that are faced by the numerous agents that determine the urban form and function of the Warwick public transportation precinct. The selection procedure involved choosing

specialists who would be most suitable to provide answers to the interview questions (Marshall and Rossman, 2006 and Teddlie and Yu, 2007).

- The *eThekweni Energy Office* was contacted so that a quantitative analysis on the developments undertaken in dealing with the provision of energy resources to public traders could be obtained, and also as to get a sense of whether or not the municipality would favour such an initiative as piezoelectric pavements, to be implemented within the city's mobility corridor, and if this would, in their opinion, make a valuable contribution to the city's renewable energy mission.
- The *GO! Durban* office which deals with the comprehensive planning of the municipality's integrated public transportation plan, was meant to give insight into what the municipality has planned for one of region's busiest public transportation hubs, which is the Warwick Junction, and also to see if the new plans cater for the bustling public trade that takes place in public spaces and mobility spaces along Julius Nyerere Road.
- *Asiye'eTafuleni* is an NGO that deals with civil society issues within the Warwick Junction and is located within range of the research study area. It has taken on the identity as being the formal voice and vanguard for Informal Trader rights and also has a team of urban practitioners who regularly publish, or are involved with public engagement forums, to improve the quality of public enterprise within the public transportation precincts, in and around the city.
- The informal trader committee head was meant to give his insight into the strategic issues faced when trying to promote public trading within a formal and well-managed process. Indeed, many traders trade for themselves, however, they also form a collective body which becomes a platform for voicing issues that pertain to public trading, police harassment and permit issues. Public engagement has been a missing element when trying to develop public spaces and this shows, at times, when public spaces which are developed marginalise informal trading practices.
- Mr. Khomo has been a public trader since 1992 when he lost his job as a taxi driver. He has been occupying the Durban streets of Victoria Market and the greater Warwick

Junction since then. As a public activist for informal trader rights, he has now become the chosen chairperson for the trading committee, representing traders in the area from Victoria Market to the Workshop Precinct. Mr. Khomo even took the eThekweni Metro Police to court for the illegal confiscation of his trading goods. This later resulted in the court ruling in favour of Mr. Khomo in November 2014 and this was a watershed moment for public trader rights along pedestrian spaces.

- Informal traders were consulted at their location of trade as this would provide a contextual feel of what it means to be a public trader, and also allowed the interviewer to observe the day-to-day issues that surround public trading. By having a grassroots understanding the interviewer was able to properly assess the infrastructure conditions of many traders and also to see what sort of energy resources are used and the appliances used when they prepare food on-site.

***List of interviewees:***

***Magash Naidoo – eThekweni Energy Office***

***Nick Combrink – eThekweni Municipality GO! Durban Head (Strategic Public Transportation)***

***Richard Dobson – Asiye’Tafuleni NGO***

***Mr. John Khomo - Deputy President of Masi’bamibisane Street Traders Organisation (Informal Trader Committee Head)***

***Public Trader Focus Group –***

- ***Mealie-cooker committee head***
- ***Pavement kebab griller***
- ***Pavement catering***
- ***Franchise itinerant merchant***

### 3.7 DATA COLLECTION & ANALYSIS PROCEDURE

The research encompassed qualitative and quantitative data sources, being primary and second in nature (Teddlie and Yu, 2007). The data collection and analysis procedure will follow a mixed-method analysis strategy (Bandini et al. 2011). This links pedestrian traffic observations with interviews and data extrapolated from pilot projects, to improve the overall conceptualisation of the technological implementation and also the output of a well-integrated template for transport interchange zone pavement lay-out.

1. Observation of proxemics' behaviour of walking groups, focusing on the spatial arrangement and cohesion of pavements according to the degree of pedestrian intensity, pedestrian traffic speed and the location of informal traders.
2. Evaluation of the potential size and shape of pedestrian footfall along Julius Nyerere Road.
  - *Size depicts the rate of footfall within a given space.*
  - *Shape illustrates the spatial pattern of pedestrian footfall through the mobility corridor and also for how long the footfall is loyal to the pavement catchment area.*
  - *How often does the footfall come into contact with or in range of informal traders.*
  - *Where are the strategic points within the mobility space corridor?*
3. Design a spatial template that incorporates the pedestrian traffic corridor alongside Julius Nyerere Road (R102) and the transport interchange nodes along the pedestrian corridor.
  - *Taxis occupy the extreme left lane and this results in the extension of the fixed node.*
  - *Express access to commuters getting on or disembarking from a transit mode (bus or mini-bus taxi).*
  - *A fixed transport node that has interchange/ranking rows to accommodate taxis heading to local and regional destinations.*



- *High rise kerb separating each row, could be retrofitted to collect the pedestrian pressure from commuter queues within the node.*
4. Calculate the economics of scale into a potential scenario whereby they follow a generic method of implementation and function.

## 4. CHAPTER 4 – DATA ANALYSIS

### 4.1 INTRODUCTION

This chapter will present the analysis of the data. Responses from stakeholder interviews will be presented and images from the site visit and surveillance will provide a better understanding of the first and third objectives of this research paper. Just to reiterate what these objectives were:

1. *To identify the potential of Warwick mobility (pedestrian) spaces and their pavements, as being the focal point for harnessing piezoelectricity from pedestrian footfall and public transport traffic at strategic points; and*
2. *To evaluate how effective the piezoelectricity harnessing pavement could be for Warwick informal trade by formulating an energy harnessing spatial template.*

The responses from the interviews could be used to sketch the guidelines for the formulation and implementation of a spatial template within the Warwick Junction. Chapter two provided the conceptual, theoretical and practical framework, while also navigating the current energy generation and distribution trends within South Africa and abroad. The fourth chapter will attempt to deliver guidelines for the strategic application of the piezoelectric pavement template within the research study area.

For the following chapter, the researcher decided to utilise extrapolated figures from the *Innowattech piezoelectric pavement system* that estimates that a 100m passageway for 1 hour with an average of 3000 people is able to generate 1kWh/hour (*Kinetic Tiles*, 2012 and *Innowattech*). Therefore, the 660m section of Julius Nyerere Road could generate 6,6kWh/hour with sufficient thresholds.

In trying to interpret the views of the local constituency, the researcher will make use of the *Greater Warwick Junction Needs Assessment Report of 2014*, which was compiled by Mr Nick Combrink and team, to add value to the insight drawn from interview questions.<sup>13</sup>

---

<sup>13</sup> The report hasn't been published and so was viewed under the supervision of Mr. Combrink at the *GO! Durban* Offices

## 4.2 INTERVIEW ENGAGEMENT

The interview engagement will be discussed in detail under the relevant question titles and subsections as laid out in the interview question list. The interview engagement was broken down into urban practitioners and public traders, so as to get a comprehensive understanding of views by those who would be stakeholders and beneficiaries of the application of a piezoelectric pavement template system. The underlying principle was still maintained throughout the engagement procedure so as to find out how to integrate such technology within KZN's busiest transport interchange zone.

### 4.2.1 Urban Practitioners

**Richard Dobson, Nick Combrink, Magesh Naidoo<sup>14</sup>**

#### **1) *Piezoelectric Technology relevance within the eThekweni CBD***

- The technology could well be a solution to the issue of energy security within the research study area. From the figures provided in the statement question, it seems to be feasible. The certainty of occupation by public traders of available spaces has, however, to be assured.
- Within the current context of trying to be more energy resilient as we face the imminent threat of load-shedding, we are seeking novel ways to source energy as a metropolitan city and also as a developing municipality. The possibility of utilising piezoelectric technology within pavements is appropriate if we are to be proactive towards the situation. By understanding the manner in which trading occurs within the Warwick Junction Precinct, we can develop strategies to promote such enterprise initiatives.

#### **2) *Strategic application of piezoelectric technology within transportation planning and urban planning***

- According to Richard Dobson and the organisation he works with, *Asiye'Tafuleni*, they are aware of the NMT (Non-Motorised transportation) plan proposed by the Municipality, however, during the public consultation that they attended, it was evident

---

<sup>14</sup> It is worthy to note that Mr. Combrink and Mr. Naidoo chose to not sign the interview waiver due to conflict of interest but were willing to be participants.

that the plan was mainly a 'recreational mobility' tool since it only seemed to cater for cycling paths and did not service urban pedestrians and or any other NMT users such as informal cart haulers. The eThekweni Municipality Transportation Authority has promised to look at improving NMT paths and also to give attention to cart hauling service routes. With a more public trader-orientated plan, this brings the element of durability to light, since an average cart hauls up to 300kg. In the development of a strategic template to harness energy from multiple pressure sources, there needs to be a factoring in of multiple mobility modes and sources such as pedestrians, cart haulers and motor vehicles.

- There should also be strategies in place within public facilities such as: efficient waste collection; functioning storm water infrastructure; and secure service provision, to see that the piezoelectric pavement application is a success. These strategies would look at how immediate externalities such as waste and storm water management could improve the quality of the urban environment and make it sustainable to trade and harness energy within the area.
- A proactive strategy would show that the Municipality is not just thinking or debating about whether or not renewable energies are the way forward, but must act in a manner that shows willingness and forward thinking in trying to provide a basic service to informal traders, or even looking at how to reinvest a portion of that energy into the grid. This would have a resultant effect on other urban form institutions and sector departments such as those in urban planning, transportation planning and also energy planning. Since *GO!Durban* has been working on the IRPTN that sees the robust development of multiple transportation nodes that cater for over 80 000 per day, it is important to note all interactive features of a mobility corridor. The transportation planning project that is *GO!Durban* is being undertaken by the eThekweni Municipality in an attempt to provide an urban planning framework that sees the alignment of public policies with the mandate of the city council to develop urban transportation nodes. However, it has been noted that, in the past, the council was not supportive of the socio-economic progression of such precincts and its traders. By not having proper

bottom-up strategies, the development of trader needs are never realised, and this also has a negative impact on the development project as a whole.

### **3) *Sustainable energy to power and empower urban development***

- The sustainable provision of basic services to traders could have a lasting effect on the functional nature of urban precincts such as that of the Warwick Junction. The culture of sustainability within the scope of energy use can be enhanced if the beneficiaries are given a vital role to play in the harnessing and utilisation of energy. When talking about the informal economy and its energy needs, there is usually a negative stigma attached to perceptions. The general public holds the view that informal traders benefit unjustly from public resources that they are not paying for. Therefore, reimagining and dignifying the perception of the people trading within public spaces could be used as a tool to support those working within public spaces and those who are to manage them.
- The sustainability of current energy sources within the precinct is a factor recognised as being of cardinal importance by the Municipal officials as they work on renewable energy projects and also on climate change mitigation strategies that note the importance of reducing the city's CO<sub>2</sub> emissions. But can public traders adopt a new culture of utilising primarily clean technologies and also reducing their reliance on dirty fuels? There is also the problem of how to regulate or manage a system of public traders that already has some participants operating illegally while consuming state resources.
- If we are to empower those who occupy the busy pavements of compact transport interchange zones, we should not use the provision of energy as a political token for votes, however, we should assist traders with more than just permits and by-laws. The use of by-laws and permits only hinders public traders from moving up the ladder into the lease section due to the by-laws in places. Traders are victimised by the city council as they are usually marginalised in the development procedure, and the police also confiscate trading stock, thus making obtaining a sustainable livelihood challenging. What needs to be noted is that the public trading sector is the largest safety net for the unemployed and unqualified (formal certificate or qualification). What's needed is the

realisation of potential within urban spaces and the willingness to assist the public trader in operating and adding value to their trading initiatives.

- What seems to be the pressing issue is that the civil society groups and public traders have requested that the city give them licences to trade instead of permits. The former would allow them to access credit to purchase stock when revenue is low. The city, on the other hand, is looking at ways to develop a city that reduces the presence of informal trade and to formalise the traders by issuing permits for the use of trading spaces. The permits are seen as a limiting tool by the public trader committees and have also resulted in John Khomo taking the eThekweni Municipality Metro Police to the Durban High Court for the illegal confiscation of goods when he left his stall unattended. This triumph for a single trader gave many the hope that the city was still required to consider public traders

#### **4) *Energy harnessing spatial templates developing urban districts***

- Taking into consideration that the Municipality spends 15 percent of its GDP on electricity provision, it is critical to look at locally produced energy since the current Eskom failures and load-shedding is not viable for municipalities. The eThekweni Municipality is experiencing rapid growth and it requires more energy as this occurs, therefore making it essential to seek to exploit all viable options for renewable energy as long as they are feasible. The viability of the proposed piezoelectricity spatial template would be a success if properly integrated into such spaces and should be welcomed by the Municipality as it already loses a lot of electricity to illegal connections.
- In terms of integrated strategies, we can only anticipate that the NMT Plan that's going to be rolled out by *GO! Durban* has the foresight to cater for all modes of transportation, since the Warwick Junction is going to be a major transportation interchange zone for the eThekweni Municipality NMT Plan, and the pedestrian footprint of commuters and location of traders needs to be identified and well integrated. It can be most effective if it also caters for routes which offer alternatives to the already

existing, frequently used pedestrian routes. Even though a Municipal official noted that once such technology begins to be installed the Municipality will to be aware of the criminal elements who will seek to steal the expensive installation. This reminder and warning by Richard Dobson included the suggestion that, if we make public trader committees equal stakeholders and primary beneficiaries of such infrastructure developments, the criminal element and vandalism would be minimal. Dobson and Khomo alluded to a few examples where the city council had not considered their views on development strategies within the area before, and this marginalisation by city officials had resulted in public facilities worth millions being destroyed in protest action.

- If public traders were co-opted into such a strategy, then its success would be guaranteed. Public traders would appreciate the presence of pedestrian routes that allow for a spread of circulation that's canalised or funnelled at certain points of concentration. This would strengthen public trader bargaining power when negotiating for services within public facilities, as the renewable energy that would be produced within these spaces would be due to the two-way relationship between public traders and commuters. This sort of coexistence in urban regeneration would be a positive tool in allowing public traders to access necessary infrastructure services for promoting their trade, and also would strengthen the sense of place for the trading precinct.
- Theoretically, some spots have large catchment potential which can be determined by first-hand observations when looking at the pedestrian influx in the area. However, it is also wise to note that not all people/ pedestrians are moving through the area for amenity interest (particular traders of goods & services), but use the precinct as a transportation hub and transport corridor, e.g. the Cambridge corner sees 500 000 people per hour on a busy day.
- From the in-depth interviews that were conducted, the main points that would have to be considered and factored in before large scale implementation are:
  1. When is high energy demand likely, and at what operation times?
  2. What are some of the conventional cooking methods that rely on carbon-based fuel sources?

3. What are the end-user applications that the harnessed energy would need to supply?
4. Suitable energy distribution methods and urban layout of traders and commuters would need planning;
5. Illegal energy connections need to be discouraged; and
6. Public safety within public spaces and facilities when the technology has been implemented needs to be catered for.

#### 4.2.2 Public Traders

The public traders were presented with a different format of questions. These were also based on the in-depth interview method and allowed the research to have a comprehensive understanding of the situation and the *status quo* of trade within the research study area. The four respondents were able to shed some light on how traders, franchisees or private entities operate within the 660m stretch that was focused on by the research. Ulundi Baloyi, Duduzile Matshukuza, Sbonelo Zondi, Sthe Warwick and John Khomo were all willing participants however Sthe Warwick is a pseudo name that was given to this participant as they wanted to stay anonymous. Mr. Khomo was able to provide us with an understanding for underlying issues and concerns of public traders.



<i>Survey Questions</i> <i>Survey Respondents</i>	<b>How long have you been a public trader and what do you trade in?</b>	<b>What sort of appliances do you use in product preparation?</b>	<b>What sort of energy source do you use and how much do you use?</b>	<b>What issues do you face as a public trader in terms of energy use?</b>	<b>Do you have any peak times for you trade?</b>	<b>What could improve your profit margins in terms of trading conditions and energy sources?</b>
<b>Ulundi Baloyi</b>  <b>Public Catering</b>	<p>I have been a trader here for 5 years now, since 2010. I have had a permit for my marquee for a trading spot at the corner of Warwick avenue and Johannes Nkosi road.</p>	<p>I use a gas stove when I prepare the food in the mornings here in my stall (from 5am – 8pm). I usually keep the leftover food and other preparation products such as meat in the fridge/freezer when I get home in the evenings.</p>	<p>I use size 19 gas tanks (3) and I refill them every 5 days.</p> <p>A plate of food or take-away costs around R20-25 depending on what is requested.</p>	<p>The profit margins vary and so therefore at times, you are unable to refill all gas tanks as you need. The permits are steep as we have to pay R520 a year. The conditions in which we have to trade in could be improved.</p>	<p>There is no specific day, however what I have noticed is that there are rush hours during lunch hour and also an afternoon rush.</p> <p>On some days it is just dry and we hardly have clients.</p>	<p>I could make more if maybe I didn't have to worry about refilling gas tanks every week.</p>

<p><b>Dudzile Matshukuza</b></p> <p><b><i>Barbeque livers and giblets kebab</i></b></p>	<p>I have been an illegal trader since 2009. I do not have a permit yet I have been occupying the same spot on the corner of Acorn and Lancers Road. I sell barbecued livers and giblets.</p>	<p>I use an impromptu coal griller, made of a metal basin, steel mesh and bricks for support.</p>	<p>I use coal to prepare the kebabs. I am able to use a 5kg bag of coal for two days if there are no strong winds. Each bag of coal costs R30.</p> <p>Each kebab costs about R5-6.</p>	<p>The Metro police always come and take away the stock and throw it in the bin when they find us here. After hours we are worried about street lighting as there is a matter of safety while trading in the evenings.</p>	<p>There are no peak hours of trade. As soon as I set-up, people will buy as this is fast food you can have on the way.</p> <p>I usually set-up shop from around 10 a.m. to 8 p.m. or even later, depending on customer presence.</p>	<p>Per stock-take I am able to make R70 profit.</p> <p>And would be able to make more if I didn't have to worry about the random presence of police to confiscate our selling and preparation material.</p> <p>In terms of buying coal, if there was a cheaper source of energy I could use, I would use it.</p>
---	---	---	--	--	---	--

<p><b>Sbonelo Zondi</b></p> <p><b>Pie City</b></p> <p><b>Cart Owner</b></p>	<p>I am the owner of the pie city cart for 1 year 6 months now.</p> <p>I do not have a trading permit as I still pay a monthly fee to the franchise for selling their pies from this cart.</p> <p>I'm mainly based within the Warwick Junction, however, depending on the day, I sometimes head out into the CBD or other areas such as Berea or Umbilo.</p>	<p>The pies I receive have already been baked.</p>	<p>My cart has a small gas tank and a cooler box. The gas tank is to make sure that the pies stay hot and warm for the customer, and the cooler box has ice that keeps beverages cool as I make my way through the city.</p> <p>I refill the gas tank once every 4 weeks.</p>	<p>There are no permits</p> <p>After-hours I cannot trade as my cart is not safe.</p>	<p>I do not have any, I just follow the crowd and commuters.</p> <p>Most customers do buy during midday and the afternoons.</p>	<p>Having to pay no rental fee to the franchise since I also still have to pay for my own gas tank refills and other beverages for trading.</p>
---	--	--	---	---	---	---

<p><b>Sthe Warwick</b></p> <p><b>Mealie Wholesale Supplier</b></p>	<p>I am a supplier of cooked mealies to many traders throughout the city. They buy their mealies from us and then they use metal basins and coal to keep them warm.</p>	<p>We use large tin drums with water to cook mealies.</p>	<p>We use wood or planks as they have a longer burning period than coal and they are also able to produce an intense flame for over a longer period of time.</p>	<p>The city should assist us in getting better access to shelter for preparing the mealies. The issue of waste used for in starting fires and keeping them going is a matter of health concern to the commuters and pedestrians.</p>	<p>We arrive at around 5 a.m. and start cooking mealies in large metal drums until maybe 10-11 a.m. in the morning. From around 6 am many traders come and purchase the already cooked mealies and sell at their stalls. Some traders, if located in a busy part of the city, can come back two to three times a day. To avoid the constant up and down movement of traders and stock (cooked mealies), traders buy in bulk and then use self-constructed devices to keep their mealies</p>	<p>We are currently in talks to upgrade the existing Mealie-cookers' infrastructure as there is a lot of smoke being emitted from all that is being burnt.</p> <p>Sometimes, on rainy days, we have to buy wood and bring it in by vehicle, so the sourcing of local energy would help.</p>
--	---	---	--	--	---	---

					warm for clients. The additional cost of buying coal is on them as they also diversify their trade by having barbecued mealies instead of the cooked ones.	
--	--	--	--	--	---	--

### According to Mr. John Khomo<sup>15</sup>

- He trades in cosmetics and non-perishable goods and his main energy needs are met by the public streetlight since he just occupies a pavement corner.
- He insists that informal traders find that the municipality has been acting in an authoritative and inconsiderate manner when dealing with the development of the public trading spaces. This is evident, since there are no transparent communication channels or fair dialogue concerning the spatial needs of public traders. There is little regard for trader knowledge and trader participation in the decision-making processes, when development is concerned with the marginalised traders who are seen as a nuisance.
- The city officials have done this before with the shelter renewal idea which was not discussed with the public traders, however they expect traders to pay rent for the trading spaces once they had erected them. The rent that's expected is also high and many traders end up unable to operate legally due to such barriers. The trading permits have become an instrumental piece of legislation to reduce the number of public traders that are allowed to legally trade. Those who are deemed illegal can have their property confiscated and served with a fine. What Mr. Khomo saw as a solution was the issuing of trading licences which could be utilised as collateral for traders if they wanted to access any loans or used for purchasing of stock. The licence system would ensure that you're a life-time holder of your trading space for as long as you pay for annual fees.
- In terms of implementing piezoelectric pavements to generate renewable energy, it would benefit all traders and specifically solidify the presence of local traders, who could also be forerunners in the use of energy-harnessing pavements and catchment areas. It is very important though to engage traders so that they can see how important their role and contribution is to the strategy. The criminal element comes into play when the public views infrastructure developments as having no meaning or sense of

---

<sup>15</sup> Mr John Khomo was a willing participant but was reluctant to sign. To obtain the interview he gave consent to use his name.

value to their daily lives and operations. Once people are aware of how they can benefit they will be more willing to look after the technology that's in place.

- The main matter of concern though, is if local traders would be willing to change their usual operations and energy use practices away from carbon intensive sources and utilise the renewable energy source. I admit that most traders do operate their business in a space that does not allow for open flames, as it may be hazardous to the general public and also to municipal assets, according to the Informal Trader By-laws, however, if people are given a cheaper option they would be willing to utilise it.

### 4.3 CONCLUSIONS TO CHAPTER FOUR

To conclude, it is evident from the perspective of public traders that the only way that any development plan, strategy and project would be successful in implementation, within the Warwick Junction and along Julius Nyerere Road, is if the municipality officials approached traders beforehand and discussed the ideas or problems at hand. They also have to understand the traders' needs. They should also only make promises within the ability of the Municipality to meet those needs and promises. A third imperative is to negotiate and to find a common ground for development to occur that ensures that sustainable economic strategies or infrastructure developments work to benefit all traders and not just to satisfy Municipal behests.

Another matter of concern is that the city officials and some urban practitioners see the value and importance of public trader presence within the Warwick Junction, however, the growth of the informal economy needs to be regulated so as to make sure that we do not have congested mobility spaces, and also we should still be able to provide public spaces with more efficiency in terms of service and infrastructure provisions. Even though renewable strategies can be simple in process, the conceptualisation of integrated development would call on urban development that is able to maximise the knock-on effect for socio-economic growth.

From conducting in-depth interviews, a sample view of perceptions was gathered regarding what it would be like if piezoelectric pavements were to be implemented. This received a very positive response in terms of finding sources to help contribute to the energy mix and also the local grid. If urban development is to be technological, then it needs to cater for the innovative will of public traders. It does, however, need an integrated approach that adheres to the basic needs of traders in terms of space, legality of occupation of space and an approach that also provides for basic infrastructure and services. Mobility corridors attract a bustling pedestrian traffic and we have to take advantage of that if we are to empower those who eke out a living within those mobility spaces.



## 5. CHAPTER 5 – RESEARCH FINDINGS

### 5.1 INTRODUCTION

This chapter is meant to synthesise the multiple components that have been discussed throughout the body of this study. The researcher considered where and how to harness the renewable energy from pedestrian footsteps along the mobility corridor, and also how to distribute such a service in a manner that would be feasible for the Municipality, but would also assist in improving the quality of Municipal public spaces. Public transportation interchange zones within the African city context have multiple functions for public traders and commuters, making it imperative to consider properly all facets of development that would be involved in rolling out such technology. The researcher has compiled a guide to the theoretical formulation of a piezoelectric pavement spatial template from primary (via interviews and on-site observations) and secondary sources (via desktop research and academic articles) which can be applied to the Warwick Junction.

### 5.2 THE PIEZOELECTRIC PAVEMENT TEMPLATE CONCEPT

The aerial photo in Figure 3 below was provided by *Google Maps™* and edited to assist in the identification of the research focus area which is the 660m pedestrian mobility route along Julius Nyerere Road, coloured in *yellow*. The major intersections that enjoy the majority of the compact footfall traffic are the three ringed in *red*. The three major intersections, from left to right, within the research study area are: (1) Lancers and Acorn Road, (2) Cannon Gate and David Webster Road and (3) Chris Ntuli and Johannes Nkosi. The rest of the pavement sections in between are still the main channelling routes that host a thriving community of traders and also retail outlets which have also encroached onto the pavement to attract pedestrians who are commuting through the mobility corridor.

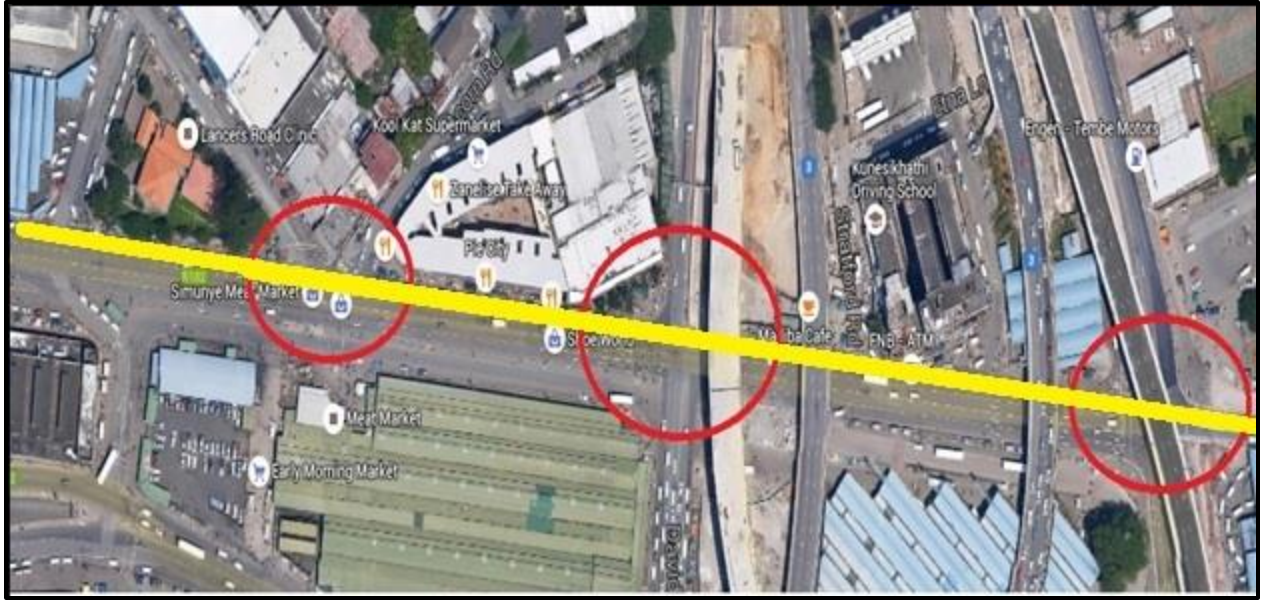


Figure 3: Aerial photo of identified compact intersections for potential catchment zones along the 660m route (Source: Researcher, 2015)

The characteristics of these intersections which would make them suitable for the implementation of such technology within the precinct are the following:

- Motor vehicular go-slow zones and intersection points along Julius Nyerere road;
- Frontage access to multiple public transport interchange zones (taxi ranks);
- High volumes of pedestrian footfall have been observed;
- High frequency presence of public traders; and
- Public trader activities are diverse and require sustainable yet safe energy sources.

If we try to frame a spatial template for the African city then we have to identify the intersections of any mobility corridors and integrate them as focal points for renewable energy harnessing and storage through the precinct. As the diagram illustrates below, it is meant to show the focal point of all catchment areas at three main intersections within the study area. The linking channel pavement, which is illustrated by the red arrows, will serve as a supporting and distribution network for pedestrian, and also for the localised smart grid within the precinct.

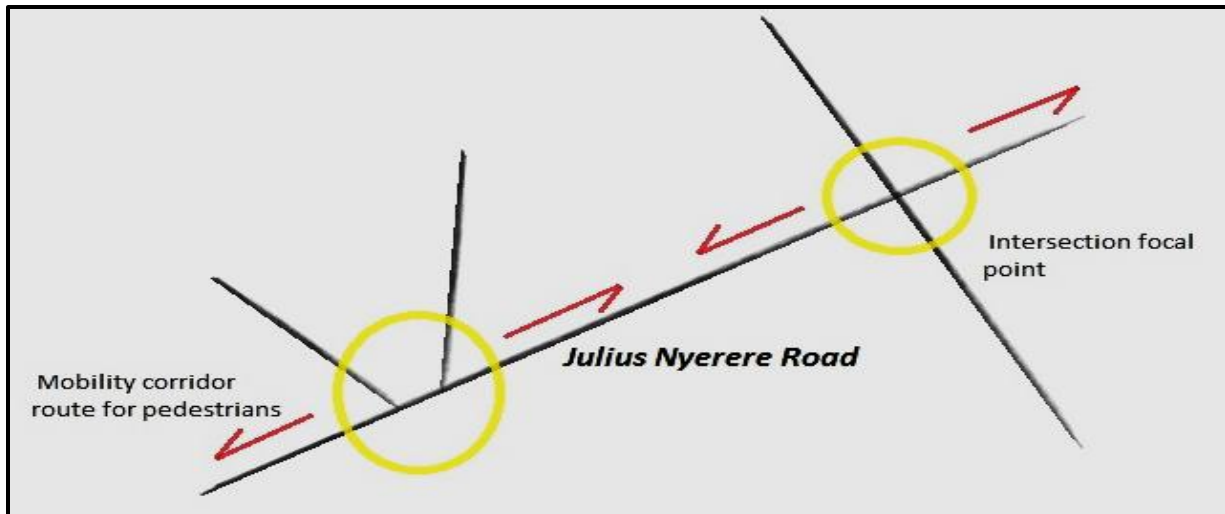


Diagram 10: Piezoelectric pavement implementation within a mobility corridor (Source: Researcher, 2015)

The images below show how intersections along Julius Nyerere Road are vital trading epicentres that provides the commuting pedestrians with goods (e.g. fresh produce, perishable goods) and services (e.g. mobile phones, barbers). The presence of public traders along the pavement reserve automatically forms a pedestrian canalising effect revealing a suitable footprint pattern for the implementation of piezoelectric pavements in a spatial template to maximise the potential of active mobility spaces to produce sufficient renewable energy from catchment areas.



Image 10: Cannon Gate Intersection (Source: Researcher, 2015)



Image 11: Potential piezoelectric pavement catchment area at intersections (Source: Petitinvention, 2015)

### 5.3 PIEZOELECTRIC PAVEMENT TECHNICAL COMPONENTS

The researcher has been able to gather what is needed to construct the pavement tile modules. These would be assembled before being installed within the research study area. These items can be sourced from local sources and retailers. However, the method of assembly for the renewable energy module tile can vary from application to application.

ITEM	QUANTITY	PURPOSE
<i>Piezoelectric Module</i>	<b>2</b>	Energy harnessing platform. Active pavement tiles <b>*two tile pedestrian lane</b>
<i>Installation Tools</i>	<b>1 set</b>	Access components and materials for installation of the active pavement tiles and electrical system, e.g. wiring.
<i>Battery Bank</i>	<b>2</b>	Deep-cycle Lead batteries. Stores the DC current from the active pavements. 12V 102A/ H
<i>Inverter (1.5 kw) 203VAC/ 24VDC</i>	<b>1</b>	The inverter converts the DC into AC so that the localised system is synchronised with the main grid.
<i>20A Charge Controller</i>	<b>1</b>	The charge controller regulates the DC charge so that the batteries are not overcharged.
<i>Bi-directional Meter</i>	<b>1</b>	The bi-directional meter is able to spin backwards to show how much energy has been utilised within the localised grid and how much is exported.
<b>TOTAL</b>	<b>2 Tiles</b>	

Table 4: Technical components for piezoelectric pavements and a local network

From the desktop study that has been done, and also with the professional assistance of an electrical engineer from *Innowattech*, the suitable method of assembly, implementation and also maintenance can be suggested. *Innowattech* have sought to utilise the embedded method, rather than having a mobile casing module for the piezoelectric inducers (Innowattech, 2014). And, unlike the *Pavegen* method, which seeks to create a casing that can hold a piezoelectric inducer, energy storage components and can also emit a slight illumination when somebody steps on it, the researcher believes that by combining both methods, it would be possible to maximise the application of such technology without disrupting the daily flow of pedestrians, while also still maintaining the electricity out-put that has been generated. To understand the mechanical undertaking that would be necessary, the researcher consulted the patent application that was handed in by *Innowattech* for *Piezoelectricity Energy Generators (PEGs)* (Innowattech, 2009), and also conducted primary investigation at renewable energy micro-grid retailers and installers to seek out a suitable method of application and maintenance of such a micro-smart grid.

Power harvesting tile module comprising:

- (1) A base plate at the bottom
- (2) A top plate above
- (3) A plurality of piezoelectric devices capable of producing electrical power placed in between both plates
- (4) An elastic member (spring) connecting/binding both plates and excreting compression force on a plurality of piezoelectric devices
- (5) A power-conditioning unit for storage
- (6) Electrical conductors connected to the piezoelectric devices.

**Source: *Innowattech Patent – Piezoelectricity Energy Generators (PEGs) US 20090195124 A1***



The main difference between *Pavegen* and *Innowattech* is that the *Innowattech* method does not utilise the embedded surface of the tile module as a storage centre, as it has designated power storage units that are part of a larger energy network and distribution node within the vicinity of the active pavement catchment area (Innowattech,2014). This results in a smooth transition between a normal pavement section and an upgraded pavement section. From what has been stated by the interview respondents, there is a threat that such technology would be vandalised or even stolen, so it is important to embed such technology within a durable module to keep it safe from the natural elements and also from criminals. A matter of concern for implementation within the Warwick Junction is the low-lying gradient of Warwick Junction and regular drainage failure coupled with litter as shown in the images taken below. The study area is located in a low-lying area within the CBD and therefore the water drainage issue would be of concern, as this would call for regular maintenance since the tile module would become corroded by high traffic volumes and constant water presence.



Image 12: Drainage system failure along road and pavement reserve  
(Source: Researcher, 2015)<sup>16</sup>



Image 13: Drainage channels crossing mobility pathway  
(Source: Researcher, 2015)<sup>17</sup>

---

<sup>16</sup> On-site visit and observation

<sup>17</sup> On-site visit and observation

This goes to show that the packaging method of the piezoelectric module is also linked to the expected maintenance timeframe of the catchment areas. This is why the materials utilised in the manufacture of the modules need to be durable, coupled with a high standard of drainage control and of waste pollution awareness within the Warwick study area. When looking at such a high frequency pedestrian area, one would have to limit the amount of maintenance interferences, as these might divert pedestrians onto other pathways, frustrating public traders as their clientele wouldn't be able to access them, and therefore this would affect the profit performance of public traders within the specific section of the mobility corridor.

#### 5.4 SPATIAL TEMPLATE FOR PIEZOELECTRIC PAVEMENTS

Julius Nyerere Road/ Warwick Avenue is the identified pedestrian and vehicle mobility route that will be utilised in providing a simple example and method of application for the active pavement system. The research area focuses on the pavement segment between University Avenue and North Old Dutch Road. The 660m segment offers us four major pedestrian and vehicle catchment intersections, these being at (1) North Old Dutch Road, (2) Cannon Gate Road, (3) Acorn Road and (4) Lancers Road. The order of intersections as stated above is arranged in the order of intensity of footfall, within the epicentre of the intersection. This order is linked to the conceptual diagram that showed how catchment areas at intersections are the epicentres of pedestrian traffic and public trade.

From ground surveillance, the identified pedestrian route offers a 2-tile lane for pedestrian mobility along the 660m trade and mobility route. Recorded measurements and calculations show that each tile section is **1764 cm<sup>2</sup>**, which, multiplied by two, is **3528 cm<sup>2</sup>**. When converted into square metres and multiplied by the total length of the mobility route, we have **0, 3528 m<sup>2</sup> × 660 m = 232, 85 m<sup>2</sup>** of total coverage for catchment, including walking path and intersections for the entire run.

A suitable lay-out that would see the most productive use of the catchment area is the one which has been diagrammatically represented below. This diagram shows how the epicentres of multiple intersections become the sites for harnessing renewable energy from pedestrians, primarily, and then from any other slow moving bodies whether these be motorised or non-

motorised. The spatial template that has been provided is based along a single direction of Julius Nyerere Road.

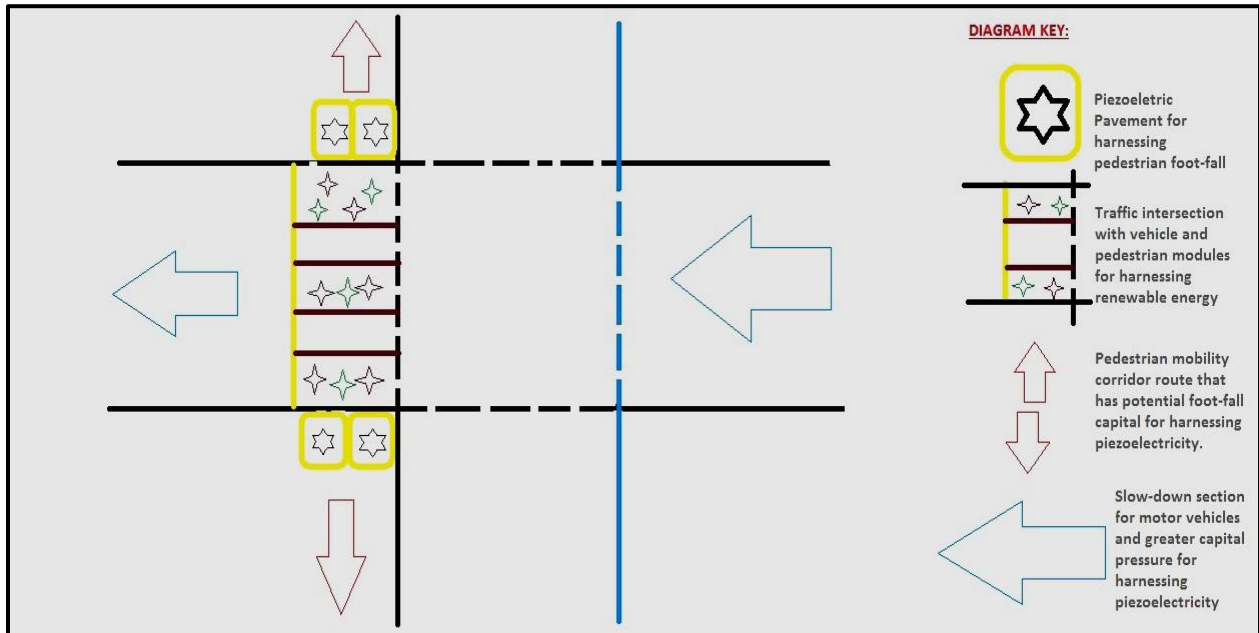


Diagram 11: Piezoelectric pavement template at an intersection (Source: Researcher, 2015)

The street that was chosen is one that closely resembles the research study area of Julius Nyerere Road in terms of its high pedestrian frequency and single direction mobility route that's utilised as a high priority inner-city corridor. The mobility space and corridor has multiple stores which encroach onto the pavement reserve during operational hours. From the conceptual diagram that is presented above, the researcher utilised the image captured in Cape Town at Longmarket Street, so as to show a different side of the African city when designed with designated pedestrian and NMT zones. Even though the overall footfall volumes aren't the same as those enjoyed by Warwick Junction, this can serve as a real life example of how the spatial template would look.





Image 14: Cape Town walkway – Long Market Street (Source: Researcher, 2015)<sup>18</sup>



Image 15 &16: Footfall agents at the Julius Nyerere Road and North Old Dutch Road intersection (Source: Researcher, 2015)<sup>19</sup>

<sup>18</sup> Site visit and observation

<sup>19</sup> On-site visit and observation

### 5.5.1 RENEWABLE ENERGY PAVEMENT ECOSYSTEM

<b>STRATEGIC ENERGY PAVEMENT ECOSYSTEM</b>	
<b>SOURCES</b>	Kinetic Energy – Pedestrian and Vehicular
<b>EXTRACTION POINT</b>	<ul style="list-style-type: none"> <li>• Mobility spaces along corridor pavement</li> <li>• Road intersections</li> <li>• Pedestrian crossing zones</li> <li>• Transportation interchange zones</li> </ul>
<b>CONVERSION TECHNOLOGY</b>	Piezoelectric ceramics/ pressure membrane
<b>STORAGE &amp; TRANSMISSION</b>	On-site energy storage in batteries
<b>DISTRIBUTION</b>	<ul style="list-style-type: none"> <li>• On-site / mini-off grid network</li> <li>• Supply main grid network</li> </ul>
<b>CURRENCY OF ENERGY</b>	Electricity generated in c /kwh
<b>SERVICE TECHNOLOGY</b>	<ul style="list-style-type: none"> <li>• LED Boards</li> <li>• Smart street furniture</li> <li>• Street Lighting</li> </ul>
<b>POTENTIAL SERVICE SECTORS</b>	<ul style="list-style-type: none"> <li>• Public Traders</li> <li>• Traffic signals</li> <li>• Marketing and Communication</li> </ul>

Table 5: Strategic Energy Pavement Ecosystem (Source: Researcher, 2015)

The above table sets out to show how the overall system would work from the point of extraction up until the potential end users in various sectors and also the main beneficiaries who would be public traders and the eThekweni Municipality.

The main reasons why the researcher utilises this mechanism of approach is that the eThekweni Municipality needs to consider local/mini grid systems to balance the power supply with

varying demand to various users. The design of the urban fabric needs to be more strategic in the way it creates a suitable energy mix that is not too taxing for the municipality to maintain. NMT routes and public transport lanes can be identified and consolidated into the IRPTN as well as the Energy Management Plan.

## 5.5.2 PREFESABILITY STUDY ON JULIUS NYERERE ROAD

INTERSECTING ROADS / ROAD SECTION	PEDESTRIANS PER DAY AT INTERSECTION	NUMBER OF TRADERS AT INTERSECTION	NUMBER OF TRADERS BETWEEN INTERSECTIONS
University Road / Julius Nyerere Road	15574	4	
University road to Willis Road			7
Willis Road/ Julius Nyerere Road	17242	6	
Willis Road to Lancers Road			5
Lancer Road/ Julius Nyerere Road	22888	7	
Lancers Road to Acorn Road			6
Acorn Road/ Julius Nyerere Road	29304	7	
Acord Road to Cannongate Road			9
Cannongate Road/ Julius Nyerere Road	36456	9	
Cannongate Road to Old North Dutch Road			6
Old North Dutch Road/ Julius Nyerere Road	32500	8	
<b>Julius Nyerere Road Total</b>	<b>154 014</b>	<b>41</b>	<b>33</b>

Table 6: On-site visits and observation figures (Source: Researcher, 2015)<sup>20</sup>

<sup>20</sup> The figures for the pedestrian counts were sourced from the *Greater Warwick Needs Assessment Report* of 2014 that was viewed under the supervision of Nick Combrink at the *GO!Durban* offices based on readings from 6 a.m. to 6 p.m.

- Eskom and NERSA agreed at the 3rd REIPPP bid that renewable energy unit cost was at 89c / kWh.
- Julius Nyerere Road/ Warwick Avenue is the identified pedestrian and vehicle mobility route. The project focuses on the segment between University Avenue and North Old Dutch Road. The 660m segment offers us four major vehicle and pedestrian catchment areas.
- The total two-lane coverage area along 660m is 232, 85 sqm. There is a daily average of about 154 014 pedestrians commuting through the mobility corridor.
- The identified pedestrian route is 660m and the extrapolated data from *Innowattech* indicates 6, 6 kWh that can be harnessed every hour from the pedestrian route. Every 100m per hour with 100 people can harness 1kWh.
- Multiplied by 3 hours during the morning and afternoon rush, as a single peak period may last, for e.g., 6 a.m. to 9 a.m. and 3 p.m to 6 p.m.
- 154014 Pedestrians\12 hours =12834; 5 pedestrians per hour moving through intersections.
- If you had to divide the number of pedestrians per hour per 100m coverage, we get 128, 35 pedestrians per sqm for every hour. Then, if we multiply the pedestrian coverage by the average of 6.6kWh that can be harnessed from the entire length of the corridor, we get  $128.35 * 6.6\text{kWh} = 847.08 \text{ kWh}$  for all intersections in a day.
- If we were to calculate the average potential of energy generation over a 660m segment of pavement of Julius Nyerere Road for 257 days a year (Monday – Friday), with 280

---

The rest of the figures for trader presence were taken during the research site visit and data collection.

piezoelectric tiles then we can generate **217.70 MWh**. And if sold at the tariff rate for renewable energy of 2015 (0.89c) then the city can generate **R244 606.25** worth of revenue.

The concluding picture that is being framed by the prefeasibility study that was conducted to try and show the potential of the piezoelectric template along the Julius Nyerere Road reserve and intersections is as follows: From what we can see, **217.70 MWh** of energy can be generated per annum to try and address the over-reliance the city has on the national energy grid that is powered by Eskom. The researcher believes that such an initiative can be utilised as a strategic tool to contribute to the Municipal GDP in terms of renewable energy sales, securing a clean energy reserve that can be harnessed, stored and distributed locally, and can also be an added incentive to amending and strengthening the *Informal Trade Policy and the Itinerant Trader Policy Framework*, so as to acknowledge the strategic role that public traders play in dictating the form and function of mobility spaces and urban corridors. However, the underlying purpose of acknowledging public traders is so that such technology and strategic infrastructure development can improve the quality and overall capacity function of such nodes, allowing them to become centres for harnessing renewable energy and public spaces which promote micro-enterprises and entrepreneurial growth, as more people are empowered to diversify their sustainable livelihoods with publicly produced and supplied energy.

### **5.5.2.1 BENEFITS TO ETHEKWINI MUNICIPALITY**

The overall function and purpose of the strategic energy pavement system proposed to be implemented in the Warwick Junction precinct along the activity corridor of Julius Nyerere Road (R102), is to serve the local public trader constituency with a reliable and efficient energy source, and also to serve the function of providing the Municipality with another source for their renewable energy catalogue that already has wind, solar and methane from landfills (eThekwini IDP 2015/2016, 2014).

The GDP Composite for 2014 showed that 3 percent of the Municipality's revenue came from the sale of electricity. With that being stated, it also reflected that the Municipality's urbanisation rate was rapidly increasing at 85.1 percent and this also catered for the increase in informal practices in space such as informal settlements and also the presence of informal trade (EDGE, 2015: 24). This has resulted in large spatial expansions, increasing densification of urban areas and concurrently, in a growing need for new connections, greater amounts of bulk electricity from Eskom to meet growing demand and an increase in Eskom tariffs and thus local prices of energy resources being on the rise. The Municipality has to balance revenue generation with distribution costs, as there is an energy loss in transmission through the network grid and also in infrastructure maintenance over the aging network. Other challenges that also have an impact on the electricity connection and distribution sale are those of cable theft, illegal connections and vandalism to infrastructure, with illegal connections costing the municipality R150 million per year (EDGE, 2015: 24 -25).

In terms of the renewable energy strategy, the broad-based application of clean energy sources, such as solar and wind, was seen to affect the revenue of the municipality by 8 percent – 15 percent by 2024, and so it has now become evident that the Municipality has to adopt an innovative strategy to counter this loss of electricity revenue and its reserve margins for when there is load-shedding. By being able to factor in the mass generation capabilities of the piezoelectric pavement system, we could see an increase of electricity revenue and also GDP growth. What the Municipality has to do is to start looking at the small scale embedded generation framework to see how a feed-in tariff would work. This is said to be able to compensate for the Municipality's loss in revenue from renewable energy sources while also

being able to supply the excess generated electricity from renewable energy sources. The framework envisages the creation of a battery bank or power storage facility and distribution network that does not rely so much on the Eskom supply of bulk electricity. The framework would be much more progressive if it had a rich energy mix from renewable energy sources (EDGE, 2015: 25-30).

Resilient urban infrastructure development that can benefit area-based smart-grid networks is said to be the key in enhancing area-based LED initiatives that are centred on informal trader innovation. Strategic technological interventions, such as piezoelectricity pavements can be a tool to sustain a smart city, and by really working to demarcate high frequency mobility spaces, the city can even have a feed into hubs for all the renewable energy that is to be generated. The prefeasibility findings show that R2 million rand's worth of electricity can be generated from a single 660m section of pedestrian pavement reserve along Julius Nyerere Road. This could go a long way towards implementing urban improvement projects within the Warwick Junction and its crowded public spaces. And with 217,70 MWh from pedestrian traffic (excluding vehicle generation) per year, it would even prove possible to connect the growing urban constituency to its own power by means of a local and small scale network or smart grid. If the Municipality hopes to meet its carbon-conscious goals, then it has to look at innovative means and strategies to fuel sustainable economic growth without imposing the cost on the end user or consumer.

## **5.7 CONCLUSION TO CHAPTER FIVE**

The need to plan in a manner that is considerate of the needs of the informal sector is important, as this sector contributes more than one billion rand to the eThekweni Municipality GDP. The piezoelectric pavement system, implemented as a spatial template for the Warwick Transport Precinct, would be able to target the relevant end-users, those belonging to the informal catering industry, as agents for innovative cities. The informal traders who may benefit may have an opportunity to utilise cleaner and cheaper renewable energy than that currently being currently utilised and the Municipality could benefit from being able to meet the urgent calls for national energy security.



By following relevant urban theories such as sustainability, smart growth, green urbanism and innovative cities, the research supports the integrative process for strategic active pavements and demonstrates how the implementation process of piezoelectric pavements could be transferred to other public transport precincts.

To conclude, it is evident that the piezoelectric system, once incorporated and applied to public space pavements in strategic zones, could be a progressive tool for onsite energy planning and urban layout, if implemented within pedestrian-intense mobility spaces. Since active pavements can be applied even to retro-fitting scenarios, they can improve energy security for transport interchange zones and can also be the impetus for energy-efficient street facilities for informal catering traders.

## 6. CHAPTER 6 – RESEARCH SYNOPSIS

### 6.1 INTRODUCTION

The final chapter will draw conclusions from the entire research and possible linkages and future research opportunities will be presented under recommendations. A synthesis of key findings will be drawn up related to the research objective and research outcome which was to formulate a spatial template for Julius Nyerere Road.

### 6.2 REVIEW OF RESEARCH QUESTIONS AND OBJECTIVES

To understand the course and purpose of this research it is necessary to revisit the research hypothesis, the research question, the main aim and the key objectives that were meant to guide the research procedure and provide with a platform for understanding the research findings and drafting valuable recommendations. This was introduced in Chapter One where relevant explanations of the key definitions and the conceptual framework were given.

The researcher had hypothesised that the implementation of piezoelectric pavements within transport nodes could leverage a source of energy from intense pedestrian traffic at strategic sections of the mobility corridor which is attracted there by informal traders. The pressure of their footfalls could be harnessed into providing renewable electric energy for on-site utilisation. The main aim of the research was thus to evaluate the possibility of harnessing piezoelectric energy from strategic pavements within transport interchange zones that could be a renewable energy source for the informal economy within the perimeters of the precinct. The research hypothesis and the main aim of the research resulted in the researcher posing the question: *Could proactive precinct planning for transport nodes be able to take advantage of the high rate of pedestrian footfall on pavements within transport node perimeters, so as to provide a reliable and efficient source of renewable energy?*

To answer the research question while fulfilling the main aim of the research, the researcher had three main objectives that were to be adhered to in the course of undertaking this research which are as follows:

- I. To identify the potential of Warwick mobility (pedestrian) spaces and its pavements as being the focal point for harnessing piezoelectricity from pedestrian movements and public transport traffic at strategic points and corridors within the precinct.
- II. To investigate whether proactive precinct planning of public transport nodes could maximise energy generation to meet energy demands of informal/public traders within Warwick Junction mobility spaces.
- III. To evaluate how effective the piezoelectricity harnessing pavement system would be for Julius Nyerere Road informal/public trade by formulating an energy-generating spatial template for the Warwick Junction.

### **6.3 RESEARCH SYNOPSES**

The research findings and outcomes were guided by the research methodology that was outlined in Chapter One and Chapter Three, by utilising a variety of methods and techniques to investigate the research question. The major use of secondary data from academic documentations, online news articles and ongoing research presentations by various international institutions and state departments, was able to provide a transportation planning and energy planning context as to how the urban development of mobility spaces, with the use of a piezoelectric pavements, could provide a reliable energy source to the African city. While the large scale use of green pavement technology, such as solar-harnessing pavement tiles, electricity-generating wheel ramps and piezoelectric pavement tiles, has been mainly tested in the developed world, the research found that the African city was a more suitable context for the implementation of such technology to assist in providing a clean alternative energy. The theoretical review and literature review within Chapter Two was able to give sound reasons and justification for how the strategic implementation of such pavement technologies would be able to improve the spatial quality of urban public spaces.

The strategic integration of such technology would see the proliferation of smart grid technology, a cheap and reliable power supply to public traders and the Municipality as a whole. The spatial template that the researcher attempted to formulate was meant to create an innovative and resilient city design intended to be aligned with global urban sustainability

goals, for the guidance local development towards the National Development Plan of 2030 and its goals of spatial equality. In the past decade, the main objectives of urban sustainability have been to reduce carbon emissions, promote sustainable livelihoods, utilising various green technologies such as energy harnessing pavements, and to create urban spaces and systems that are responsive to current urban deficiencies that hinder the progressive development of socio-economic ventures that could uplift the urban form and function within the African city.

Innovation and resiliency are the intrinsic features of an African city, when one considers the infrastructure and function that has shaped the gradual growth of cities over the past decades, and the researcher believes that a proliferation of such intrinsic features should sound the call signalling an outreach to those who have been excluded from urban development. Public traders have also been in the vanguard of urban space development as they are able to make a living and also ensure a sense of safety in spaces that have been left out of urban regeneration/improvement projects, and it is now that this revolutionary technology can become a catalyst to diversify their trade and source of income within the same space. The presence of public traders and pedestrians makes visible the need to implement a sense of green urbanism and TOD to ensure that urban design can be linked to urban mobility to improve public space efficiency.

It is this vibrant space and function that interconnects people with resources and services within a high priority node. From the interview responses that were given in Chapter 4, it is evident that such an idea would be welcomed as a viable pilot within the city. If this were possible, then it could be stated that the pavement ecology will have been able to exploit the potential that has been lost within mobility spaces through which pedestrians and commuters make their way. The pre-feasibility study showed that the spatial template that would be produced along the 660m segment of road along Julius Nyerere Road would allow the Municipality to harness **217.70** MWh of renewable energy per year.

## 6.4 RECOMMENDATIONS

The research has shown that the Warwick Junction precinct has a suitable contextual framework to implement the active spatial template to the benefit of both public traders and also the eThekweni Municipality. The following recommendations have been drawn from the previous section of synopses and are suggested as relevant to the future success of any development within the precinct. If the spatial integration of compact mobility spaces with local smart grid networks is to be attempted, then it is crucial to attend to the following matters as stated below:

- I. With a spatial template for piezoelectric pavement with the capability of generating a potential of 217.70 MWh of renewable per year, the city really needs to consider such an innovative system to increase the storage capacity margins for their smart grid network that is currently being developed. The smart grid network may be able to provide micro-scale energy security, however, the Municipality will not then have to purchase as much bulk electricity from Eskom. It can also be ensured that the Municipality will not lose revenue from its renewable energy projects, with a single 660m stretch of pedestrian pavement being able to generate close to R2million per year in capital revenue.
- II. Public trader integration within sidewalks is the main point of contestation when looking at public space development and the delivery of services to those who make a valuable contribution to the city's GDP. It is recommended that the city officials take the time to consider the needs of public traders and seek to amend the existing Informal Trader by-laws to ensure that public spaces offer an equal and fair opportunity to the city's most vulnerable working group. Most public traders and some urban practitioners made mention of the fact that the issuing of permits was an actual hindrance in the path of public traders formalising their presence and moving up the socio-economic ladder. The issuing of licences was the recommended strategy, as this would serve as collateral for traders to access financial products such as loans and would mean that a lifetime of trading would be able to serve as a sort of solid investment that could be inherited.

- III. The research has also noted that the use of positive language in dialogue and in policy articulation can give public trading a sense of dignity and consideration when undertaking strategic development that is meant to be sustainable. An attitude shift needs to take place so that city officials become sympathetic to the needs of public traders, which could open the door for progressive dialogue as to how public traders could become stakeholders in the formalisation of a green economy within public spaces.
- IV. If dialogue is open and fair, then an equal and fair distribution of public resources within public spaces may be possible. Indeed, many of the city's constituents and local business owners feel that the public traders benefit unfairly from public services, in terms of illegal connections, to run their 'informal' businesses. However, a municipality creates a strategic infrastructure in public spaces, like piezoelectric pavements, it is crucial to have the public traders and public transport industry buy-in, as these entities can also serve as guardians, who protect and provide surveillance over the technology. This can only happen, however, if these entities can also benefit from the renewable energy that is to be harnessed. What was suggested by Richard Dobson, and endorsed by the researcher, is that the capital revenue that's generated from the sale of renewable energy units should be utilised to initiate urban improvement programmes such as paying for scant or non-existent services and facilities within the Warwick Junction. This could result in more formal employment opportunities under the Municipality but within the precinct, as the area can afford infrastructure maintenance. Such funds could also be used to improve the overall quality of public spaces and public facilities.
- V. There needs to be a sense of understanding by city officials of how to improve and efficiently manage capacity growth of public spaces, by identifying and exploiting the potential sustainable livelihoods that already exist within the Warwick Junction precinct. Public traders have expressed their need for a reliable energy supply that could allow them to trade for longer hours as they would feel safer, while also allowing them to utilise tools that would allow them to improve the quality of their products and to earn more from their trade of choice. Mini-bus taxi ranks and bus terminals have also been

plagued by unreliable electricity supplies and this causes many commuters to feel vulnerable to crimes such as mugging, after dark. The city has embarked on various urban improvement programmes and has implemented a wide variety of interventions to assist the rejuvenation of the Warwick Precinct as a whole; however, the major gap that still remains is that these interventions were not tailored to the needs of traders within public spaces. This has thus created a vacuum in development, showing a lack of understanding for grassroots initiatives that are being undertaken by public traders to diversify their sustainable livelihoods. A reliable energy supply to all could empower those marginalised on the road reserve of development.

## 6.5 CONCLUSION

In trying to find alternate energy sources and harnessing methods, the one method that could have mass-scale potential is that of integrated piezoelectricity pavements within the road reserve, for instance, along Julius Nyerere Road. This would involve the installation of pressure membranes or piezoelectric material that could be embedded into the pavements of high frequency mobility spaces to harness the mechanical pressure and convert it into electric energy. By formulating a spatial template for transport interchange zones, the potential catchment areas for harnessing pedestrian and vehicular traffic pressure could be mapped out and could all be aligned with available thresholds. This could also expand the scope of the municipal renewable energy strategy and could recover the lost capital revenue from electricity theft and illegal connections.

Even though renewable strategies can be simple in process, the conceptualisation of integrated development would call on urban development that is able to maximise the knock-on effects for socio-economic growth. By legislatively recognising public traders, it would be possible to formally see them as catalysts in generating renewable energy from mobility spaces within public spaces. By harnessing renewable energy and then utilising the feed-in system, the grids could be transformed into smart electricity networks, which could open up doors of opportunity to other facets of smart and green pavement development, production and maintenance.

By understanding the spatial function and socio-economic nature of mobility spaces, it can be demonstrated how pavements have a dual purpose that could see local off-grid energy harvesting systems making a positive contribution towards local renewable energy production and an improving spatial efficiency by acknowledging all variables that make up an African City. The researcher believes that the African city and its way of functioning can liberate those who find themselves in marginalized spaces. The researcher's personal philosophy exhibits the belief that, *"It is imperative to build not for the liberty of men but to build for men to be able to fulfil their God-given free will, within spaces of liberty"*.



## REFERENCES

- Allen, C and Clouth, S. (2012). *A Guidebook to the Green Economy*. United Nations Division for Sustainable Development, UNDESA.pp.1-65.
- Babbie, E (1998) *The Practice of Social Research*. California, USA: Wadsworth Publishing Company.
- Bandini, S, Rubagotti, F, Vizzari, G, Shimura, K (2011) An agent model of pedestrian and group dynamics: experiments on group cohesion. *Artificial Intelligence Around Man and Beyond*. Springer, pp. 104-116.
- Beatley, T (2000) *Green Urbanism: Learning from European Cities*, Washington, D. C., Island Press
- Bekker B, Gaunt CT, Eberhard A, Marquard A (2008) Uncertainties within South Africa's goal of universal access to electricity by 2012. *Journal of Energy in Southern Africa*.Vol.19, pp4-13.
- Benner, C and Pastor, M. (2014). Collaboration, Conflict, and Community Building at the Regional Scale: Implications for Advocacy Planning. *Journal of Planning Education and Research*. University of California, Santa Cruz, United States of America.pp.1-16
- Chen, M, Bonner, C, Chetty, M, Fernandez, L, Pape, K, Parra, F Singh, A and Skinner, C. (2012). *Urban Informal Workers: Representative Voice & Economic Rights*. Background Paper for the World Bank Report 2013.pp.1-65
- Cervero, R and Sullivan, C. (2011). Green TODs : Marrying transit-oriented development and green urbanism. *International Journal of Sustainable Development & World Ecology*. Vol.18.No.3 pp.210-218.
- Cervero, R. (2014). Transport Infrastructure and the Environment in the Global South: Sustainable Mobility and Urbanism. *Jurnal Perencanaan Wilayah dan Kota*. Vol.25.No.3.pp.174-191
- Coetzee, M, Waldeck, L, le Roux, A, Meiklejohn, C, van Niekerk, W and Leuta, T. (2014). Spatial Policy, Planning and Infrastructure Investment: Lessons from urban simulations in three South African cities. *Research Articles. CSIR Built Environment*.pp.1- 9

- Coca-Stefaniak, A and Bagaeen, S. (2013). Strategic management for sustainable high street recovery. *The Journal of the Town and Planning Association: Town and Country Planning* .Vol. 82.No.12.pp.532-537
- CSIR Red Book Volume II. (2009). *Chapter 5.1 Movement Networks*.pp.1-16
- Department of Science and Technology. (2007). *Innovation towards a Knowledge-Based Economy: Ten-Year Plan for South Africa (2008 - 2018)*. Pretoria: Government Press.pp.1-40
- Department of Environmental Affairs. (2011). *National Strategy for Sustainable Development and Action Plan (NSSD1)*. Pretoria: Government Press.pp.1-48
- Department of Economic Development Environmental Affairs & Science and Technology & Trade and Industry. (2010). *Green Economy Summit*. South Africa, Pretoria .pp.1-65
- Department of Provincial and Local Government Affairs (DPLG) (2000) *Local Economic Development: Guideline to Institutional Arrangements*. Local Economic Development Manual Series. Vol.1, pp1-48
- Eberhand, A, Rosnes, O, Shkaratan, M and Vennemo, H (2011) *Africa's Power Infrastructure*. The World Bank. Washington DC, United States of America
- Economic Commission for Europe (ECE) (2008) *Spatial Planning: Key Instrument for Development and Effective Governance*. United Nations.Geneva.pp.1-56
- Edery-Azulay, L. (2010). *Innowattech: Harvesting Energy and Data: A stand-alone technology*. *Innowattech Energy Harvesting Systems*. Israel National Roads Company Ltd. First International Symposium.pp.1-9.
- Eskom. (2014). *Eskom Schedule of Standard Prices 2014/2015*.pp.1-41.
- eThekweni Municipality Integrated Development Plan 2012/13 – 2016/17. (2014). *Draft of 2014/2015 IDP*. eThekweni, South Africa.pp.1-391
- eThekweni Municipality. (2012). *Electricity and Economic Growth in eThekweni*. *Economic Development and Investment Promotion Unit: Policy, Strategy, Information and Research department*.pp.1-4

- eThekweni Municipality. (2015). Economic Development and Growth in EThekweni (EDGE). *Utilities and Smart Cities*. 14<sup>th</sup> Issue. pp.1-48
- eThekweni Unicity Municipality. (2001). *Durban Informal Economy Policy*.pp.1- 59
- eThekweni Municipality. (2012). *First Draft Policy Framework for Improved Management and Control of Itinerant Traders*.pp.1-17
- eThekweni Municipality Electricity. (2015). *eThekweni Electricity Tariffs 2015/2016*.pp1-64
- eThekweni Municipality. (2014). *eThekweni Municipality 2015/2016 IDP*. pp.1-294
- eThekweni Municipality. (2010). *A Census of Street Vendors in eThekweni Municipality – The Consolidated Report*.pp.1-116.
- eThekweni Municipality (2012) *Spatial Development Framework (SDF) Report 2012/2013*.Durban.pp.1 -177
- eThekweni Municipality (2010) *eThekweni Transport Authority: Integrated Transport Plan*. pg. 1- 259
- European Union. (2008.) *New Road Construction Concepts (NR2C)*. April. pp.1-252
- Faehnle, M and Tyrväinen, L. (2013). A framework for evaluating and designing collaborative planning. *Land Use Policy*. No.34. pp. 332-341
- Gkoumus, K, Petrini, F and Bontempi, F. (2013). *Energy harvesting for life-cycle of structure and infrastructures: State of art, recent trends and future developments. Life-Cycle and Sustainability of Civil Infrastructure Systems*. Rome, Italy. pp. 2102 - 2109
- Kang-Won, W. and Correia, A. (2010). A Pilot Study for Investigation of Novel Methods to Harvest Solar Energy from Asphalt Pavements. *Final report for Korea Institute of Construction Technology (KICT)*, Kingston, RI. pp 23-65.
- Lehman, S. (2009). Chapter 9: Green districts and carbon engineering. *Low Carbon Cities: Transforming Urban Systems*. Earthscan Series on Sustainable Design. New York. pp.191-210.
- Lehmann, S. (2010). Green Urbanism: Formulating a Series of Holistic Principles. *S.A.P.I.E.N.S* .Vol.3.No.2.pp.1-11

- Logan, S (2012) Urban Planning and Transport Planning. The Need for an Integrated Modal- The case study of the eThekweni CBD, Umgeni Road Corridor. University of KwaZulu Natal, Durban.pp.1-149
- Lourenço-Lindell, I (2002) Walking the tight rope: Informal livelihoods and social networks in a West African City.
- Malinga, S. (Prof). (2014). *Renewable Energy in eThekweni*. Proceedings from the MILE Research Symposium. Conducted by MILE, UKZN, DUT, MUT and the eThekweni Municipality. Durban
- Marshall, C and Rossman, G (2006) Designing Qualitative Research. Thousand Oaks: Sage Publications (4<sup>th</sup> Edition)
- Nassar, U (2013) Principles of Green Urbanism: The Absent Value in Cairo, Egypt. International Journal of Social Science and Humanity.Cairo,Egypt.Vol.3,No.4.pp 339-343
- National Land Transport Transition Act 22. (2000). *Government Gazette No 21493*. Pretoria: Government Printer. August.pp.1-175
- Nomico, M, Sanders, P (2003) Dichotomies of urban changes in Durban. *Urban Design International*. Volume 8, No.4. pp.207-222
- O'Connor ,A (2013) The African City.Routledge
- Pramathesh and Ankur, S (2013) Piezoelectric Crystals: Future Source of Electricity. International Journal of Scientific Engineering and Technology. Vol.2.No. 4.pp.260-262
- Prestorius, T. (2000). Greater Pretoria: Proposed System of realms, nodes and corridors. *South African Transportation Conference: 'Action in Transport for the New Millennium'*.Pretoria.pp1-21
- Roshani, H and Dessouky, S. (2015). *Feasibility Study to Harvest Electric Power from Highway Pavements using Laboratory Investigation*. ASEE Gulf-Southwest Annual Conference. The University of Texas at San Antonio, Department of Civil and Environmental Engineering. pp.1-10
- van Schilfgaarde, K. (2013). The Trajectory of Warwick Junction as a Site of Inclusivity in Post-Apartheid South Africa. *Independent Study Project (ISP) Collection*. No. 1672.pp.1 – 72

- Skinner, C (2009) Challenging City Imaginaries: Street Traders Struggles in Warwick Junction. *Agenda*.Vol.81.pp.1-12
- South African Department of Energy (DoE) (2008) National Energy Act No.34. Section 7 (2).pp1-28
- South African Committee of Transport Officials. (2012). TRH 26 *South African Road Classification and Access Management Manual*.pp.1-99
- South African Committee of Transportation Officials (COTO). (2012). *Road Classification and Access Management Manual*. Technical Recommendations for Highways. The South African National Roads Agency Limited (SANRAL). pp.1-89
- South African Regional Poverty Network (SARPN) (2003) CBD Durban With Special Emphasis on Warwick Junction.pp.1-25
- Seyfang, G and Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*. Vol.16,No.4.pp.584-603
- Sturzaker, J. (2013). Progressive Town Planning and Community Engagement. *The Journal of the Town and Planning Association: Town and Country Planning* .Vol. 82.No.12.
- Spatial Planning and Land Use Management Act 16. (2013). *Department of Rural Development and Land Reform*. Pretoria: Government Printers.pp.1-72
- Todes, A (2012) New Directions in Spatial Planning? Linking Strategic Spatial Planning and Infrastructure Development. *Journal of Planning Education and Research*.Vol.44.No.32.pp.400-415
- Verhoog, R, Ghorbani, A, Dijkema, G and Weijnen, M (2013). Structuring Socio-Technical Complexity in Infrastructure Systems: The Biogas System. *International Symposium for Next Generation Infrastructure*. Wollongong, Australia.pp.1-6
- Wayne, L. K. (2013). Intelligent Transportation Infrastructure and System. *Technical Committee on Asphalt Pavements and Environment*. Working Group 7 – Energy Harvesting. University of Rhode Island, Transportation Research Centre. United States of America.pp.1-20

- Teddlie, C. and Yu, F (2007). Mixed methods sampling: A typology with examples. *Journal of Mixed Methods Research*, Vol.1.No.1.pp. 77-100.
- United Nations Human Settlements Programme (UN-Habitat) (2014) Re-imagining sustainable urban transitions .*The State of African Cities*. Kenya, Nairobi: UN-Habitat pp.1-278
- United States Department of Transport (2013) Harnessing Pavement Power: Developing Renewable Energy Technology in the Public Right-of-Way. Federal Highway Administration. Washington.pp.1-2
- World Economic Forum (2010) Accelerating Successful Smart Grid Pilots.Geneva.pp.1-46

### **WEBSITES**

- Deloitte. (2015). KZN Northern Growth Corridor: *Unlocking Eco-friendly Growth Areas*. South Africa  
[http://www2.deloitte.com/content/dam/Deloitte/za/Documents/manufacturing/za\\_kn\\_gc\\_unlocking\\_eco\\_friendly\\_growth\\_12032015.pdf](http://www2.deloitte.com/content/dam/Deloitte/za/Documents/manufacturing/za_kn_gc_unlocking_eco_friendly_growth_12032015.pdf) (Accessed 29 May 2015).
- Muller,M. (2014). SA needs to make decisions on energy and act on them. *Business Day Live*.  
[http://www.bdlive.co.za/opinion/2014/11/25/sa-needs-to-make-decisions-on-energy-and-act-on-them?cx\\_tag=bcuf](http://www.bdlive.co.za/opinion/2014/11/25/sa-needs-to-make-decisions-on-energy-and-act-on-them?cx_tag=bcuf) (Accessed 25 November 2014).
- South African New Agency. (2015). President unveils bold plan to tackle energy. crisis<http://www.sanews.gov.za/south-africa/president-unveils-bold-plan-tackle-energy-crisis> (Accessed 19 May 2015).
- Sturgis, S. (2015). Expanding Walkability in Two African Cities: What's at Stake? .*Atlantic City Lab*.  
<http://www.citylab.com/commute/2015/01/expanding-walkability-in-two-african-cities-whats-at-stake/384815/> (Accessed 18 August 2015).
- XE (2015) XE Currency Converter  
<http://www.xe.com/currencyconverter/convert/?Amount=1&From=GBP&To=ZAR> (Accessed 21 May 2015).

- Phillips, R. (2009). Speed bumps to get new role as a source of green energy. *The Guardian*.  
<http://www.theguardian.com/environment/2009/feb/08/alternative-energy-speed-bumps> (Accessed 20 May 2015).
- Sasitorn, T. (2015). SolaRoad is producing more energy than expected. *Second Nexus*.  
<http://secondnexus.com/technology-and-innovation/solaroad-producing-energy-expected/> (Accessed 20 May 2015).
- Smart Growth/ Smart Energy Toolkit (2012) Environmental Protection Agency.  
[www.mass.gov/envir/smart-growth-toolkit/pages/mod-tod.html](http://www.mass.gov/envir/smart-growth-toolkit/pages/mod-tod.html) (Accessed on 13 April 2014)
- Raunekk and Stonecypher, L. (2009). Electro-kinetic road ramp: A New Way for Generating Energy - Speed Bumps. *Bright Hub Engineering*.  
<http://www.brighthubengineering.com/hvac/32750-a-new-way-for-generating-energy-speed-bumps/> (Accessed 20 May, 2015).
- Google Images (2015) Julius Nyerere Avenue.  
<https://www.google.co.za/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=warwick%20avenue%20durban> (Accessed 20 May 2015).
- Innowattech Energy Harvesting System (2012)  
<http://www.wejew.com/files/24d5e1cf80255b42.swf> (Accessed 09 August 2015).
- Kinetic Tiles (2015) Piezoelectric Floor Tiles.  
<https://kinectictiles.wordpress.com/tag/piezoelectric-floor-tiles/> (Accessed 09 August 2015).
- South African New Agency (2015) President unveils bold plan to tackle energy crisis  
<http://www.sanews.gov.za/south-africa/president-unveils-bold-plan-tackle-energy-crisis> (Accessed 19 May 2015).
- Klinger, R. (2012). Asphalt Magazine. The future is bright for solar energy and asphalt pavements.  
<http://asphaltmagazine.com/the-future-is-bright-for-solar-energy-and-asphalt-pavements/> (Accessed 09 August 2015).

- Lehmann, S (2010) Green Urbanism: Formulating a Series of Holistic Principles. S.A.P.I.EN.S. <http://sapiens.revues.org/1057> (Accessed on 29 April 2014 )
- Open City Projects (2012) The Markets of Warwick Junction, Durban <http://opencityprojects.com/blog/identity/the-markets-of-warwick-junction-durban> (Accessed 14 June 2014).
- Markets of Warwick (2010) <http://www.marketsofwarwick.co.za/home> (Accessed 13 May 2014).
- Innovattech Patent – Piezoelectricity Energy Generators (PEG’s) US 20090195124 A1 [www.petitvention.com](http://www.petitvention.com) (Accessed 20 November 2015).
- Venter, I. (2012). New Green Roads Council SA seeks to develop local rating tool. *Engineering News*. Creamer Media. <http://www.engineeringnews.co.za/article/new-green-roads-council-sa-seeks-to-develop-local-ratings-tool-> (Accessed 01 April 2015).
- Electro-Kinetics Road Ramp (2009) [http://www.fahad.com/pics/electro\\_kinetic\\_road\\_ramp.jpg](http://www.fahad.com/pics/electro_kinetic_road_ramp.jpg) (Accessed 26 August 2015).
- Patwari, S.V. (2014). Solar Roadways. Swami Ramanand Teerth Marathwada University. <http://www.slideshare.net/swapneilpatwari/solar-roadways-the-future-necessity-seminar-report-by-swapnil-patwari> (Accessed 26 August 2015).
- Solar Roadways <http://www.solarroadways.com/main.html> (Accessed 08 September 2015).
- WordPress.com (2011) *New York City vs. Smart Growth Principles* <https://megacitysustainability.wordpress.com/suggestions-for-new-york/> (Accessed 19 May 2015).

#### **TV MEDIA / BROADCAST MEDIA**

- Aljazeera Interview, *Inside Story ; The Real Cost of Energy (Fossil Fuels vs Renewable Energy)*. Douglas Parr (GreenPeace UK) and Klaus Webber (Centre for sustainable energy, Australian National University). *U.A.E, Al-Ain*. (Accessed 05 July 2015).



## **APPENDIX**

**A: Aerial photography of Warwick Junction Greater area and Julius Nyerere Road**

**B: Aerial photography of Julius Nyerere Road and detailed land uses along the mobility route**





