John Ogony Odiyo · Peter Bitta Bikam · James Chakwizira *Editors*

Green Economy in the Transport Sector

A Case Study of Limpopo Province, South Africa

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John Ogony Odiyo · Peter Bitta Bikam ·
James Chakwizira
Editors

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To all those involved in the everyday struggles, challenges, and joys of working tirelessly in the trenches of the green economy and transport sectors

Preface I

Like other developing countries, South Africa is characterized by high energy intensity, low efficiency, and dependence on imported fuel. The motivation for a green economy in the transport sector project in South Africa is related to both local and global mandates. The Sustainable Development Goals (SDGs), The National Transport Master Plan (NATMAP) (2050) and the National Development Plan Vision 2030 for example spur on the country, sectors of the economy, spheres of government, industrial and non-industrial stakeholders in the country to conduct and assess potential opportunities and options to promote a green economy in the transport and non-transport sectors. The foundations that motivated the multi-year research project work on transport and the green economy in Limpopo province was sparked by the need to oversee the green economy in terms of low carbon, resource efficient and socially, inclusive growth and development. A tripartite approach was envisaged as an innovative approach and steering mechanism for a green development agenda via the following:

- Exploring the green transport scape: i.e., fuel efficiency for public transport and private vehicles is a critical part of both the energy and transport policies.
- Critically reviewing South Africa's transport sector energy options.
- Assessing South Africa's progress in the transportation sector towards a green economy making use of Limpopo province as a case study.

Such investigation should assist in the development of clear evidence-based objectives on information and transition to transportation investment decision-making processes, innovation, and priorities. Decisions resulting from a study of a green economy in the transport sector may lead directly to a project definition and design process for sustainable transport infrastructure and services that may be absent from a broader planning process. For this reason, green economy in the transport sector may occur after a long-range plan and analysis to identify appropriate scenarios, towards a green economy in the transport sector. A green economy in the transport sector plan begins with understanding topical and current discourses by incorporating the dynamic complexity of the transport sector economy in a province and their relationship with other sectors of the economy in general.

During the research findings workshops held in Johannesburg (Gauteng province), eThekwini (formerly Durban), (KwaZulu-Natal Province), Cape Town (Western Province), Free State, Mpumalanga, Eastern Cape and Northern Cape (on-line Workshops) during the period 2016–2021, broad issues linked to the advancement of green economy in the transport sector, new trends and innovation in green transport and the green economy, smart land use planning and policy directions were raised. It is these topics which are presented in this book to assist in a better understanding of the role of green transport and economy in ensuring environmentally sustainable growth and development.

We wish to thank: Ms. Maphefo Anno-Frempong, Mr. Avukile Dlanga, Ms. Liza Monthsiwa, Ms. Ouma Mashabane Ledwaba, Mr. Vusimuzi Lushaba, Mr. Nkosinathi Gumbi and Mr. Matsemela Moloi and Prof. Peter Mbati for their inspiration and respective endeavors to ensure the success of the transport and the green economy in Limpopo province project, workshops, and subsequent publication of this book.

Vanderbijlpark, Gauteng,
South Africa
Thohoyandou, Limpopo,
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Potchefstroom, North-West,
South Africa
May 2021

John Ogony Odiyo
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James Chakwizira

Preface II

Towards a Green Economy in the Transport Sector: A case study of Limpopo Province is written for all those who seek to gain deeper insights and perspectives into the green economy in the transport sector governance and planning practice in South Africa, making use of Limpopo province as a case study. Throughout this book, our focus is providing insights on the green economy through a transport sector lens, focusing on how the transition to green economy and transport is crucial to reduce environmental problems such as greenhouse gas emissions and climate change impacts in South Africa. To better understand these realities, the challenges associated with the transition to the green economy are explored in respect of presented opportunities for innovation and mitigation within the green economy and transport sector. To understand these realities of the green economy complexities, the book covers various themes and topics which are relevant in contextualising the green economy in the wider transport sector growth and development realms of places and regions. The substantive issues that are covered in the book also confirm the growing realisation that transport and the green economy are complex systems that require an integrated, holistic, multi and interdisciplinary approach and insights into the socio-economic realities. In this way, the focus of the themes and topics discussed and presented in the book has been on the environment and climate change, transport modes, pollution and emissions control, innovation, transport law and policy, skills and capacity building, all of which are critical in understanding the complexities and transition realities linked to implementing the green economy. Acknowledging that there is no "*one-size-fits-all*" prescription for implementing strategies and interventions for green economy and transport sector growth, we focus through the thematic chapters of the book on the main levers that act as a fulcrum in steering green economy and transport transitions further. We argue that greening the growth path of an economy and the transport sector depends on the policy and institutional settings, transportation modes and technologies, level of development, skills and knowledge transfer, technology innovation and management, resource endowments and environmental pressure points. Given the unique and differentiated South African apartheid-driven historical legacy, we portray how the emerging green economy and transport sector faces different challenges and opportunities, with implications for livelihoods,

climate change, environmental sustainability and economic diversification opportunities. While acknowledging the numerous changes and the wide range of influences, this book provides a sectoral and case study-based approach that identifies the challenges, opportunities and prospects for climate change, sustainable development and transportation which may enable South Africa to advance and develop in a sustainable, inclusive and resilient manner. This is so because no other book has the same geographical and green economy in the transport sector planning focus. While other books have a specific topic such as governance and climate change pollution, this book examines a range of green economy issues related to the transport sector. We adopted a spatial (geographic) "lens" for re-examining the current economic growth paradigm while at the same time offering an actionable policy framework for policy- and decision-makers, practitioners, researchers and academics in developed, emerging and developing economies. This coupled with social, ecological, technological and governance perspectives to multiple issues facing the green economy agenda in South Africa created a critical narrative in green economy policy analysis that gives insights into the green economy in the transport sector.

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The responses from the various key informants working in the public and private sector are greatly appreciated, together with the residents from various cities and towns who took their time to share their daily lived experiences with the authors have been of much assistance in putting together this book. The assistance from Fermine Shaly (Mrs.), Ram Prasad and Margaret Deignan concerning book publication, language editing and technical formatting of the manuscript is greatly appreciated.

Contents

1 Introduction 1
John Ogony Odiyo, Peter Bitta Bikam, and Rachel Makungo

2 Environment, Climate Change and the Green Economy 9
Jason Samuel Ogola

3 Transport Modes and the Green Economy 21
Nthaduleni Sam Nethengwe

4 Technology Innovations in Green Transport 37
Peter Bitta Bikam

5 Vehicle Management and Emission Control and Maintenance 51
Peter Bitta Bikam

6 Skills and Knowledge Transfer for Transitioning into the Green Economy 65
John Ogony Odiyo, Agnes Musyoki, and Rachel Makungo

7 Regulatory Frameworks, Policies, Norms and Standards 79
James Chakwizira

8 Conclusion 119
John Ogony Odiyo, Peter Bitta Bikam, and James Chakwizira

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Abbreviations

AKAP	Attitudes, Knowledge, Awareness and Practices
AMCE	AM Consulting Engineers
B-BBEE	Broad Based Black Economic Empowerment
BRT	Bus Rapid Transport
CFCs	Hydrofluorocarbons
CITPS	Comprehensive Integrated Transport Plans
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CoGHSTA	Human Settlements and Traditional Affairs
COP	Conference of the Parties
CSDP	Consumer Supplier Development Programme
CSIR	Council for Scientific and Industrial Research
CTVET	Capricorn Technical Vocational Education and Training
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DHET	Department of Higher Education and Training
DME	Department of Minerals and Energy
DOT	Department of Transport
DTI	Department of Trade and Institute
ECSA	Engineering Council of South Africa
EPWP	Expanded Public Works Programme
GAAL	Gateway Airports Authority Limited
GCOS	Global Climate Observation System
GEM	Global Environmental Monitoring System
GHG	Greenhouse Gas Emissions
GTS	Green Transport Strategy
GUMP	Gas Utilisation Master Plan
HC	Hydrocarbons
ICCT	International Council on Clean Transportation
ICSU	International Council of Scientific Unions
ICT	Information, Communication Technology

IDC	Industrial Development Corporation
IDPs	Integrated Development Plans
IEA	International Energy Agency
ILO	International Labour Organisation
INC	Intergovernmental Negotiating Committee
IPAP	Industrial Policy Action Plan
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
IRPTN	Integrated Rapid Public Transport Plan
IT	Information Technology
ITPs	Integrated Transport Plans
KPAs	Key Performance Areas
LDoR&A	Limpopo Department of Roads and Transport
LEDET	Limpopo Department of Economic Development Environment and Tourism
LPG	Liquefied Petroleum Gas
LTT	Louis Trichardt
MBTs	Minibus Taxi Buses
MSA	Municipal Structures Act
MSA	Municipal Systems Act
NAMAS	Nationally Appropriate Mitigation Actions
NATMAP	National Transport Master Plan
NCCRP	National Climate Change Response Policy
NDP	National Development Plan
NEMA	National Environmental Management Act
NGP	New Growth Path
NIPP	National Industrial Participation Programme
NLTA	National Land Transport Act
NMT	Non-Motorised Transport
NOx	Nitrogen Oxides
NPC	National Planning Commission
NSSD1	National Strategy for Sustainable Development
NTF	National Transport Forum
OECD	Organisation for Economic Co-operation and Development
PLTF	Provincial Land Transport Plan
PPP	Public-Private Partnerships
PRASA	Passenger Rail Agency of South Africa
R&D	Research and Development
RDP	Rural Development Programme
S&T	Science and Technology
SACPLAN	South African Council of Planners
SAGEM	South African Green Economy Modelling Report
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SAPI	South African Planning Institute

SAPIA	South African Petroleum Industry Association
SDGS	Sustainable Development Goals
SETAs	Sector Education and Training Authorities
SPLUMA	Spatial Planning, Land use and Management
TETA	Transport, Education and Training Authority
TVET	Technical Vocational and Educational Training
UK	United Kingdom
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISA	University of South Africa
UNIVEN	University of Venda
USA	United States of America
VOC	Volatile Organic Compound
WCIF	Western Cape Infrastructure Framework
WHO	World Health Organisation

List of Figures

Fig. 1.1 Elements required to optimise green transport economy 4
Fig. 1.2 Transition towards a green economy in the transport sector 5
Fig. 1.3 Municipalities covered in the case study 6
Fig. 2.1 Global long term solar radiative balance of the atmosphere (IPCC 1995) 10
Fig. 2.2 Primary energy supply in South Africa for the years 2000 and 2006 (Department of Minerals and Energy Annual Report 2009) 12
Fig. 2.3 Carbon dioxide emissions into the atmosphere since the industrial age (Letsoalo 2013) 12
Fig. 2.4 Contributors to greenhouse gas emissions in South Africa 14
Fig. 2.5 Floods in Kwazulu Natal in 2017 (https://www.news24.com/SouthAfrica/News/live-massive-storm-hits-durban-causes-flooding-chaos-20171010) 17
Fig. 3.1 Organisation of research findings: survey and stakeholder engagement 26
Fig. 3.2 Percentage (%) travelers using a particular mode of transport 26
Fig. 3.3 Green transportation hierarchy, based on *eco-friendliness* (Source: Bradshaw (2014)) 27
Fig. 3.4 Consumers preferred mode of transport 28
Fig. 6.1 Responses on training and awareness, existing skills on green transport and adequacy of information on transport and the green economy in Limpopo Province 73
Fig. 7.1 Importance of green issues as an overall strategy in the transport sector of Limpopo province. Sample size N = 21. *Source* Research Findings, 2016 101
Fig. 7.2 Suggested key issues in developing a green economy in Limpopo province. Sample size N = 21. *Source* Research Findings, 2016 107
Fig. 7.3 Summary highlights of regulatory framework, policies, norms and standards research findings. *Source* Authors own conceptualization, 2021 107

List of Tables

Table 1.1 Areas covered in the case study 6
Table 2.1 Summary of research priorities—coastal/marine[a] 15
Table 2.2 Summary of research priorities—coastal/rail and road[a] 16
Table 2.3 Summary of research priorities—interior/rail, road and pipeline* 16
Table 3.1 Study's sampling frame and size 24
Table 4.1 Technological and Non-Technological Innovations 43
Table 4.2 Classification of technical and non-technical innovations in Limpopo Province 45
Table 5.1 Greenhouse gases emission from 2000 to 2010 in South Africa 53
Table 5.2 Contribution of different modes of transport emission in 2010 53
Table 5.3 Contribution to total transport emission in 2010 54
Table 5.4 Respondents experience with vehicle licensing in Limpopo Province, 2016 60
Table 5.5 Relevant skills required to upscale the control of emission in a green transport economy 62
Table 6.1 List of participants 68
Table 6.2 Generic jobs and skills for the green economy 69
Table 6.3 Skills needs for green transport 70
Table 6.4 Preferred career for the green economy in transport sector 71
Table 6.5 Preferred institutions 72
Table 6.6 Training preference 73
Table 6.7 Short, medium and long term policy recommendations 75
Table 7.1 Sample list of stakeholders consulted in the Green Transport Project in Limpopo province 83
Table 7.2 Sample list of legal, policy and strategic documents consulted for the Green Transport Project in Limpopo province 84
Table 7.3 National policy frameworks and strategy documents supporting green economy and transport in South Africa 86

Table 7.4 Linking the transport policy and energy nexus dimension in South Africa 90
Table 7.5 Derives norms and standards in the transport sector of South Africa 91
Table 7.6 Examples of green economy and transport initiatives in South African provinces 92
Table 7.7 A sample selection of green transport initiatives in South Africa 94
Table 7.8 Highlights of some transport sector major challenges in Limpopo province, South Africa 96
Table 7.9 Selected highlights of transport and related policy document shortcomings from a provincial green transport perspective 99
Table 7.10 Suggested drivers for integrating green transportation and logistics initiatives in Limpopo province, South Africa . . . 100
Table 7.11 Provincial long-term plan viewed as providing direction for green transport in Limpopo province 102
Table 7.12 Some innovative ways that the province can introduce to move from conventional energy sources of supply 103
Table 7.13 Planned and current green transportation and logistics initiatives in Limpopo province, South Africa 104
Table 7.14 How policy makers can promote PPP in the green transport sector 105

Chapter 1
Introduction

John Ogony Odiyo, Peter Bitta Bikam, and Rachel Makungo

Abstract This book provides policy framework on "towards a Green Economy in the Transport Sector" draws inspiration from the UNEP report on Green Economy Modeling (2014), which focused on South Africa with respect to Transport, Natural Resource Management, Agriculture, and Energy sectors. This is because in the last 10 years natural resources, environmental risks and ecological issues have come to the attention of the international community because the subject is fundamentally important for overarching sustainable growth. It is important to note that environmental problems such as greenhouse gas emissions and climate change in different regions of the world including South Africa result in significant problems. However, the challenges can provide an opportunity to do things differently. Further to this in 2010, South Africa hosted the Green Economy Summit to set up the stage for the formulation of a Green Economy Plan. In line with this, the choice for a New Growth Path (NGP) was formulated and it was aimed at creating new green jobs in their thousands by 2020. It was in this context that the NGP policy framework on green economy in the transport sector was envisaged to respond to the request by Transport Education and Training Authority (TETA) to assess potential opportunities and policy levers to inform a green economy in the transport sector. The findings from the desktop research, the stakeholder workshop and the field survey reports form the basis from which the policy framework recommendations in this report were made.

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1.1 Vision

The proposed vision of the policy framework recommendations are in line with suggestions made in 2013 by South African Green Economy Modelling report (SAGEM) (UNEP 2013). It was based on system dynamics modeling aimed at exploring new opportunities in a green economy in the transport sector. In view of this, the suggested vision for 'towards a green economy in the transport sector is as follows:

A transport sector that promotes energy efficiency, reduces per capita km traveled, enhances innovations, creates new green jobs, ensures modal integration, increases investment opportunities, enhances new skills development, reduces CO2 emissions, uses renewable energy resources and light material to build vehicles.

1.2 Strategic Objectives

In view of the vision suggested above, the strategic goals of the policy framework recommendations are outlined as follows:

- Access to affordable public transport
  To ensure that commuters have access to mass transit modes of transport and services with opportunities for modal integration and choices.
- Smart transport logistics
  To ensure integrated land use planning and smart transport management for modes of transport such as the Bus Rapid Transport (BRT).
- Shift to environmentally friendly transport
  To promote environmentally friendly transport modes to ensure transport demand management, efficiency and provision of pedestrian and cycling lanes and shift to alternative fuels.
- **Improve funding in green transport initiatives**
  Increase capacity of sustainable transport and funding mechanisms to leverage green transport modes.
- **Promote skills development**
  Explore new ways to promote new skills and green jobs in the transport sector to ensure access to jobs in the value chain of green transport.

In view of the importance of finding the right balance between an intensive transport sector and the need to adopt green transport innovations to ensure sustainable development in South Africa, it is important to explore a new policy framework to inform a new path for the creation of new green jobs and the initiation of investment opportunities. This policy framework recommendation explores new opportunities with respect to green economy in the transport sector. To put this policy framework in the context of the green economy, the report identified six policy framework levers as follows:

- Environment, climate change and the green economy,
- Transport modes and the green economy,
- Technology innovation in the green economy,
- Vehicle management, emission control and maintenance,
- Regulatory framework in the transport sector, policies and standards, and
- Skills and knowledge transfer.

It was based on the policy framework levers identified through literature review, workshop with the stakeholders and the field survey report that the policy levers findings and recommendations were drawn. The six policy levers were proposed on the understanding of the following:

I .**Access** that forms the basis for increased ridership in green transport modes,
II .**Logistics** that integrates smart transport into human settlements,
III .**Shift** towards environmentally friendly transport modes,
IV .Increased capacity for sustainable transport modes, and
V .Development of **new skills** and the creation of new jobs in the green transport sector.

1.3 The Approach to the Policy Recommendations

The approach to which the findings and recommendations outlined in this document centers on was aimed at aligning the six policy levers to skills development in the transport sector, creation of new job opportunities, reduction in CO_2 emissions, increased intermodal transport choices, smart transport logistics such as the Bus Rapid Transport (BRT), environmentally sustainable transport and shift towards alternative fuel such as electric cars and biofuel. The concept is illustrated in Fig. 1.1.

Figure 1.1 shows the elements required to optimise "towards a green economy in the transport sector". The illustration shows the elements of green transport that can maximise the primary drivers of green transport with respect to the following:

- **Access** to green affordable public transport,
- **Integrated land use** and sustainable public transport,
- Promotion of **efficient and environmentally friendly** modes of transportations,
- **Leverage funding** for investment to improve innovative research and transport technology, and
- **Development and training of new skills** across the value chain towards a green economy in the transport sector.

The framework approach illustrated in Fig. 1.1 should ensure the transition towards a green transport economy in the transport sector as illustrated in Fig. 1.2. The link between the vision and strategic goals and policy levers are clearly shown in Fig. 1.2.

The policy levers include:

Skills Lever I: Environment, climate change and the green economy,

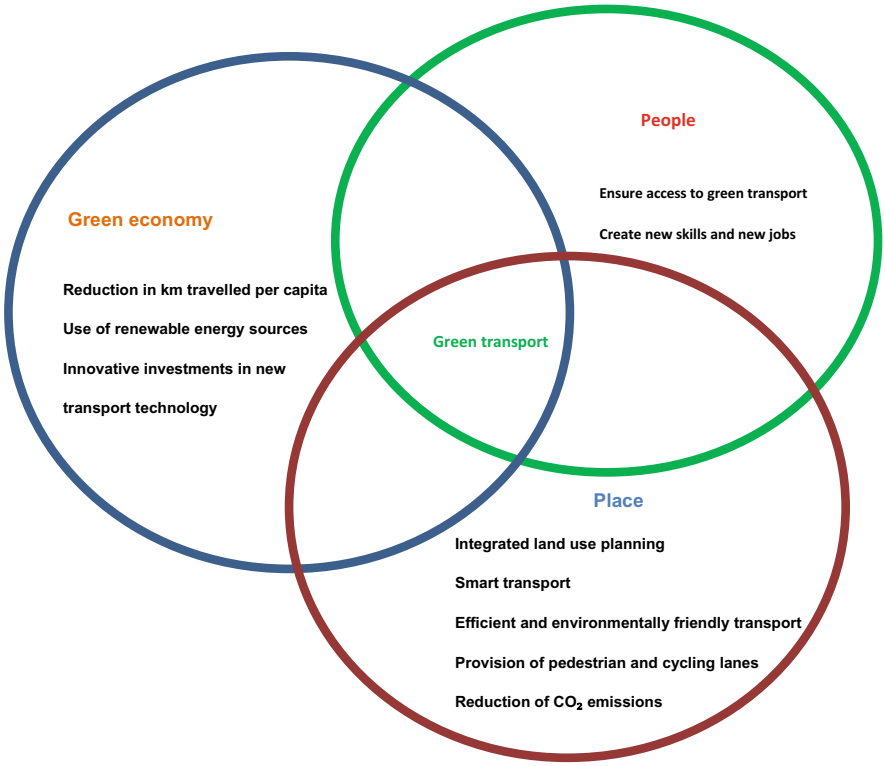

Fig. 1.1 Elements required to optimise green transport economy

Skills Lever II: Transport modes and the green economy,
Skills Lever III: Technology innovations in green transport,
Skills Lever IV: Vehicle management and emission control and maintenance,
Skills Lever V: Skills and knowledge transfer for transitioning into the green economy, and.
Skills Lever VI: Regulatory frameworks, policies, norms and standards.

1.4 Case Study

A case study was conducted in Limpopo Province to provide knowledge and evidence on green economy in Limpopo Province with emphasis on transition to green transport. The study was also aimed at identifying short- and long-term recommendations that can assist in transition to green transport. Chapters 2 to 7 are based the case study linked to skills levers I to VI. The case study covered municipalities within selected districts in the Limpopo Province (Table 1.1 and Fig. 1.1). The area is composed

Vision	Strategic goals	Policy levers
A transport sector that promotes energy efficiency, reduces per capita km traveled, enhances innovations, creates new green jobs, ensures modal integration, increases investment opportunities, enhances new skills development, reduces CO_2 emissions, uses renewable energy resources and light material to build vehicles.	Access to affordable public transport Smart transport logistics Shift to environmentally friendly transport Improve funding for green transport initiatives Promote skills development	1. Environment, climate change and the green economy 2. Transport modes and the green economy 3. Technology innovation in the green economy 4. Vehicle management, emission control and maintenance 5. Regulatory framework in the transport sector, policies and standards 6. Skills and knowledge transfer

Fig. 1.2 Transition towards a green economy in the transport sector

of predominantly rural communities and hence transition to green economy will be beneficial to these communities.

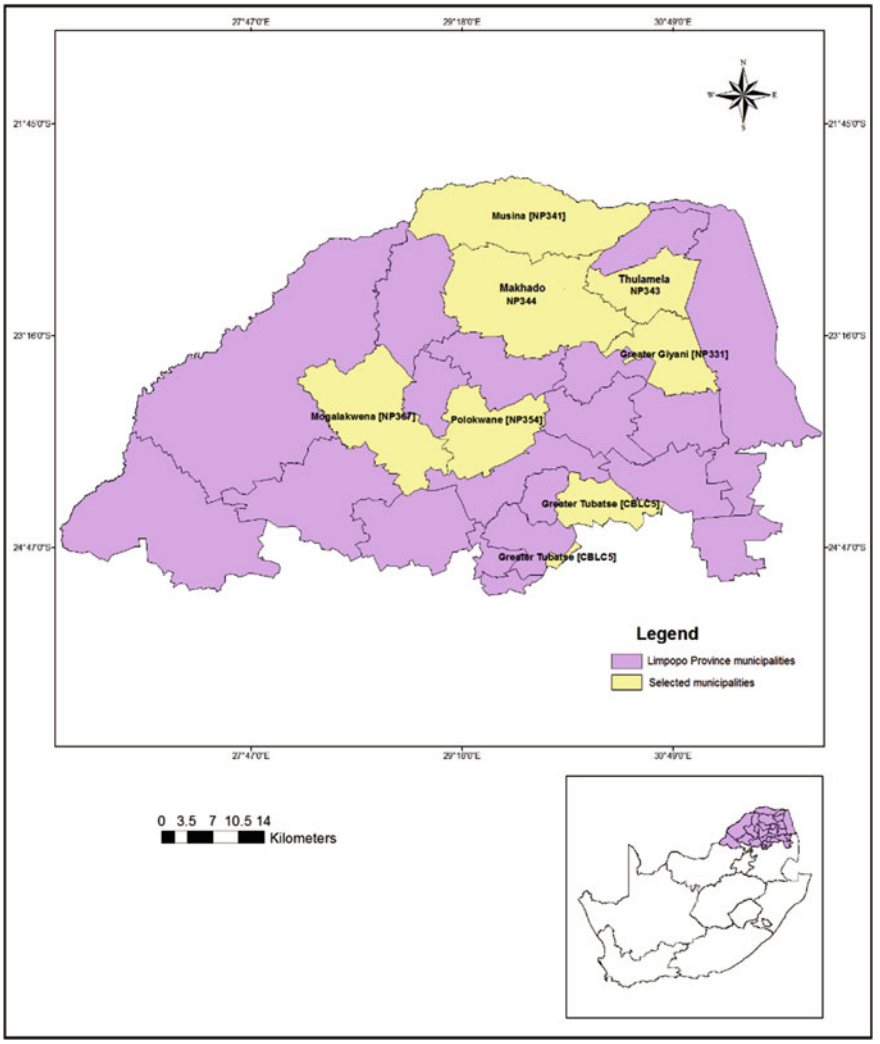

Fig. 1.3 Municipalities covered in the case study

Table 1.1 Areas covered in the case study

Districr	Municipality
Vhembe	Thulamela, Makhado and Musina
Capricorn	Polokwane
Sekhukhune	Greater Tubatse
Waterberg	Mogalakwena
Mopane	Greater Giyani

Reference

United Nations Environment Programme (UNEP), 2013. Green economy modelling report for South Africa: Focus on the sectors of natural resource management, agriculture, transport and energy. Available from: https://www.environment.gov.za/sites/default/files/docs/greeneconomy_modelingreport.pdf, accessed 20 September 2020

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Chapter 2
Environment, Climate Change and the Green Economy

Jason Samuel Ogola

Abstract To identify and evaluate possible impacts of climate change on transportation in Limpopo province, it is necessary to define the scale and scope of the transportation system in the province and determine its sensitivities to climate change. This chapter, therefore locates the environment, climate change and the green economy matters in context. The science of climate change is explored, while the main sources of greenhouse gases are discussed. Additionally, the impacts of climate change in South Africa is outlined. Strategies to reduce greenhouse gas emissions (GHG) in the transport sector are provided.

Keywords Climate change · Transportation system · Green economy · Greenhouse gas emissions · Transport sector

2.1 Science of Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) in 1992 defined climate change as "**a change in climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variations observed over comparable time periods**".

Past climate variations are attributed to natural processes while the observed climate change is due largely to anthropogenic causes (Ogola et al. 1997). Climate change results from the increased emissions and subsequent concentration of gases such as methane (CH_4), carbon dioxide (CO_2), nitrous oxide (N_2O), chlorofluorocarbons (CFCs). These gases are referred to as greenhouse gases (GHGs) that form a cloud in the atmosphere due to human activities. They help to trap heat energy from the surface of the Earth, thus prevent heat from escaping into space (Fig. 2.1). Global warming results in shifts in weather patterns that lead to melting of icebergs

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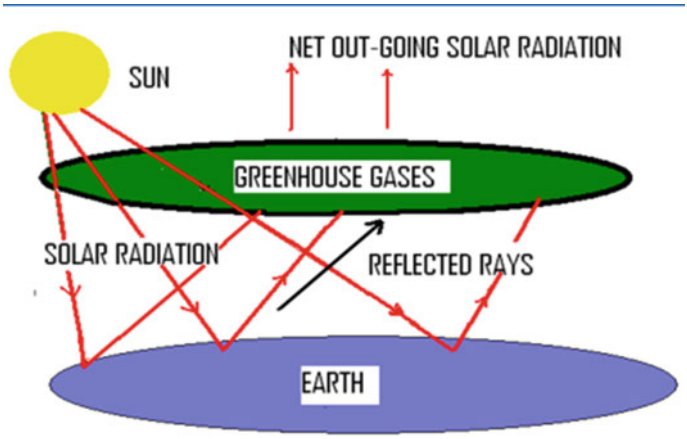

Fig. 2.1 Global long term solar radiative balance of the atmosphere (IPCC 1995)

and sea-level rise, frequent hurricanes, impacts on water resources, agriculture, biodiversity, energy demands and other resources. The result is the effect on the quality of life with some species becoming extinct.

Awareness of climate change has been due to a number of initiatives that include:

- The Stockholm's Declaration of the United Nations Conference on Human Environment that took place in 1972;
- First World Climate Conference held in Geneva in 1979 by the World Meteorological Organization and the United Nations Environmental Programme, resulting in the creation of the World Climate Research programme;
- First Joint UNEP/WMO and the International Council of Scientific Unions (ICSU) held in Villach, Austria, in 1980 to initiate debate on a global convention and in 1985, the Group concluded that climate change and sea-level rise are closely related;
- Formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988 and establishment of the three Working Groups: Working Group I on scientific analysis; Working Group II on impacts; and Working Group III on related legal instruments;
- United Nations Assembly in 1990 established the Intergovernmental Negotiating Committee (INC) to draft a Framework Convention on Climate Change (IPCC 1990);
- United Nations Conference on Environment and Development in Rio de Janeiro in June 1992, adopted the United Nations Framework Convention on Climate Change by the world community and it became known as the Climate Change Convention.
- The Kyoto Protocol was adopted in Kyoto, Japan, in 1997 and the purpose was for nations to agree to take action to address global warming. The treaty committed state parties to reduce greenhouse gas emissions;

- Johannesburg Summit 2002—the World Summit on Sustainable Development produced three outcomes: political declaration now known as the 'Johannesburg Declaration on Sustainable Development'; the Johannesburg Plan of Implementation; and 'Type II' commitments by governments and other stakeholders, including business and non-governmental organisations;
- Paris Agreement (French: Accord de Paris) of 2015 is an agreement within the UNFCCC, dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, starting in the year 2020, the agreement was negotiated by representatives of 196 state parties at the 21st Conference of the Parties of the UNFCCC and adopted by consensus, and the Paris Agreement's long-term goal is to keep the increase in global average temperature to well below 2 °C above pre-industrial levels; and to limit the increase to 1.5 °C.

The development and improvement of the science of climate change involved a number of international programmes and projects that included:

- Global Environmental Monitoring System (GEM) sponsored by UNEP;
- World Climate Data Programme that provides information on the state of climate system and diagnosis of significant anomalies of regional and global sequence;
- Climate Change Defection Project, which regularly updates estimates of climate change on global and regional basis and assessing the relative importance of these change; and
- Global Climate Observation System (GCOS), which is intended to meet the needs for climate system monitoring, climate change determination and systematic observations of responses to climate change.

2.1.1 Sources of Greenhouse Gases

The main sources of greenhouse gases include energy use and production (57%), chlorofluorocarbons (17%), agricultural practices (14%), deforestation (9%) and others including industrial (3%). Burning of coal, oil and natural gas produces large quantities of CO_2, CH_4 and N_2O to the atmosphere. In South Africa, coal is the main source of electricity in the country, accounting for 79% in 2000 and 65.7% in 2006 (Fig. 2.2).

Carbon dioxide constitutes about 55%, methane-15%, nitrous oxide-6%, chlorofluorocarbons-11% and others-6% (IPCC 1990). Since the industrial age, about 200 years ago, the rate of CO_2 emissions to the atmosphere had increased steadily up to 1950, but after that the increase has been quite rapid (Fig. 2.3). This rapid increase of CO_2 to the atmosphere is largely attributable to energy use, especially in the transport sector.

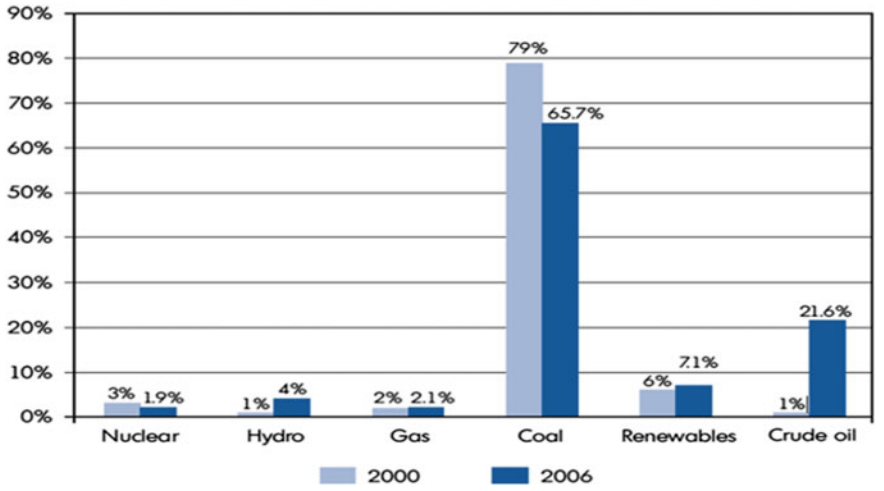

Fig. 2.2 Primary energy supply in South Africa for the years 2000 and 2006 (Department of Minerals and Energy Annual Report 2009)

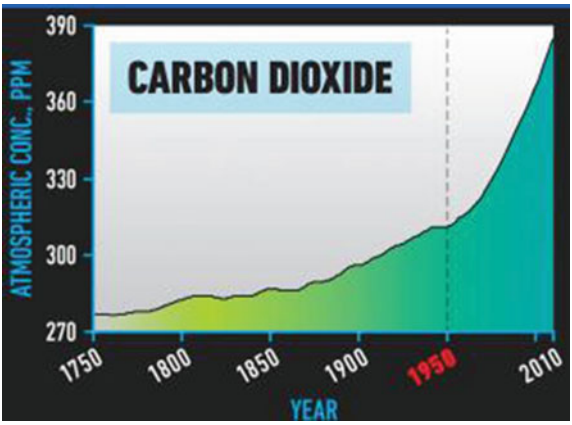

Fig. 2.3 Carbon dioxide emissions into the atmosphere since the industrial age (Letsoalo 2013)

2.2 Impacts of Climate Change in South Africa

South Africa has set two main objectives of dealing with the impacts of climate change (National Climate Change Response White Paper 2011):

- Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity; and
- Make a fair contribution to the global effort to stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that avoids dangerous anthropogenic

interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner.

The climate change response objectives is based on risk reduction and management; mitigation actions with significant outcomes; sectoral responses; policy and regulatory alignment; informed decision making and planning; integrated planning; technology research, development and innovation; facilitated behaviour change; behaviour change through choice; and resource mobilisation.

The White Paper looks at the overall mitigation strategy that encompasses the following:

- Using a National GHG Emissions Trajectory Range, against which the collective outcome of all mitigation actions will be measured;
- Defining desired emission reduction outcomes for each significant sector and sub-sector of the economy based on an in-depth assessment of the mitigation potential, best available mitigation options, science, evidence and a full assessment of the costs and benefits;
- Adopting a carbon budget approach to provide for flexibility and least-cost mechanisms for companies in relevant sectors and/or sub-sectors and, where appropriate, translating carbon budgets into company level desired emission reduction outcomes.
- Requiring companies and economic sectors or sub-sectors for which desired emission reduction outcomes have been established to prepare and submit mitigation plans that set out how they intend to achieve the desired emission reduction outcomes.
- Developing and implementing a wide range and mix of different types of mitigation approaches, policies, measures and actions that optimise the mitigation outcomes as well as job creation and other sustainable developmental benefits. This optimal mix of mitigation actions will be developed to achieve the defined desired emission reduction outcomes for each sector and sub-sector of the economy by ensuring that actions are specifically tailored to the potential, best available solutions and other relevant conditions related to the specific sector, sub-sector or organisation concerned;
- The deployment of a range of economic instruments to support the system of desired emissions reduction outcomes, including the appropriate pricing of carbon and economic incentives, as well as the possible use of emissions offset or emission reduction trading mechanisms for those relevant sectors, sub-sectors, companies or entities where a carbon budget approach has been selected; and
- A national system of data collection to provide detailed, complete, accurate and up-to-date emissions data in the form of a Greenhouse Gas Inventory and a Monitoring and Evaluation System to support the analysis of the impact of mitigation measures.

2.3 Climate Change and Its Impacts on the Transport Sector

Between 2000 and 2010, the greenhouse gas emissions in South Africa increased by 27%, producing a total of accumulated greenhouse gases of 4,204,640 Gg CO_2 equivalent (Department of Environmental Affairs 2014). The main contributors of GHG emissions were energy sector (63.6%), predominantly from coal combustion to produce electricity (55.1%), followed by transport (10.8%) and manufacturing industries (9.8%) (Fig. 2.4). The transport sector contributes to greenhouse gas emissions through combustion of fossil fuels. Emissions are primarily from diesel and petrol consumption for road and rail transport and jet and aviation gasoline. This results in the release of CO_2 and to a lesser extent, CH_4 and N_2O.

In 2010, road transport consumption of fuel was about 91.2% and this resulted in greenhouse gas emissions of 92% of the transport sector (Department of Environmental Affairs 2014). Fuel consumption is by cars, light delivery vehicles, trucks, buses, trailers, tractors and motorcycles. Railway locomotives are of three types; diesel, electric and steam. The diesel locomotives use engines driven by diesel, while electric locomotives use electricity from power stations. GHG emissions from steam locomotives are currently negligible as their use is low. Civil aviation GHG emissions are due to combustion of jet and aviation gasoline. Aircraft GHG emissions constitute 70% CO_2, less than 30% water and 1% of other components (Department of Environmental Affairs 2014).

At a workshop in the USA on the impacts of climate change on transportation (Federal Research Partnership Workshop 2002) some of the outcomes of the workshop included recommendation on research on Coastal Regions/Marine (Table 2.1) so as to have a better understanding of the potential effects of climate change on ports and marine shipping due to storms, sea level rise, sedimentation and erosion

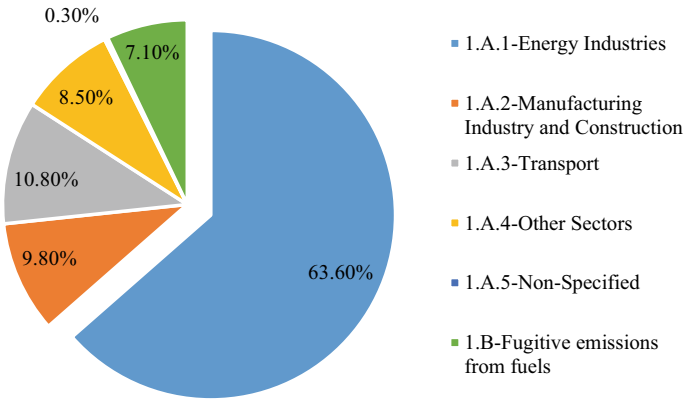

Fig. 2.4 Contributors to greenhouse gas emissions in South Africa

Table 2.1 Summary of research priorities—coastal/marine[a]

Research challenge	Specific research needs
Storms and sea level rise	– Climate change effects on storm intensity, location, track – Clarification of projected trends – Exploration of local sea level changes and land movements – Simulation of storm events – Impact of sever events at different geographic scales
Sedimentation and erosion	– Impact on wave- and current-induced sedimentation – Changes to rainfall and river hydrology, sedimentation rates – Case studies at ports – Dredging disposal options
Changes in prevailing winds, waves, currents, and precipitation	– Improved monitoring, modelling – Relation to shipping, port design
Shipping routes	– Monitor extent and thickness of sea ice—Arctic and Great Lakes
Decision making and policy tools	– Improved models, elevation maps, GIS; communication tools
Socio-economic patterns, legal issues	– Localised land use, watershed, transport development trends

[a]Federal Research Partnership Workshop (2002)

rates, and changes in key variables such as prevailing winds, waves, currents, and precipitation rates.

Focus was also made on coastal regions rail and road transport that focused on the effects of weather-related travel delays on rail and road system performance (Table 2.2).

As concerns the interior regions and their implications for surface transportation and pipelines the expert group focused on four priority research challenges (Table 2.3).

As summarised in the National Climate Change Response White Paper (2011), South Africa is vulnerable to impacts of climate change. According to the IPCC Working Group II (2014), there is a possible increase in temperature within Africa of over 2 °C by mid-century and this may reach 3–6 °C by the end of the century. This will be accompanied by heat waves and droughts in many parts of Africa. Coastal areas are likely to suffer from sea level rise and frequent storm surges. In the case of South Africa, it is predicted that by 2050, South African coastal area will warm up by 1–2 °C and by about 3 °C in the interior. By 2100, warming is projected to reach 3–4 °C along the coast and 6–7 °C in the interior. These high temperature increases will have adverse effects on the transportation system. Consequently, there will be need to have changes in construction and designs of transportation infrastructure

Table 2.2 Summary of research priorities—coastal/rail and road[a]

Research challenge	Specific research needs
Weather related travel time delays	– Regional effects on transportation system performance – Travel behaviour response to delays
Impacts of climate change on roads and ecosystems	– GIS overlay of coastal roads and elevations—impacts of sea level rise on roads and habitat – Regional case studies of road design that minimise environmental impacts – Best practices for road construction and location
Smart growth	– Economics of coastal development and impacts of climate change – Analysis of anticipated sea-level rise and local development plans, using GIS technologies
Lack of public awareness of climate change consequences	– State and local case studies – Website development on potential climate change impacts

[a]Federal Research Partnership Workshop (2002)

Table 2.3 Summary of research priorities—interior/rail, road and pipeline

Research challenge	Specific research needs
Tools to support local/regional scale impacts projection and decision making	– Service interruptions – Development of appropriate design parameters for new facilities – Integration of climate and impact models at comparable resolution – Data "info mining"
Hydrologic impacts on road, rail and pipeline infrastructure	– Evaluation of existing hydrologic models (under climate change scenarios) – Effects of hydrological changes on groundwater table/quality – Landslides/washout, flooding impacts on transportation facilities – Effects of sediment transport on infrastructure, and response strategies
Extreme events and impacts on roads, rail and pipelines	– Methods to characterise risks without complete reliance on historical data – Validation of climate, hydrological and impacts at multiple scales
Spatial and temporal shifts in demand	– Timing and location of shifts in transportation demand, relative to life of infrastructure – Impacts on port facility capacities and inter-modal flows

Fig. 2.5 Floods in Kwazulu Natal in 2017 (https://www.news24.com/SouthAfrica/News/live-massive-storm-hits-durban-causes-flooding-chaos-20171010)

and alternative sources of energy to mitigate against climate change. Transportation modes will have to be equipped with effective air conditioned facilities as daily minimum and maximum temperatures increase. Some of the impacts of climate change in South Africa have resulted in reduced crop yields due to prevailing drought in the country, increased coastal erosion, impact on tourism and loss of jobs, and interruption of transport systems, for example, the recent floods in Kwazulu Natal (Fig. 2.5).

In order to identify and evaluate possible impacts of climate change on transportation in Limpopo province, it is necessary to define the scale and scope of the transportation system in the province and determine its sensitivities to climate change. Transportation infrastructure is generally vulnerable to flooding and storm surges. Changes in precipitation patterns can put to risk the existing infrastructure in Limpopo province. Higher temperatures as have been experienced in 2015 and the earlier part of 2016 can pose risks to the existing infrastructure. Storm surges can also results in landslides as was experienced in the Vhembe district in the year 2000. Floods and landslides can affect the road and rail transportation network. This calls for a survey to identify valuable road sections in order to come up with mitigation strategies. Road tunnels like the Hendric Verwoerd tunnel between Louis Trichardt and Musina need to be monitored so as to prevent any potential calamities due to storm surges, floods and landslides or land subsidence.

In Limpopo province, changes in precipitation, soil moisture, groundwater regimes and flooding may put to risk both surface roads and railway network. This may call for the need to adjust engineering standards, location of infrastructure, maintenance of schedules, and safety management. Likewise, there could be need to

re-evaluate the existing hydrologic models to cope with the identified climate change scenarios. Risks due to potential changes in the frequency and intensity of extreme weather events will also require attention.

Mitigation strategies for the potential impacts of climate change in Limpopo province will have to address the following questions:

(a) What are the most significant potential problems that climate change poses for transportation?
(b) What are the priority research areas that require immediate intervention?
(c) Are transportation planners equipped with the relevant tools that integrate climate change and impact models to support transportation decision making at the local and regional level?
(d) Who should take lead on mitigation strategies as the issues at hand are inter-departmental?

The relevant tools for decision making include risk analysis information and the ability to translate impact findings to meaningful data for mitigation. Apart from broad issues, the study should focus on weather-related travel delays on the road and trail systems. Research on the effects of weather on travellers' response to adverse weather can help inform real-time operational and maintenance decisions of transportation managers. A better understanding of weather activity and its effects on surface transportation could support better planning and investment for long-term climate impacts (Potter 2002). This could result in best practices in road design and construction that respond to challenges of climate change.

2.4 Strategies to Reduce GHG Emissions in the Transport Sector

There is need to develop policies to reduce greenhouse gas emissions for a range of transport modes as well as the need to maintain the momentum towards a low carbon economy and towards decarbonising the transport sector through the use of alternative sources of energy that do not emit CO_2.

Whereas the Limpopo provincial mitigation strategies against climate change and environmental protection are well stipulated in the Green Economic Plan of 2013 and in the Strategy on Climate Change of 2016, the implementation is lacking. Strategies for extreme weather events fall within the docket of the Department of Disaster and Risk Management, but impacts affect all sectors of the economy, including the transport sector, thus there is need for coordination amongst the various departments. The environmental principle that "the polluter pays" is extremely difficult to monitor on site. What is being monitored is the ambient air quality and not gas emissions from individual sources. Development and utilisation of renewable energy sources is generally hindered by the powerful oil industry, vehicle manufacturers and transport companies. The perception that "the bigger the car the better" also hinders the development of the environmentally friendly vehicles.

2.5 Discussion

The main concern of the UNFCCC (1992) was that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind. This led to the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992 and the subsequent adoption of the United Nations Framework Convention on Climate Change by the world community and it became known as the "Climate Change Convention." Following this, was the Kyoto Protocol and the Conference of the Parties (COP) comprising UNFCCC participating member States. At the COP 21 meeting in Paris in December 2015, the member states adopted by consensus to reduce emissions as part of the method for reducing the greenhouse gas emissions. It looked at greenhouse-gas-emissions mitigation, adaptation, and finance, starting in the year 2020.

The long-term goal of the Paris Agreement is to keep the increase in global average temperature to well below 2 °C above pre-industrial levels; and to limit the increase to 1.5 °C, since this would substantially reduce the risks and effects of climate change (COP 21 2015). According to this Accord, each member state must determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. COP21 noted that in the first half of 2016 average temperatures were about 1.3 °C above the average in 1880, when global record-keeping began. The IPCC Working Group II (2014), however, noted that there is a possible increase in temperature within Africa of over 2 °C by mid-century and this may reach 3–6 °C by the end of the century. For South Africa, it is predicted that by 2050 the coastal area will warm up by 1–2 °C and by about 3 °C in the interior. The situation is likely to worsen by 2100 when warming is projected to reach 3–4 °C along the coast and 6–7 °C in the interior.

The described scenario above of temperature rise in general and for South Africa in particular calls for changes in construction and design of transportation infrastructure and alternative sources of energy to mitigate against climate change. There will be need to equip transportation modes with effective air conditioned facilities as daily minimum and maximum temperatures increase. Increase in intensity and frequency of precipitation will also result in floods and landslides, for instance, in Limpopo Province that will put at risk the existing transportation infrastructure. For example, in 2000 storm surges resulted in landslides in the Vhembe district and this led to landslides and destruction of houses.

Strategies to mitigate the impacts of climate change in the transportation sector include development of policies to reduce greenhouse gas emissions for a range of transport modes as well as the need to maintain a low carbon economy.

References

Conference of the Parties (COP 21 2015) The Paris Accord adopted by UNCCC Member States
Federal Research Partnership Workshop (2002) The potential impacts of climate change on transportation. USA Department of Transportation Centre on Climate Change and Environmental Forecasting, 251 pp
https://www.news24.com/SouthAfrica/News/live-massive-storm-hits-durban-causes-flooding-chaos-20171010. Cited 19 Nov 2018
IPCC (1990) Executive summary on energy and industry. In: Climate change: the IPCC response strategies, WMO/UNEP, pp 47–72
IPCC (1995) Radiative forcing of climate change: an evaluation of the IPCC 1992 emission scenarios. Cambridge University Press, pp 24–34
IPCC Working Group II (2014) The Fifth Assessment Report (AR5)
Letsoalo A (2013) Limpopo green plan, Polokwane
National Climate Change Response White Paper (2011) Department of Environmental Affairs, Republic of South Africa, 49 pp
Ogola JS, Abira MA, Awuor VO (1997) Potential impacts of climate change in Kenya. Climate Network Africa, Nairobi, Kenya, 190 pp
Potter R (2002) The potential impacts of climate change on transportation: workshop summary. USA Departments of Transportation Centre on Climate Change and Environmental Forecasting, pp 3–26
South Africa Department of Environmental Affairs (2014) GHG inventory for South Africa 2000–2010, 316 pp

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Chapter 3
Transport Modes and the Green Economy

Nthaduleni Sam Nethengwe

Abstract This chapter provides empirical evidence regarding the various transport modes and the green economy in the Limpopo Province of South Africa. Issues pertaining to green transport, strategies for implementation and any challenges associated with the transition towards green transport are grounded on empirical research conducted in the province. In South Africa, transitioning to a green economy is envisioned as a vital means to respond to critical development challenges that the country is facing and will continue to face in the near future. Many of these challenges are intertwined and they range from high levels of unemployment, poverty and inequality, to energy, security and climate change. The transition to a greener economy is articulated in the national development policy through a series of frameworks, strategies, policies and Acts which all enshrine sustainability or the notion of making the South African economy greener (Department of Environment Affairs (2016) . However, the implementation of green transport in general and particularly in the Limpopo province, is still in the infancy stage.

Keywords Transport modes · Green economy · Implementation strategies · Transitions towards green transport

3.1 Background

3.1.1 Transition to Green Transport

In South Africa, green transport is a very complex enterprise, mainly because the transition towards it, presents a mix of challenges and opportunities. In terms of challenges, South Africa is at a crossroads, because while it has developed effective policies, which are in line with international trends, placing the country on a

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low carbon trajectory, there is still a great need to overcome socio-economic challenges such as poverty and unemployment (Mahadea & Simson 2010). Through the development of frameworks, policies and Acts, South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people and implementing global collaboration (Department of Environmental Affairs and Tourism 2008). Currently, this aspiration seems to be far-fetched, and the challenges are not being addressed except the maintenance of current transport systems that directly contribute to GHGs. On the other hand, transition to green transport is likely to afford us the opportunity to engage communities in meaningful and non-academic discourse in order to harness common green transport skills and job opportunities which will allow us to integrate them in the general value chain for the advancement of an eco-friendly, low carbon and energy efficient transport sector (RSA 2003; Cetinkaya et al. 2011).

3.1.2 The Concept of Green Transport and Its Contribution to Green Economy

In simple terms, green transport means any kind of transportation practice or vehicle that is eco-friendly which also has minimal negative impacts on the immediate environment. It is sometimes referred to as sustainable transport and has the main aim of minimizing the adverse impact of transport on the environment while addressing current and future transport demands based on the principles of sustainable development. Green transport, therefore, requires that socio-economic growth targets are met in a way that guarantees greater safety to citizens and commuters alike (Limpopo Green Economy Plan 2013). Such targets should also harmonise with the natural, social or economic environment (DEAT 2008). In addition, green transport intends to reduce the adverse impact of carbon emissions and the effects of transport infrastructure on the immediate environment. This is argued to be achieved through reducing private car dependence in favour of public and non-motorised transport as well as using a low impact design and materials for transport infrastructure (DBSA 2011).

However, the artificially enforced separation between places of work and shopping and places of residence (Davies 2015) makes road transport, the primary source of CO_2 emissions in South Africa, unavoidable. The heavy reliance of various sectors (energy, transport, mining, industrial, commercial and agricultural) on road-based transport, in order to move people and freight, contributes both to a quicker deterioration of road infrastructure and higher levels of greenhouse gas emissions. The pressures on transport and its associated infrastructure to develop the economy are enormous and the increasing resources consumed to develop the transport sector will negatively impact the environment in the long-term (Pearce et al. 1989).

3.1.3 Legislative and Policy Instruments

The following are South Africa's legislative and policy instruments which all have a bearing on green transport:

- National Land Transport Act (2009);
- National Environmental Management Act (1998);
- Energy Efficiency Strategy (2005);
- White Paper on National Transport Policy (1996);
- National Climate Change Response White Paper (2011); and
- National Development Plan (2011).

These legislative instruments aim to ensure sustainable road transport with minimal impact on the environment by managing it in a sustainable manner. Other objectives provided for in the legislations are to:

- Make public transport affordable, safe, reliable and accessible as an alternative to private modes of transport;
- Reduce traffic congestion and carbon emissions;
- Promote non-motorised transport by providing safe infrastructure for its use;
- Ensure the use of environmentally-friendly materials in road construction and maintenance;
- Esure that spatial and route planning enhances green transport initiatives; and
- Promote sustainable partnerships for better integration of various modes of transport.

3.2 Study Aim and Specific Objectives

The aim of this study was to explore fundamental issues pertaining to green transport modes in rural areas of the Limpopo Province. The specific objectives were to: determine dominant types and characteristics of green transport modes; identify resources, infrastructure, skills and enhancement plans needed for green transport support; examine the perceptions of the public (commuters) and stakeholders pertaining to green transport modes; identify the challenges as well as the strategies to support effective implementation of GT modes; and identify and examine the level of green skills development for particular transport modes.

Table 3.1 Study's sampling frame and size

Province	District	Municipality	No of commuters
Limpopo	Vhembe	Thulamela	10
		Makhado	7
		Musina	8
	Mopane	Greater Giyani	10
	Capricorn	Polokwane	10
	Waterberg	Mokopane	10
		Total (N)	55

3.3 Research Methodology

3.3.1 Study Location

The study location is comprised of selected districts in the Limpopo Province, namely: the Vhembe, Mopani, Capricorn and Waterberg districts (Table 3.1). This is home to predominantly rural communities that often distance themselves from urban areas. In the Waterberg district, communities that were interviewed were situated along the main transport route to town and they were living in rural development programme (RDP) houses probably due to proximity to towns.

3.3.2 Research Design

The research design adopted for this study was a case study coupled with grounded theory which allowed us to investigate transport modes from the points of view of commuters and main stakeholders in the transport sector. This design also provided us with a framework for understanding green transport within a particular social and institutional context. It has also allowed us to form our own impressions and reactions, as researchers, about green transport issues which then presented an opportunity to develop a theoretical account of the general features of GT modes in the province and ground the account in empirical observations/data.

3.3.3 Sampling Approach

Considering the difficulties which would be faced when attempting to interview all travellers and drivers in transit, 55 commuters using public and private transport modes in four districts were randomly sampled for a questionnaire interview. Purposive sampling of the main transport stakeholders (from all the districts in Limpopo)

was adopted and these stakeholders were invited to a workshop organised for this study.

3.3.4 Data Collection and Analysis

Questionnaires and the cluster analysis technique were used to collect and analyse data. Questionnaires were distributed to 55 respondents (mainly consumers) who elicited empirical evidence on transport mode preferences; rationale behind these preferences; current utilisation of available green transport modes; general readiness with the shift to green transport economy; and the use of IT to reduce business trips. Cluster analysis as a technique was used to group similar observations into a number of clusters based on the observed values of several variables for each individual. It is an exploratory data analysis tool for organizing observed data or cases into two or more groups. Stakeholder engagement in the form of a workshop and interviews elicited data on the use ratio of motorised and non-motorised transport; technology, innovation and skills transfer in green transport; policy implications and directions about green transport; roles and responsibilities as well as challenges associated with green transport. The emphasis was placed on strategies/enhancement initiatives, green technology and challenges associated with the transition to green transport. Collected data were then captured into SPSS for analysis.

3.4 Results and Discussion

3.4.1 General Modal Spilt

The results of the study are organised as shown in Fig. 3.1. Modal split represents the percentage of travellers using a particular mode of transport to and from work. Green or sustainable transport reduces the impact on the environment with respect to carbon emissions and the effects of transport infrastructure on the immediate environment. Empirical data from the Limpopo Province, especially in the Mopane (63%) and Waterberg (40%) districts, showed that the respondents interviewed regarded Taxi's as the preferred form of transport (Fig. 3.2) when compared to other forms. More importantly, the overall use of Taxi's and single occupant cars was greater in all selected districts as compared to walking, cycling, the use of buses and car sharing/pooling. However, walking is the preferred mode in Mopane (38%), followed by the Capricorn (33%) and Waterberg (20%) districts. The district in Limpopo (excluding Sekhukhune) which walked the least was the Vhembe district which together with Waterberg used "bakkies" to commute to work and school. This is regarded by Bradshaw as the top priority and most ecologically friendly mode of transport (Fig. 3.3). Pedestrian mode requires one to prefer to walk to school, to

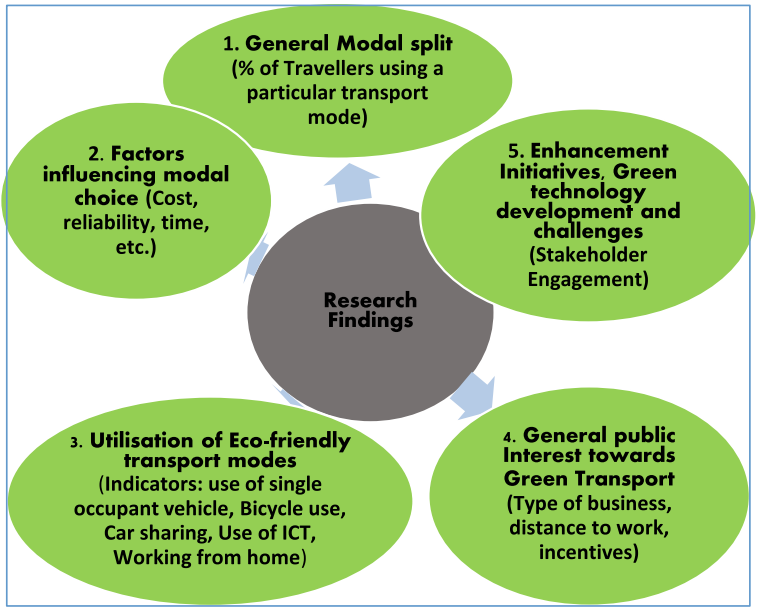
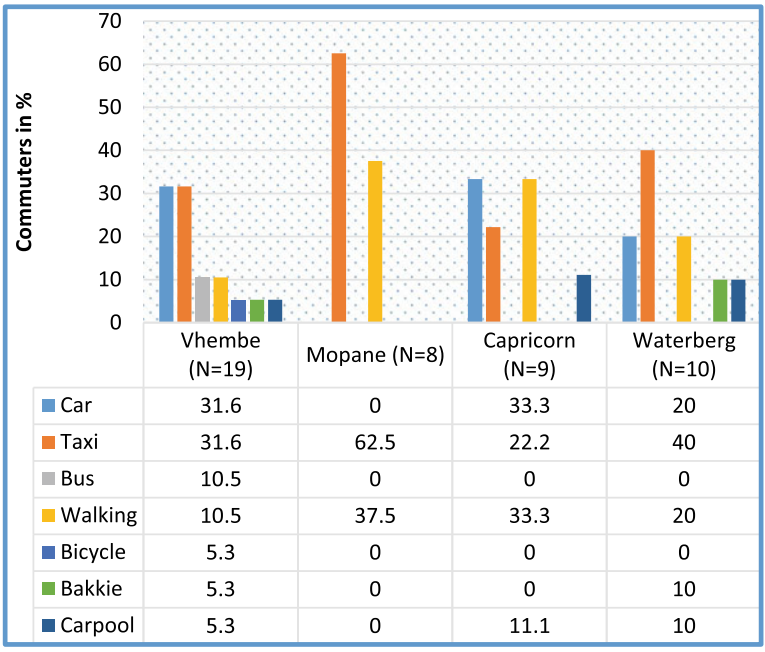


Fig. 3.1 Organisation of research findings: survey and stakeholder engagement



	Vhembe (N=19)	Mopane (N=8)	Capricorn (N=9)	Waterberg (N=10)
Car	31.6	0	33.3	20
Taxi	31.6	62.5	22.2	40
Bus	10.5	0	0	0
Walking	10.5	37.5	33.3	20
Bicycle	5.3	0	0	0
Bakkie	5.3	0	0	10
Carpool	5.3	0	11.1	10

Fig. 3.2 Percentage (%) travelers using a particular mode of transport

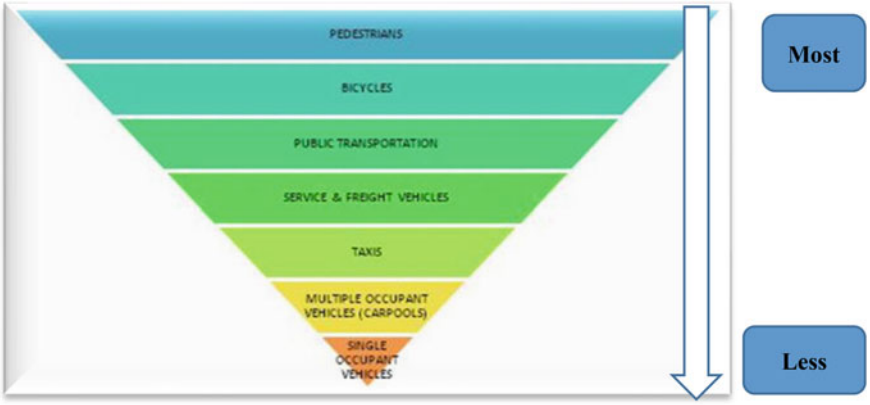
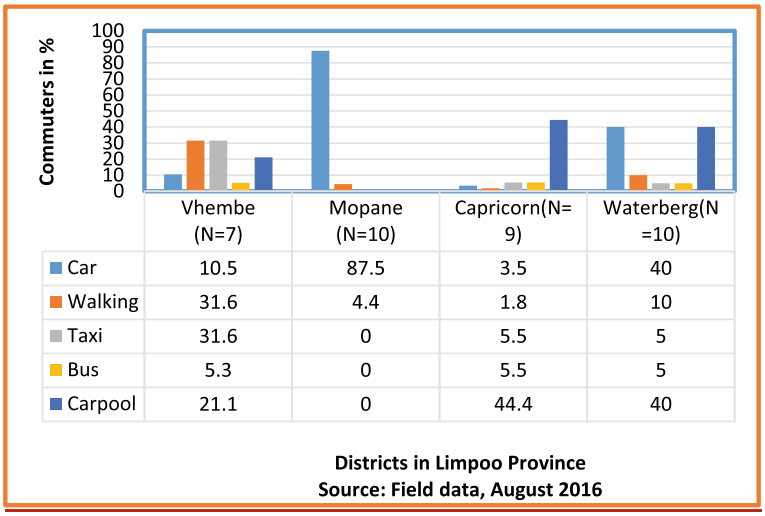


Fig. 3.3 Green transportation hierarchy, based on *eco-friendliness* (Source: Bradshaw (2014))

work and to shops, because walking does not emit any greenhouse gas (Hass-Klau 1993). It is also free and a good form of exercise for the body. The main impediments in rural areas are long distances from home to work, due to the artificial separation of the two sectors.

3.4.2 Factors Influencing Modal Choice

Respondents were asked to provide reasons as to why they preferred a particular mode of transport. Of the four districts visited, Mopane recorded the highest use of single occupant vehicles (88%), followed by the Waterberg district (40%). In terms of carpooling, Capricorn and Waterberg showed the highest figure compared to the Vhembe district. The concept of carpooling (multi occupant vehicle) seemed non-existent in the Mopane district. This is a favorable mode of green transportation, where groups of people, can use one vehicle, when heading in similar directions on a regular basis. It is a more economical and eco-friendly option, especially if all rotational vehicles are insured and well serviced. Cost, income, comfort, driving license ownership, time and reliability are perceived as factors influencing transport modal choice (Chee & Fernandez 2013; Wibowo and Chalermpong 2010). Most respondents (54%) attributed their choice of a single occupant car to *reliability* (Box 3.1). Taxi's, though not perceived as cheap and reliable, were chosen by the majority (50%) due to *time effectiveness.* Similarly, walking was regarded as cheap and quick, especially for shorter *distances.* Respondents have not selected income, comfort and driving license ownership as factors which have influenced their transport modal choice. However, the lack of an alternative was perceived as the most important rationale for the choice of a bus as a mode of transportation (Fig. 3.4).



	Vhembe (N=7)	Mopane (N=10)	Capricorn(N=9)	Waterberg(N=10)
Car	10.5	87.5	3.5	40
Walking	31.6	4.4	1.8	10
Taxi	31.6	0	5.5	5
Bus	5.3	0	5.5	5
Carpool	21.1	0	44.4	40

Fig. 3.4 Consumers preferred mode of transport

Box 3.1 Perceived factors influencing transport modal choice in Limpopo

- **Car:** Cost (Cheap) (22%); Time (Quick) (27%); **Reliability (54%);**
- **Taxi:** Cost (Cheap) (33%); **Time (Quick) (50%);** Reliability (46%)
- **Bus: Lack of Alternative (33%);**
- **Walking:** Cost **(Cheap) (44%); Time (Quick) (44%)**

3.4.3 Utilisation of Eco-Friendly Transport Modes

The study has used various indicators to assess the use of eco-friendly modes of transport amongst consumers. Such indicators included the use of public transportation; bicycle ownership and use; car sharing/pooling; use of IT to reduce business trips and the concept of working from home.

Use of Public Transport

Public transport is regarded as the third greenest mode according to Bradshaw's (2014) green transportation hierarchy (Fig. 3.3). Regardless, most respondents (51%)

do not use public transport when going to work compared to 47% who used it due to the lack of an alternative. The difference between the commuters who used public transport to work and those who did not is not of statistical significance at ($p = 0.01$). However, this finding is consistent with a study by Alvinsyah Soehodho and Nainggolan (2005) who argued that most commuters, especially men, prefer to drive to work instead of using public transport due to the lack of comfort. Perceptions of mode attributes are significant in determining the likelihood of a modal shift from private to public transport (Nurdden et al. 2007; Satiennam et al. 2011). According to Nor Ghani et al. (2007) preferences for comfort and convenience significantly increase the likelihood of choosing to drive over using a bus service. Though it is much more comfortable and convenient to drive one's own private vehicle to the office or market every day, it is required of responsible world citizens to opt for green transportation modes that are easily accessible to everyone. 18% of people who use public transport have employer subsidised tickets. Perhaps, lack of employer subsidy is an issue of concern, especially for those who use taxis to and from work.

Bicycle Ownership and Use

Using bicycles to commute to work is another great mode of green transportation. It is faster than walking, has a low cost and is a form of healthy exercise. The buying and maintenance costs of a bicycle are only a fraction of that required for car. In many cities though, cycling has received very little attention from transport planners over the years and it has been a marginalised mode of transport. Motorised modes of transport often take up much more space in cities and within transport planning (Koglin and Rye 2014). In the Limpopo province, bicycle ownership data obtained were sparse and time series varied considerably in length from one district to another. To find similarities in ownership across geographical regions, clustering presented itself as an effective pattern recognition tool. The questionnaire survey indicated that 66% of respondents in urban areas owned bicycles but they did not necessarily use them to travel to work. This is in comparison with 34% in rural areas who said they used them to go to work. More than 30% of the urban commuters showed interest in purchasing discounted tax-free bicycles for exercising and for bicycle competitions but not to ride them to work. Despite, this geographic variation in bicycle ownership among the five districts of Limpopo, we were able to identify two distinct districts (i.e. Vhembe and Makhado) in which riding bicycles to work is perceived as a sign of 'poverty and the onset of mid-life crisis'. In these two districts, cycling is also hampered by a lack of appropriate bicycle lanes and a generally negative attitude by motorists towards cyclist which may impose an accident risk to cyclists (de Hartog et al. 2010). It cannot be assumed though, that simply by developing a "walkable" (or "cyclable") environment, public health goals will be achieved; the relationships are more complex than this (Andrews et al. 2012).

Despite the health benefits associated with cycling and walking, few people use bicycles to get to work. This trend is different from that of the USA and Scandinavian countries where bicycle ownership is high and regarded as a sustainable mode of transport, especially by workers and students. In South Africa, the government at all levels with the help of public health experts, health and transport geographers

(Davison & Curl 2014), and other stakeholders, can harness and mobilize cyclists as change agents by developing policies that support bicycle education, infrastructure, and a culture of safety for all road users. As highlighted by Rind et al. (2013) and Andrews et al. (2012), attention should be paid to inequality, both in the built environment in terms of its ability to facilitate walking and cycling as well as active travel behaviour, which may or may not be related to the environment.

Car Sharing/Pooling

Globally, the growth of car-sharing services as a new and more sustainable way of transportation is shifting the private mobility from ownership to service use (Ferrero et al. 2018; Thamizh Arasan & Vedagiri 2011). The basic idea of car-sharing is quite simple: you share the usage of a vehicle fleet by members for trip making on a per trip basis which is an option often motivated by economic reasons. In the Limpopo province, 4.3% of motorists usually drove with three or more people to work showing little evidence of car sharing. More than twenty percent (23%) of commuters used single occupant vehicles to make business trips outside the province. This practice was often considered by employees as a safety precaution in order to avoid significant loss in the case of an accident. According to Chee and Fernandez (2013), the possession of a driving license and regular access to a private vehicle are both significant factors in influencing the choice of transport mode. These factors contribute towards the tendency to use single occupant vehicle. Other barriers to the adoption of car sharing services in Limpopo, include: long distances to cover, lack of comfort, distrust and fear of liability in the case of an accident.

Use of ICT to Reduce Business Trips

Combating carbon emissions to advance a low carbon trajectory is an urgent task for us all. ICT can have a positive impact on the reduction of CO_2 emissions while making businesses more efficient. A survey in the Limpopo province, indicated that the state of green technology, in the form of Skype, face time and video-conferencing to reduce business trips, is in infancy stages. About 35% of respondents were unaware of these facilities compared to 30% who were aware of these facilities. All in all, 23% did not have the required skills. The spatial variation is insignificant and negligible. The only difference is that most urban respondents were aware of these facilities but were not using them regularly in order to reduce business trips. The use of teleconferencing in some businesses was motivated by the cutting of costs rather than environmental considerations (Rasagam 1999).

The Concept of Working from Home

Work from home is a concept where the employee can do his or her job from home. Work from home gives a flexible working hour to the employee as well as the job for the employer is done with ease. In South Africa, working from home is often perceived as informal and self-employment. 30% of respondents who work in the corporate world or formal sector would be interested in working from home if their companies or government could approve and advance such initiatives. However, 28%

of the respondents who are self-employed were already working from home as a cost saving initiative.

3.4.4 General Public Interest Toward Green Transport Modes

There is a general lack of interest in cycling, walking, car sharing, IT use for business trips and the use of public transport. This could be attributed to the *type of business*; *distance to work*; lack of dedicated lanes, *cost and lack of general awareness on IT uses for business meetings*. Empirical evidence from Limpopo suggests a general lack of readiness with regards to a shift towards green transportation. In Limpopo, this shift is constrained by longer distances to be covered to work, underdeveloped pedestrians/cyclists' lanes and overcrowded public modes of transport. In South Africa, especially in Limpopo and other remote rural areas, most of these public modes of transportation are not fuel-efficient and still use high Sulphur diesel (500 ppm) that contributes to GHGs. Hence, most people in Limpopo still resort to private transportation to commute to and from work.

3.4.5 Enhancement Initiatives, Green Technology Development and Challenges

In a workshop organised for stakeholder engagement in the Limpopo Province, participants from various transport chambers were asked to identify green transport enhancement initiatives, green skills and challenges associated with the transition to green transport in Limpopo.

Enhancement Initiatives on Green Transport

Various commissions identified the following initiatives to advance transition to green transportation:

- Need to make all modes of transport (motorised and non-motorised) green in the long run:
  - Buses, motorcycles, taxi's, walking, skating and donkey carts for rural transport;
  - Promote non-motorised transportation and prioritise mass public transportation with the identification of hotspot (high volumes) zones;
- Partial banning of small vehicles in highly congested areas during peak hours.

Green Technology Development for Green Transport

Commissions at the Limpopo Stakeholder Workshop have pinpointed the fact that each transport mode has different green technology skill requirements and that there is need to harness green transport common technology and integrate it into the general transport value chain. The specific common area identified in green transport was the energy sector which requires the identification of mechanisms and knowledge in dealing with various energy components in terms of various transport modes, transport infrastructure and technology required for maintenance of such transport modes (Winston 1991).

- Green Technology for Car/Bus/Bicycles/Motorbikes:
  - Fuel – transition from Lead to Unleaded (already existing); From high sulphur (500 ppm) to less sulphur (50 or 10 ppm) (already existing).
  - Battery—electric cars and motorbikes while also providing adequate charging points/stations and/or high capacity batteries.
  - Solar—solar car (effective if hydro-electricity is generated); solar powered bicycles/motorbikes;
  - Bio-gas—provide adequate pump services; effective utilisation of waste in landfills;
  - Bicycles—Using Chinese bamboo or waste instead of metals for bicycle frames, especially for non-racing bicycles, could be problematic and dangerous for mountain biking.
  - Bio-diesel—provide adequate pump services; take extra care of the environment; do not utilise staple food crops for bio-diesel production since this will impact food security negatively.
  - Hybrid cars—reduce cost and improve reselling value.
- Green Transport Infrastructure:
  - Bus stops – solar lighting could be introduced.
  - Traffic lights/Street lighting—solar lighting adequate.
  - Introduction of daylight devices for automating the switching off and on of lights in order to save power.

The development of green transport technology in Limpopo is still at an infant stage. The situation is relatively similar in most developing economies (Marchán & Viscidi 2015).

Challenges Associated with Green Transport in Limpopo

With regard to challenges associated with the transition to green transport, stakeholders in Limpopo identified the following:

- Poor Investment in energy efficient public transport, including rail;
- Green transport is perceived as another Taxi re-capitalisation programme;
- Lack of mobility alternatives for short distances;
- Poor rail, taxi and bus linkage system;

- No specific effective policy for green transport although a green economy strategy exists;
- Role identification poor, responsibilities fluid and co-ordination lacking at all three tiers of government with respect to green transport;
- Job losses, and people would have no skills for new green jobs created; and
- Lack of integration of green transport skills in the general value chain.

These are consistent with green transport challenges in more developing and emerging economies in Africa and Latin America (Caia et al. 2011; Maia et al. 2011; Mxolisi 2006; UNEP 2008, 2011).

3.5 Summary of the Major Findings

- The use of private cars is typical in most districts of the Limpopo province; although walking is predominant for shorter distances;
- Lack of alternative cheaper modes of transport to cover long distances due to apartheid spatial planning;
- Subsidisation of green transport and green initiatives by employers not available;
- There is a general lack of interest in cycling and walking to and from work.
- Rudimentary use of IT (Skype, tele and video-conferencing, face time, etc.) to reduce business trips;
- Very little evidence of car sharing or car-pooling.
- Solar lighting at bus stops and robots not administered.

3.6 Policy Recommendation for Sustainable Implementation of Green Transport

- *Short to medium term recommendations include*:
  - Developing green transport awareness and sensitisation programmes.
  - Enhancing access to green affordable public transport.
- *Other policy recommendations include*:
  - Incorporating green transport in relevant policy making processes;
  - Conducting monthly audits for the utilisation of green transportation;
  - Training more local green transport professionals;
  - Making all modes of transportation green;
  - Harnessing common green skills;
  - Integrating job creation and poverty alleviation in green transport into the general value chain.

3.7 Conclusion

The term "*green transport*" has often been used as a greenwash marketing technique for products which are not proven to make a positive contribution to environmental sustainability. Nevertheless, there is consensus that transport is a major contributor of greenhouse gases and hence, the primary target for reducing CO_2 emissions. Green transport emphasises the need to walk and the use of multi-occupant vehicles as the modes that should receive top priority since they are beneficial for the environment. Hence, it is asserted that the environmental impacts of transport can be reduced by improving the walking and cycling environment in towns and cities, and by enhancing the role of public transport, especially electric rail and fuel-efficient public buses and taxis. In South Africa, the problems regarding the balancing act of socio-economic objectives with environmental objectives may render some of the green transport initiatives ineffective. This is clearly supported by empirical evidence from the Limpopo Province. Nevertheless, some consumers and transport stakeholders in Limpopo have supported green transport initiatives and have reckoned that such initiatives are likely to alleviate poverty and unemployment in the long-term if green skills are harnessed and transport technology is adopted to support green transport initiatives in rural provinces in South Africa.

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References

Alvinsyah Soehodho S, Nainggolan PJ (2005) Public transport user attitude based on choice model parameter characteristics (case study: Jakarta busway system). J East Asia Soc Transp Stud 6:480–491. https://doi.org/10.11175/easts.6.480

Andrews G, Hall E, Evans B, Colls R (2012) Moving beyond walkability: on the potential of health geography. Soc Sci Med 75(11):1925–1932. https://doi.org/10.1016/j.socscimed.2012.08.013

Bradshaw C (2014) The green transportation hierarchy: a guide for personal & public decision-making, June 2004 (revised 02 Sept 1994). http://vault.sierraclub.org/sprawl/articles/trips.asp. Accessed 04 Nov 2015

Caia W, Wanga C, Chena J, Wanga S (2011) Green economy and green jobs: myth or reality? The case of China's power generation sector. Energy 36(10):5994–6003. https://doi.org/10.1016/j.energy.2011.08.016

Cetinkaya B, Cuthbertson R, Ewer G, Klaas-Wissing T, Wojciech Piotrowicz W, Christoph Tyssen C (2011) Sustainable supply chain management: practical ideas for moving towards best practice. Springer, Heidelberg, Dordrecht, London, New York. https://doi.org/10.1007/978-3-642-12023-7

Chee WL, Fernandez JL (2013) Factors that influence the choice of mode of transport in Penang: a preliminary analysis. Procedia Soc Behav Sci 9:120–127. https://doi.org/10.1016/j.sbspro.2013.08.409

Davies WKD (2015) Theme cities: solutions for urban problems. Springer, Netherlands

Davison L, Curl A (2014) A transport and health geography perspective on walking and cycling. J Transp Health 1(4):341–345. https://doi.org/10.1016/j.jth.2014.09.001
DBSA (Development Bank of South Africa) (2011) Programmes in support of transitioning South Africa to a green economy. Development Planning Division, Working Paper Series 32. Midrand, South Africa
de Hartog JJ, Boogaard H, Nijland H, Hoek G (2010) Do the health benefits of cycling outweigh the risks? Environ Health Perspect 118(8):1109–1116. https://doi.org/10.1289/ehp.0901747
Department of Environment Affairs (2016) About green economy. https://www.environment.gov.za/projectsprogrammes/greeneconomy/about. Accessed 14 Mar 2016
Department of Environmental Affairs and Tourism (2008) National Framework for Sustainable Development (NFSD). http://www.environment.gov.za. Accessed 19 Mar 2016
Ferrero F, Perboli G, Rosano M, Vesco A (2018) Car-sharing services: an annotated review. Sustain Cities Soc 37:501–518. https://doi.org/10.1016/j.scs.2017.09.020
Hass-Klau C (1993) Impact of pedestrianisation and traffic calming on retailing: a review of the evidence from Germany and the UK. Transp Policy 1(1):100–120. https://doi.org/10.1016/0967-370X/93/010021-11
Koglin T, Rye T (2014) The marginalisation of bicycling in modernist urban transport planning. J Transp Health 1(4):214–222. https://doi.org/10.1016/j.jth.2014.09.006
LEDET (2013) Limpopo green economy plan: provincial climate change response, 2013. Polokwane, South Africa
Mahadea D, Simson R (2010) The challenges of low unemployment economic growth in South Africa: 1994–2008. S Afr J Econ Manag Sci 13(4):391–406
Maia J, Giordano T, Kelder N, Bardien G, Bodibe M, Du Plooy P, Jafta X, Jarvis D, Kruger-Cloete E, Kuhn G, Lepelle R, Makaulule L, Mosoma K, Neoh S, Netshitomboni N, Ngozo T, Swanepoel J (2011) Green jobs: an estimate of the direct employment potential of a greening South African economy. Industrial Development Corporation, Development Bank of Southern Africa, Trade and Industrial Policy Strategies
Marchán E, Viscidi L (2015) Green transportation: the outlook for electric vehicles in Latin America. Energy (Working Paper) 1–15. Accessed 02 Feb 2018
Mxolisi SM (2006) A critical analysis of the process of taxi recapitalisation policy. Unpublished honours dissertation, North West University
Nor Ghani M, Ahmad MZ, Tan SH (2007) Transportation mode choice: are latent factors important? J East Asia Soc Transp Stud 7:894–904. https://doi.org/10.11175/eastpro.2007.0.124.0
Nurdden A, Rahmat RAOK, Ismail A (2007) Effect of transportation policies on modal shift from private car to public transport in Malaysia. J Appl Sci 7(7):1013–1018
Pearce DW, Markandya A, Barbier EB (1989) Blueprint for a green economy. Earthscan, London
Rasagam G (1999) A "step" towards sustainable transport: a case study of Penang, Malaysia. Transp Commun Bull Asia Pac 68:33–47. ISBN: 92-1-119967-0, ISSN: 0252-4392
Rind E, Shortt N, Pearce J, Mitchell M (2013) Does the natural environment impact travel behaviours? In: Presentation at RGS–IBG annual international conference, London
RSA (2003) The white paper on the renewable energy policy. Government Printers, Pretoria, South Africa
Satiennam T, Jaensirisak S, Natevongin N, Kowtanapanich W (2011) Public transport planning for a motorcycle dominated community. J East Asia Soc Transp Stud 9:970–985
Thamizh Arasan V, Vedagiri P (2011) Modelling modal shift from personal vehicles to bus on introduction of bus priority measure. Asian Transp Stud 1(3):288–302
UNEP (2008) Green jobs: towards decent work in a sustainable, low-carbon world. UNEP, Geneva. http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf. Accessed 19 Mar 2016
UNEP (2011) Towards a green economy: pathways to sustainable development and poverty eradication. UNEP, Nairobi. http://www.unep.org/greeneconomy/greeneconomyreport/tabid/29846/. Accessed 14 Mar 2016

Wibowo SS, Chalermpong S (2010) Characteristics of mode choice within mass transit catchments area. J East Asia Soc Transp Stud 8:1233–1246
Winston C (1991) Efficient transportation infrastructure policy. J Econ Perspect 5(1):113–127. https://doi.org/10.1257/jep.5.1.113

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Chapter 4
Technology Innovations in Green Transport

Peter Bitta Bikam

Abstract The paper uses the case study of Limpopo province to discuss technology innovations in green transport in South Africa with respect to the reduction of global greenhouse emission through technology innovation. South Africa's emission from fuel combustion is the world's 15th largest in forms of CO emission because it contributes about 1.2% of global emissions. In a submission from the Department of Environmental Affairs (DEA) on the impact of greenhouse emissions stated that companies are required to be innovative to reduce the carbon emission levels in South Africa. Literature on road transport in South Africa shows that road transport is the fastest growing source of greenhouse gas emissions, accounting for 19% of global energy consumption. The policy to promote an integrated public transport in municipalities is in line with the National Development Plan and the White Paper on National Climate Change Response. This requires innovative technology that promotes carbon trading markets such as taxi recapitalisation programmes and carbon tax on new vehicles. The study analysed the factors influencing green technology innovations in South Africa with specific reference to Limpopo province green transportation study. The methodology used to unpack innovative technology in South Africa discusses green technology in Limpopo province in the context of greenhouse gases emission reduction innovative technologies in the transport sector with respect to sustainable fuels, energy efficient systems and smart information as well as hybrid technologies. The study advances arguments on technologies for engine and propulsion systems, alternative energy sources, navigation technologies, cargo handling systems, heating and cooling vehicles, road and rail vehicles and maritime transportation with respect to innovations as well as battery charging systems, engine oil disposal etc. The findings shows that no single trajectory of technology innovation in green transport will suffice but technological innovations that improve fuel economy and transition from fossil fuels to cleaner fuel alternatives. The study in Limpopo province showed that green transport innovations must not obscure the role of non-technological innovations in reducing emissions, but the two should be tackled with green transport value chain as a whole.

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Keywords Green transport · Technology innovations · Greenhouse gas emissions · Reducing emissions · Green transport value chain

4.1 Introduction

Reducing Greenhouse Gas (GHG) emission from the transport sector in South Africa should be a matter of priority considering that most major role players in the transport manufacturing industry are committed to shifting to new innovative technologies such as electric cars or hybrid vehicles. The issue of technology innovation in South Africa has to be addressed from a holistic approach across the value chain in addition to tax policies to reduce greenhouse emission in the transport industry. In rural provinces, such as Limpopo the participation of traffic officers, bus and taxi drivers, car repairers, and manufacturers would be primordial (Lin and Ho 2010). The paper uses examples from Limpopo province to argue that technological innovations that improve fuel economy and the transformation of the energy bases of the transport sector are essentials for GHS abatement. However, these innovations must consider the value chain in the transport industry including non-technological innovations such as green transport logistics display of information for commuters. The technology innovations should include less visible innovations such as mass transit, access cards, radio information, and treatment of used engine oils at appropriate recycling sites. The paper argues that although innovation will play an important role in the transportation sector in South Africa in the future, at the grass root level, three concepts can be said to influence technology innovation in green transport i.e. management skills, organisational enforcement and awareness support for innovative ideas. According to Vigar (2000), the definition of technology innovation in the transport industry has been narrowed down to green transport technology. Technological innovations in the transport industry has been narrowly defined and such narrow definition can limit for example innovations in traffic management or smart transport logistics and non-technological innovations that reduce emissions related to road transport. The data that streamlines the definition were collected from the case study areas in Limpopo province and from the literature review. The survey followed the administration of questionnaires to 120 people in the transport industry including vehicle engine repairers, fuel dealers, car heating and cooling technicians, taxi and bus drivers, car electricians, private car owners, traffic officers and commuters. A desktop review of relevant literature on sustainable transport and innovation was undertaken. The paper unpacks green transport technology innovation with respect to Limpopo province because of the significance of road transport in greenhouse emissions in the province. This was unpacked with respect to the awareness on issues which can have a particular pollutant influence on air quality. The Limpopo case study demonstrates the experience of many rural dwellers who depend on the current form of motor vehicle technology to commute, but the current technology and vehicle use increases the emission of CO_2, NO_x, CO and VOC (Litman and Burwell 2006).

4.2 Literature Review

According to a report by the OECD (2005), technology innovation is defined as the introduction of technologically new or substantial changes in goods or services or the use of a technologically new or substantially changed process (Chapman and Quin 2003). This definition dates back to the beginning of the 1990's and it was inspired by sustainable transport system researchers. This concept is widely explored by Nijkamp (1994), Vigar (2000), Friedl and Steininger (2002) where they argue that there are three kinds of innovations i.e. non-technical innovations product and process innovations. Their emphasis was on the role of technological, organisational and environmental issues that help to create a social support to accompany the establishment of more ecological modes of transport with reduced GHG (Sviden 1988). Sahal (1980) however, argues that innovation in the transport sector is not only a productive activity that requires technological innovation but also an innovative technology that puts emphasis on the health of commuters. These views means that the concept of the green transport should reduce per-capital kilometer travelled in general (Miles 2005). In other words the transport sector is within the sphere of the entrepreneur and the customer and both require technological innovations to keep up with the information age and the reduction in greenhouse emissions. According to Burneister and Djellal (2004) the debate on transport service innovations started in the 1960s when innovation emerged as an area of research with respect to mainly car manufacturing. However, Schot and Geels (2008) and Swann (2009) argue that innovative theory refers to products, process, market inputs and organisational innovations. In other words, technology innovation in a green transport economy cuts across the value chain in the transport industry. With respect to the concept it can be said to include technological process innovations and organisational process innovations. The OECD (2005) defines the concept of innovation in the transport sector in the context of basic access of individuals, group interest in the transport industry as related to safety, health standards, and emission control affordable transport, access to different modes of transport in a competitive economy (Schmookler 1966).

Functional Trajectories of Innovations in Green Transport

The literature review on technology innovation shows that there are three main areas innovations can be classified, i.e. non-technical, technological product innovation process, organisational and environmental innovations. Although the survey from Limpopo province dealt with mainly innovations from road transport, other forms of innovations were discussed. The study looks at innovations that deals with the material function of the vehicle service (the car) and innovations that involves the function of treatment of information, communication and innovations that deals with organisational or relational functions. The advantage of the three categories is that it allows us to determine innovations in the transport sector from both goods and services within the value chain (Sahal 1980). The three categories can be broken down further into five functions as follows:

Technology Innovation Functions

These are innovations that involve the material substance of the vehicular product such as the body parts of the vehicles and the flow of information (Rennings 2000). The study in Limpopo province shows that for innovative light car materials, 62% of the respondents indicated that they preferred steel body parts because they are durable. In terms of information flow, 41% of the respondents indicated that the introduction of the BRT in Polokwane will enhance access to information with respect to the system. With respect to drivers and passengers, smart ticketing system, 57% indicated that in rural areas it will be difficult to implement because of the educational level of most commuters and low paying jobs which may not be enough to purchase hybrid vehicles (Aquila-Obra and Melendez 2006).

Organizational Innovation Functions

These are innovations that involve the flow of information and dealings from one service to the other within the transport sector value chain. Innovations that deal with methodological functions i.e., new approaches to provide a service for example, government support services are important for technology and logistics. When the respondents were asked to indicate their preferences to transport sector information, 87% indicated they got to know about the green transport concept from newspapers, the internet, and very little from the government. However, on taxi re-capitalization and information on the BRT 87% indicated they were well informed of government policies through the internet, the television, newspapers etc. 92% indicated that there is lack of awareness campaigns on the green transport concept in the province (Aronsson and Brodin 2006).

Environmental Innovation Function

These are innovations that deal with how external environmental factors influence the release of GHG in the air. Emissions is one of the major causes of air pollution and with respect to this (Azevedo et al 2007), indicated that customer pressure such as demand for new vehicle can trigger regulations and policy innovations to resolve environmental related issues (Lin 2007). From the study in Limpopo province, innovations that can contain the pollution of the environment such as smoke from car exhausts, can be reduced by providing policies that promote de-registration of vehicles that pollute the environment. However, 37% of the respondents were not in favour because, according to them it will be tantamount to de-registering most vehicles older than 10 years, (Aronsson and Brodin 2006).

Hybrid Vehicles

The Toyota Prius, the world's most popular hybrid car, uses a combination of an internal combustion engine and a battery electric drive system to increase fuel economy and reduce emissions. When pulling away from a stop, the electric motor powers the car, drawing on the battery for power. At the Paris worlds motor show which took place from 1st to 6th October 1–6, 2018, a hybrid car was claimed to have been charged and would travel 200 km. The electric storage and charging

technology that made this possible was powered by solar panels. The technology is said to be easily deployable at existing or future road and highway stations, as solar energy continues to develop throughout worldwide. It was indicated that it is the charging solution that will eventually enable electric cars to rival traditional combustion-powered vehicles, whose growth was made possible by gas stations. The team that developed the technology is based in France, but the development potential for this technology is clearly international (Coqueline energies 2018).

4.3 Methodology

The methodology used to discuss technology innovation in Limpopo Province was based on (Nelson and Winter 1982) method of first defining the problem before unpacking the content. To achieve this, a literature review (Sect. 4.2) of current research and publications on technology innovations in the transport industry was undertaken to put the subject in context. This was followed by the identification of key informants who attended a workshop on green transport economy in Polokwane. Among them were taxi associations' representatives, bus and taxi drivers, traffic officers, auto electricians, motor electricians, pedestrians, car dealers, rail, air and commuters in general. A total of 120 relevant stakeholders in the transport industry were interviewed to give their views on technological innovations in Limpopo Province. In addition to this, close and open-ended questionnaires were administered to them. The analysis of the survey results was mainly on how the transport industry main stakeholder's current views on the concept of innovation in green transport. In addition to the analysis, also discussed were type of skills that will be required when new innovations are introduced in the transport industry.

4.4 Discussions

The expression technological innovation emerged from the work of Dosi (1982), Dosi (1984) and Schumpeter (1983) who postulated that innovation is a process of learning which is localised but can be expanded to other sectors and regions (Kimberly and Evanisko 1981). The central theme of the discussion in Limpopo Province was to get the opinions of stakeholders in the transport sector with the aim of informing policy makers on the potentials of technology innovations in the transport industry, particularly at the grass root level (Azevodo et al. 2007). In view of the fact that road transport has a significant impact on environmental problems, most of the innovations pointed out by the respondents were with respect to pollutant impact on air quality particularly the concentration of:

- CO_2—Carbon Dioxide;
- NO_x—Nitrogen Oxide; and

- VOC—Volatile Organic Compound.

In order to determine the views of the respondents on vehicle emissions a survey was undertaken with respect to non-technical and technical innovations and the restrictions of emissions components. They were required to respond to a number of questions on emission control in the province. The perceptions of the respondents were with respect to technical and non-technical innovations in Limpopo province, (Alexe and Ezhilarasie 2011). They were asked to indicate their choice of selected transport sector value areas by indicating on a scale 0–5 with 0 being; do not agree, 1-fairly agree, 2-agree, 3- highly agree, 4-very highly agree, and 5- totally agree as shown in Table 4.1.

Table 4.1 is a compilation of 120 respondent's choice of technical and non-technical innovation categories relevant to green transport in Limpopo province. Note that the classification was to determine what the stakeholder and respondents considered technical and non-technical innovations with respect to the transport industry. In each column of the technical innovations, 120 respondents gave a rating of 0 to 5. In each column the total highest score would be theoretically 9000 i.e. $5 \times 120 \times 15$ selected transport sector value chain areas and the lowest would be theoretically 0. The total highest score was 44 or 7.33% as compared to non-technical with an average of 26 or 3.60% and material information innovation, 23 or 2.8%, communication innovation, with 43 or 7.2% respectively (ITF 2010). The field survey showed that apart from stakeholders such as traffic officers, auto electricians, auto mechanic and car dealers who had a fairly good knowledge of technology innovations in the transport sector value chain, most of the respondents were not aware of the green transport technology innovation concepts (Hamdouch and Samuelides 2001).

Summary of Technical and Non-Technical Transport Innovations in Limpopo Province

Table 4.1 innovations as perceived by the 120 respondents were derived and classified into four categories as shown in Table 4.2.

Table 4.2 shows that innovations with respect to sustainable green transport in Limpopo province would be dependent on new external technologies, new markets, new institutional rules and new forms of information from mainly major car manufacturing countries such as Japan, France, Italy, USA to mention just a few (Foster and Green 1999). Adaptations according to 69% of the respondents depends on the path the local authority follows with respect to training policies to respond to new job skills that would be needed. This would in turn depend on the degree of buy-in, flexibility and attitude of the stakeholders as and when new green transport innovations are introduced (Geels and Green 2004).

Table 4.1 Technological and Non-Technological Innovations

Selected transport sector value areas	Categories of technical innovations rating scale 0–5					
	Technical green transport innovations	Non-Technical green transport innovations	Material information innovations	Internet information innovations	Communication technology innovations	Policy and regulatory innovations
	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average score for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5
Access control i.e. low emission zones	4					3
Mass transit modes of transportation	3		3	5	4	4
Parking management fleet	4				3	5
Intelligent transport system information to users	4		5	4		
Ramp metering actual time and public transport structure	3					4
Fuel use (bio-gas and hybrid vechiles)	4					
Pedestrian/ cycling/roller scatter	5	5	4			4
Park and pay	4	5			5	3
Park and ride	4		4		4	
Car pooling		4			4	4

(continued)

Table 4.1 (continued)

Selected transport sector value areas	Categories of technical innovations rating scale 0–5					
	Technical green transport innovations	Non-Technical green transport innovations	Material information innovations	Internet information innovations	Communication technology innovations	Policy and regulatory innovations
	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average score for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5	Average scores for 120 respondents 0–5
Dial a ride			3		4	4
Flect, freight forward and clearing management and ticketing		4				4
Taxes on fuel use						√a
Data acquisition	4	4		3	5	
Technology to reduce the emission of NOx, CO_2 and VOC on thr environment	5	5	4	5	4	5
Total percentage	44 × 15 = 660/9000 = 7.33%	26 × 15 = 390/9000 = 3.60%	23 × 15 = 345/9000 = 3.80%	21 × 15 = 315/9000 = 3.50%	33 × 15 = 495/9000 = 5.50%	43 × 15 = 645/9000 = 7.20%

Source Authors field data 2016

Table 4.2 Classification of technical and non-technical innovations in Limpopo Province

Category	Innovations
Roads infrastructure	Pedestrian/cycling/roller skater Ramp metering actual time and public transport structures Air and rail Taxes on fuel use
Policy and regulations	Parking management fleet Access control i.e., emission zones Fleet, freight forward and clearing management and ticketing Intelligent transport system information to users Car pooling Dial a ride
Chemicals	Fuel use (bio-gas and hybrid vechiles) Technology to reduce the emission of NOx, $C0_2$ and VO on the environment
Transport cost	Data acquisition Park and ride

Source Authors field data 2016

4.5 Challenges to Technology Innovation in Green Transport in Limpopo Province

The study categorised the challenges to innovation in green transport in Limpopo Province into two:

Technology innovation: This is considered a new concept because of the following reasons:

- It allows basic access and development needs of individuals, companies and society to be met safely in a manner consistent with human and ecosystem health and promotes equity within and between successive generations.
- Is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as a balanced regional development.
- Limits emissions and waste within the planets ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable at or below the rates of development of renewable substitutes while minimizing the impact on the use of land and generation of noise.
- Safety and E-administrative systems.

Affordability issues: Affordability was identified by the respondents from rural areas to be one of the fundamental issues to ensure the buy-in for green transport technologies such as hybrid electric cars, bio-gas fuel etc. However, the study showed that the introduction of public transport systems such as the Bus Rapid Transport Systems can be one of the fastest ways to begin the introduction of new technologies in the transport sector (Kemp and Rotmans 2004).

Recommendations

In view of the analysis discussed above, recommendations to address the issues are outlined into short and medium term and long term as follows:

Short and Medium Term Recommendations

The short term recommendations emphasis issues that can be tackled within a period of ten years.

- Awareness campaign: to introduce and explain the green transport concept to the public.
- Framework to encourage metropolitan areas and municipalities to embark on BRT projects, which should incorporate some type of the new technologies discussed.
- Framework to integrate land use planning with dedicated lanes for non-motorised transport, BRT and cycling routes and pedestrian walk ways.
- Introduce green concept curriculum in secondary schools to sensitize them at an early age on the future of green transport economy.
- Provide collection site for the collection and recycling of used moto engine oils, and
- Provide incentives to interested companies to pilot green transport technologies.

Long Term Recommendations

The study has shown that long term strategies require more research and planning to bring on board the following recommendations, (DME 2012).

- Fund research institutions and R&D companies to embark on green transport research and technologies and prioritize policy recommendations.
- Establish green transport curriculum development forums to begin to discuss the contents of the curriculum.
- Encourage investment in bio-fuel and solar energy related vehicles.
- Identify long term key skills required for green transport development suitable for South Africa.
- Provide incentives for investors to establish electric vehicle battery stations so that the general public can have access, and
- Ensure buy-in of the green transport concept by engaging with key stakeholder such as private public bus owners and taxi associations on conversion to cleaner fuel products.

Key Role Players Recommended

The key role players identified during the study in Limpopo province but not exhaustive are outlined as follows:

- Taxi Associations
- Department of Transport (DOT)
- Transport Education and Training Authority (TETA)
- Municipalities: Land use planning unit

- Research Institutions
- Rail transport (PRASA)
- Roads agency
- Aviation industry
- Car manufactures
- Roads Traffic Department
- Department of Environmental Affairs (DEA)
- Environmental Protection Agency
- Maritime
- Gautrain
- Traffic and road safety officers etc.

4.6 Conclusions

The focus in this chapter was on technical and non-technical innovations to promote sustainable transport. The study shows that both technical and non-technical innovations are relevant concepts that require more in-depth research to address the problems of greenhouse emissions in South Africa and in particular Limpopo Province. It is difficult to assume that green transport innovations can be accepted by the stakeholders without any form of awareness campaign and support from government. The approach should be a bottom up driven process, particularly in rural areas such as Limpopo province. The targeted population in the survey showed that stakeholders will not be committed to innovations without proper awareness campaigns and buy-in considering current pack of vehicles majority of which are more than 10 years old in rural areas. The study showed that technology innovations in the transport sector are inevitable, but there will be challenges such as cost of hybrid cars, retraining in new skills and qualifications across the transport skills sector. However, research and gradual introduction of relevant policies, to support the concept, provision of vehicle charging parks and logistics incentives for non-motorised inventions etc. should be the approach.

References

Alexe A, Ezhilarasie R (2011) Cloud Computing Based Vehicle Tracking Information Systems, IJCST, Vol. 2, Issue 1, March 2011, 49–52. ISSN: 2229–4333 (Print) , ISSN: 0976–8491 (Online)

Aquila-Obra ARD, Padilla-Melendez A (2006) Organisational Factors Affecting Internet Technology Adaptation. Internet Res 16(1):94–110. https://doi.org/10.1108/10662240610642569

Aronsson H, Brodin MH (2006) The Environmental Impact of Changing Logistics Structures. Int J Logist Manag 17(3):394–415. https://doi.org/10.1108/09574090610717545

Azevedo G, Ferreira J, Leitão J (2007) The Role of Logistics Information and Communication Technologies in Promoting Competitive Advantages of The Firm, Munich Personal RePec Archive Paper, no 1359. Available at http://mpra.ub.uni-muenchen.de/1359/

Burneister A, Djellal F (2004) L.impact des technologies del l'information sur l'organisation spatiale des activities de services: le cas du transport routier de merchandises et des services intessifs en connaissance, Innovations vol 19 , pp. 53–73 https://doi.org/10.3917/inno.019.0053

Chapman RL, Quin R (2003) Innovation in Logistics Services and The New Business Model: A Conceptual Framework. Journal of Physical Distribution & Logistics Management 3(7):630–650. https://doi.org/10.1108/09604520210451849

Dosi G (1982) Technological paradigms and technological trajectories. Res Policy 11(1982):147–162. https://doi.org/10.1016/0048-7333(82)90016-6

Dosi G (1984) Technical Change and Industrial Transformation. Macmillan, Londres 1984. https://doi.org/10.1007/978-1-349-17521-5

Foster C, Green K (1999) Greening the Innovation Process, Best Paper Proceeding, pp.1–41

Friedl B (2002) Steininger KW (2002) Environmentally sustainable transport: definition and long-term economic impacts for Austria. Empirica 29(2):163–180. https://doi.org/10.1023/A:1015600911243

https://www.coqueline,energies.com/?gclid=CjwKCAiA0O7fBRASEiwAYI9QAkcvUEZZvOkTEM-9s9-6zDTwsRZdtNV1F2nqkzEhQPIii46fcZGZrRoCTo8QAvD_BwE(2018)

Hamdouch A, Samuelides E (2001). Nature et dynamique de l'innovation dans les services, Econ. Soc. Ser. EGS 6 (3) (2001) pp. 975–994

International Transport Forum (2010) Transport Outlook (2010) The Potential for Innovation. OECD/ITF, Leipzig

Kemp R (2004) Rotmans J (2004) Managing the transition to sustainable mobility. In: Elzen B, Geels W, Green K (eds) Systems Innovation and the Transition to Sustainability. Elgar, Cheltenham, pp 137–167

Kimberly JR, Evanisko MJ (1981) Organisational innovation: The influence of individual, organizational and contextual factors on hospital adoption of technological and administrative innovations, Academy of Management Journal, 24 (4), pp. 689–713. https://www.jstor.org/stable/256170

Determinants of Green Practice Adoption for Logistics Companies in China. J Bus Ethics 98:67–83. https://doi.org/10.1007/s10551-010-0535-9

Lin CY (2007) Factors Affecting Innovation in Logistics Technologies for Logistics Service Providers in China. J Techno Management in China 2(1):22–37. https://doi.org/10.1108/17468770710723604

Litman T (2006) Burwell D (2006) Issues in sustainable transportation. Int. J. Glob. Environ. Issues 6(4):331–347. https://doi.org/10.1504/IJGENVI.2006.010889

Miles I (2005) Innovation in services, in: J. Fagerberg, D. Mowery, and R. Nelson (Eds). The Oxford Handbook of Innovation, Oxford, University Press. Oxford, 2005, pp. 433–458

Nelson RR, Winter SG (1982) An evolutionary theory of economic change, 3rd ed. The Belknap Press of Harvard university press, Cambridge (mass), 1996. [1982]

Nijkamp P (1994) Roads toward environmentally sustainable transport. Transp. Res. A 28 (4) (1994), pp. 261–271

OECD (2005) Oslo manual: Guidelines for collecting and interpreting innovation data (No. 4). Org. for Economic Cooperation & Development. Oslo Manual, 3rd edn. OECD Editions, Paris

Rennings K (2000) Redefining innovation-eco-innovation research and the contribution from ecological economics, Ecol. Econ. vol 32 (2) pp. 319–332 https://doi.org/10.1016/S0921-8009(99)00112-3

Sahal D (1980) Models of technological development and their relevance to advances in transportation, Technol. Forecast. Soc. Chang. vol 16 (3) pp. 209–227 https://doi.org/10.1016/0040-1625(80)90032-3

Schmookler J (1966) Invention and Economic Growth. Harvard University Press, Cambridge (Mass)

Schot J, Geels FW (2008) Strategic niche management and sustainable innovation journeys: theory, findings, research agenda and policy, Tech. Anal. Strategy. Manag. 20(2008):537–554. https://doi.org/10.1080/09537320802292651

Schumpeter JA (1983) The Theory of Economic Development, Transaction Publishers, New Brunswick, 1983 [1911]

Sviden O (1988) Future information systems for road transport: A Delphi panel-driven scenario, Technol. Forecast. Soc. Chang. vol 33 (2) pp. 159–178 https://doi.org/10.1016/0040-1625(88)90079-0

Swann GMP (2009) The Economics of Innovation. An introduction, Elgar, Cheltenham

Vigar C (2000) Local barriers to environmentally sustainable transport planning, Local Environ. vol 5 (1) 19–32 https://doi.org/10.1080/135498300113246

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Chapter 5
Vehicle Management and Emission Control and Maintenance

Peter Bitta Bikam

Abstract South Africa range 15th as the world largest CO_2 emitter contributing to 1.2% of global emission. During the Kyoto Protocol of 2014, South Africa pledged to reduce its emission by 34% and 42% in 2020 and 2025 respectively. This study is a combination of literature review from South Africa with particular emphasis on road transport. The focus was on vehicle emission with reference to Limpopo Province to demonstrate how emissions from primarily the use of diesel and petrol as one of the major contributors to CO_2 emission in the province are vital for the sustainability debate. The methodology used to illustrate the dangers of vehicular emissions were based on statistical estimates from the Department of Environmental Affairs (DEA) inventory report from 2000 to 2010. The information used in assessing the vehicle emission standards in Limpopo were obtained from DEA. The findings from literature reviews in general and the results from the field survey from Limpopo Province shed some light on South Africa's vehicle emissions policy issues and standards. Also the analysis focused on the impact of vehicular fleet management and carbon emissions. The article concludes by drilling down to vehicle users, motor vehicle repairs, engine over haulers, used engine collection and disposal with respect to their roles in vehicle emission and control in South Africa.

Keywords Vehicle management · Emission control · Vehicle maintenance · Carbon emissions

5.1 Introduction

South African Greenhouse Gas inventory submission to the United Nations Framework Convention on Climate Change (UNFCCC) published in 2014 shows that in 2010 the energy used in the transportation industry contributed to 47.6% $MtCO_{2e}$ or 8.8% of the country's gas emissions excluding emissions from vehicles fuel used on farms. Policies on measurement of vehicles emissions in South Africa have not

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been precise particularly from the laboratories nor in the real world where vehicle users including public transport, locomotives, taxis, private vehicle users etc., do not understand what is emissions control. In addition to this, driving patterns including the use of aging vehicles, irregular vehicle maintenance and poor vehicle operational histories such as un-registered and use of non-road worthy vehicles can increase emissions. Emissions from the transport sector has grown by 32% from 2000 to 2010 (Vosper & Mercure 2007). In the case study from Limpopo, South Africa, vehicle fleets were composed of new and aging vehicles (SAPIA 2008). The ultimate goal of the government is to improve ambient air quality. The emphasis in this chapter is the analysis of vehicle emission and control processes to demonstrate whether vehicle users are in compliance of government policies on vehicle emission control or not. The analysis begins with the definition of what is fuel quality standard. This approach was necessary to unpack the impact of vehicle emission control and management in South Africa. Although the analysis in this chapter looks at what literature has on vehicle management, emission control and management in South Africa, Limpopo Province was used as the case study area to explain whether those in the transport sector understand emission issues in the local context (DES 2010).

5.2 Literature Review

Outlined in the preceding paragraph are the literature reviewed with respect to vehicle management, emission control and management. The literature begins by defining what is fuel quality standard, the standard figures with respect to vehicle emissions in South Africa, before undertaking the discussion of the field survey results.

What is Fuel Quality Standard?

According to the ICCT (2009) technical report on black carbon climate science and appropriate emission control strategies, fuel quality and emission standards are usually underlined with respect to characteristics such as lead and sulphur contents in fuel. The explanation shows that fuel sulphur is one of the culprits responsible for the sharp rise in emission levels. With respect to fuel quality standard, Woolf et al. (2007) indicated that emissions from vehicles that use fuel with lead can cause damage to human organs. In addition to this, lead can damage vehicles in three ways. For example the catalytic converters in a vehicle can be modified by de-activating the catalysts and preventing them from working efficiently to reduce NO_x, CO and HC in the vehicle exhaust. Therefore, the elimination of lead from gasoline is an essential pre-requisite for implementing policy standards to control vehicle emissions (Vosper & Mercure 2007).

Statistical Facts on Vehicle Emission in South Africa

Gas analysing instruments measure the concentration of hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Oxide (NO_X), and CO_2. The concentration units relate to the amount of HC, CO_2 to the amount of total air collected i.e. percentage or part per

million (ppm units). For example, mass emissions in towns such as Johannesburg and Polokwane can be calculated as the product of the molecular mass and measured concentration of each pollutant and the total volume of air collected. The emission from vehicles are in grams per kilometer (gpk) emission factors (Minjares & Hon 2012). The review of literature on vehicle emission shows three primary greenhouse gas emission in South Africa from the transport sector from 2000 to 2010 as shown in Table 5.1.

Table 5.1 shows the relative contribution of greenhouse gas emissions from different modes of transportation in South Africa. Note that the contribution of Methane and Nitrogen Oxide in terms of percentage of total accounts for only 2.14% of the total from 2000 to 2010 in South Africa. However, the understanding of the contribution of greenhouse emission will not be complete without considering the contribution of different modes of transport emitters from South Africa, as shown in Table 5.2.

It is clear from Table 5.2 that the figures include emission from Diesel, Liquefied Petroleum Gas (LPQ), and residual fuel oil, Kerosene and petrol consumption from road transport. However, only diesel for rail transport and jet kerosene and Jet gasoline for domestic aviation were considered. Note that electricity used in rail was not factored in the calculation (Roads and Transport Gauteng Province 2014). The statistics from the Department of Energy shows the contribution of other services to greenhouse emission in 2010 excluding emissions from the production of fuel in South Africa is shown in Table 5.3.

Table 5.1 Greenhouse gases emission from 2000 to 2010 in South Africa

Greenhouse gas	Emission (Mt CO_{2e})	% of total emission (%)
Carbon dioxide (CO_2)	444.21	97.86
Methane (CH_4)	3.19	0.70
Nitrous oxide (N_2O)	0.52	1.44
Total	453.92	99.74

Source Department of Environmental Affairs (DEA) (2014)

Table 5.2 Contribution of different modes of transport emission in 2010

Vehicle mode and energy carrier	% contribution to overall emission (%)
Domestic	7.7
Road (diesel and petrol)	91.2
Rail (diesel only)	1.1
Total	100

Source Department of Environmental Affairs (DEA) (2014)

Table 5.3 Contribution to total transport emission in 2010

Mode	Emission of greenhouse gas in $MtCO_{2e}$	% contribution to emission (%)
Electricity to run fuel pipeline	0.090 $MtCO_{2e}$	0.1
Electricity forum electric rail	2.800 $MtCO_{2e}$	4.5
Marine transport (gas and fuel oil)	9.820 $MtCO_{2e}$	15.6
Domestic aviation (jet kerosene and jet gasoline)	3.665 $MtCO_{2e}$	5.8
Rail (diesel)	0.524 $MtCO_{2e}$	0.8
Road (diesel, LPG, residential fuel oil, other kerosene and petrol)	43.411 $MtCO_{2e}$	15.6
Total	61.14 $MtCO_{2e}$	42.4

Source IEA (2015), CO_2 emission from fuel combustion: highlights

Table 5.3 shows that greenhouse emission from the transport sector contributed to 42.2% of emissions selected and road transport accounted for 15.6%. Rail and Diesel contributed 0.524 $MtCO_{2e}$ or 0.8%. If emissions from fuel manufacturing is added to the overall emission from the energy used in refineries, including those from SASOL's processing plant will be contributing 42 $MtCO_{2e}$ and South Africa's international marine bunkers emission in 2010 was 9.82 $MtCO_{2e}$ (IEA 2015). However, SASOL's coal to liquids plants are CO_2 intensive making up to half of the contribution to South Africa emissions (IEA 2015).

5.3 Methodology

The methodology to unpack vehicle management, emission control and management in South Africa discusses the concept of emission control in Limpopo Province in the context of greenhouse gases emission reduction in the transport sector with respect to vehicle fleet management, efficient systems and smart information as well as access to green transport. The study advances arguments on emission control, fuel quality standards, and greenhouse emissions in South Africa from 2000 to 2010 to determine the contribution of South Africa in greenhouse emission globally. The study drills down to the case study area in Limpopo province to discuss vehicle management approach in the province. The findings from the literature review and the results from the field survey from Limpopo province shows that vehicle emission control policy is lacking. This was attributed to the high level of carbon emissions in South Africa. The study demonstrates that through dedicated research on vehicle management control, improved emission control and reduced per capita kilometer travelled in a vehicle. The case study in Limpopo shows that public transport could be improved through

the introduction of the Bus Rapid Transport (BRT) in the province, particularly in growth point towns such as Polokwane. The pilot study demonstrates how the potential of adopting the BRT and re-skilling of vehicle repairers, traffic police, and transportation planners could enhance the buy-in of green transport management especially in rural areas. This was demonstrated with the response from the targeted respondents who indicated that awareness campaign and education via improved bus technology, improved understanding of traffic at bus stops, improved payment systems, use of low cost control systems, efficient boarding and alighting facilities will contribute to improved vehicle management, emission control and management.

5.4 Limpopo Province Field Survey Results Discussions

This section uses the research findings from Limpopo Province to unpack inherent variability of vehicle emissions, vehicle technology, vehicle age, vehicle mode to mention just a few, with respect to measurement of vehicle emissions, technology and vehicle model (SEPA 1999a, b).

5.4.1 Difficulty in Measuring Vehicle Emission Variations

The study in Limpopo Province on various modes of transport users as well as petrol, diesel or engine oil uses were factored in. Emissions vary according to the use and the condition of the vehicle. However, the study showed that 40% of the sampled road transport users including traffic officers indicated that vehicle exhaust emission from the engine occur because of unburned fuel, HC and incomplete combustion leading to the emission of NO_x, HC and CO emissions. Majority of the targeted populations' i.e., 79% of the 120 respondents indicated that when vehicles do not function properly due to lack of gadgets to reduce emissions, the result is more emissions. The study shows that vehicle engine sometimes fail to operate as designed due to exhaust aging resulting in rise in emissions depending on the vehicle condition. Outlined below are some of the factors affecting emissions with respect to different modes of transport which include vehicles make or vehicle technology, age or model or year of make, manufacturer, misuse of the vehicle, malfunctioning of the vehicle etc.

5.4.2 The Effect of Vehicle Material Technology on Emission Control

The innovation of new technologies to control greenhouse emission are said to be incorporated in new vehicles in South Africa. However, 56% of the respondents

were not aware of the exhausts gas recirculation to reduce NO_x formulation in the car engines. This can be done in addition to replacement of old carbonators with throttle body and part fuel injections and a computerised inbuilt air–fuel mixing and spark time. With respect to new car dealers that were consulted in the province, it was indicated that some new cars have emission control mechanism inbuilt by certain car manufactures who include them in their designs to promote reduction in emissions, but as the vehicle gets old the emission control efficiency decreases.

The major objective of transportation management is to move product from an origin (i.e., location) to the destination with minimizing cost and reduced negative impact to the environment (Lin 2009; Lin & Ho 2008). Innovation in engine technology for aircraft, locomotives, and trucks can reduce air pollutants and other forms of emissions (Mercure & Lam 2015). Similarly, low combustion chambers can sustainably lower the emissions of NO_x, CO_2, and unburned hydrocarbons. The development of new aircraft types, alternative fuels and engines with increased fuel efficient hybrid can mitigate the environmental impacts of aircraft operations. According to Lin and Ho, transportation technologies commonly used in logistics industry include transportation information system, global positioning system (GPS), geographic information systems (GIS), radio frequency communication system, and transportation data recorders. The transportation information system and geographical information system can help logistics managers to plan, manage and control transport challenges. The global positioning system, and radio frequency communication system can track and guide drivers during the transportation of products. This argument was supported by Murphy and Posit (2003) on the mitigation of the negative effects of vehicle emissions on the environment by emphasising intermodal transportation logistics using internet tracking system, GPS, and other means to ensure efficiency. Furthermore, they found out that electric and digital logistics management can reduce delivery time, optimize transportation and distribution routes and provide greater flexibility in the used of transportation modes.

The Effect of Age of Vehicles and the Millage Accumulated Over Time on Emission Control

The policy on the age of vehicles in South Africa shows that vehicles older than 10 years should not be on the road as well those with high millage accumulated. This is because the age of the vehicle and millage accumulation tend to increase greenhouse gas emissions. With respect to age of vehicles, 65% of the respondents against 25% agreed that emission discharge is both a function of the normal degradation of the vehicle due to the age and irregular maintenance of the vehicle. 82% of the respondents indicated that lack of regular maintenance of vehicles was one of the major reasons there is increase in vehicle gas emission particularly CO and HC emissions. 38% of the respondents did not have any opinion on whether old vehicles should be discarded. They regarded the age of vehicles as important but added that if the vehicle owner undertakes regular maintenance the vehicle emission will not be as much as irregular maintenance. Taxi drivers, bus owners were unanimous that re-capitalization may not be practicable in rural areas if the aim of the policy is just to reduce carbon emissions because they identified poverty as the main challenge.

5.4.3 The Effect of Vehicle Manufacturing Model on Emission Control

South Africa is not a major car manufacturing country as compared to those from Europe, USA and Asia. However, it is important to note that some car models perform better with respect to vehicle emission than others. With respect to vehicle maintenance, 52.2% of the respondents' indicated that vehicle models and the type of car can exhibit very low gas emission as compared to other vehicle engines that may have emission control facilities inducted in the engine. They indicated that the effectiveness of a vehicle engine in emission control and the life time durability of the car depends on the make, the model and usage, (Wagner & Rutherford 2013).

5.4.4 The Effect of Vehicle Maintenance Culture on Emission Control

The research in Limpopo showed that there is no policy on the degree to which an individual vehicle owner in South Africa should be controlled with respect to vehicle emission and maintenance of his or her vehicle. 46% of car repairers consulted in Limpopo province indicated that regular vehicle maintenance as recommended by the manufacturers can improve the engine emission system. Similarly, 75% of vehicle repairers in the province indicated that informal vehicle repairers such as road-side mechanics can affect the quality of vehicle repairs if the mechanics are not well trained. This is because poor vehicle maintenance can degrade the catalytic convertor or tuning engines which can impact on emissions. In a developing country such as South Africa, sophisticated on board sensors to monitor vehicle performance can be installed in new vehicles. Major car maintenance garages in Limpopo indicated that those who adhere to manufacturers' warranties with respect to maintenance can improve engine performance and extend the life span of the vehicles. Out of 40 vehicle owners contacted including taxi drivers on their service plans, 86% of them indicated that they do not go for regular vehicle maintenance.

5.4.5 The Effect of Misuse and Malfunctioning of Vehicles on Emission Control

The study showed that drivers that do not comply with driving rules and misuse their vehicles can lead to increase in CO_2 emissions. For example, prolonged high-power driving on steep mountain roads can lead to a rise in vehicle engine temperature which is a major cause of pre-mature damage to the catalytic conveter and this can result in increase in emissions. Similarly, regular vehicle malfunctioning due to irregular driving habits can in general trigger vehicle malfunctioning with high CO emission

and high HC emission while vehicles with high NO_x emission tend to have relatively low CO and HC emissions. With respect to misuse and malfunctioning of vehicles on emission, the main findings in Limpopo showed that 59% of the respondents agreed that it increases vehicle emissions as compared to vehicles in good working conditions.

5.4.6 *The Effect of Driving and Fuel Delivery Engine Load on Emission Control*

According to 53% of the respondents in Limpopo province, vehicle emission vary due to changing vehicle engine load. This is because the relationship between emission and load depends on the fuel-delivery and the type of emission-control technology installed in the car engine. This is because NO_x emissions will increase with increasing engine load. Six out of seven motor vehicle formal services centres consulted in Limpopo province, five (5) indicated that enrichment of the air fuel mixture can lead to elevation in CO and HC formations because of inadequate oxygen available for pollutant conversion to CO_2 and water in the catalyst (Foster & Green 1999). Out of seven auto vehicle repairers contacted all of them indicated that steep roads and the installation of air conditioning and heating devices in vehicles can put additional load on the engine and this can affect emissions. The seven auto-mechanics consulted indicated that the way drivers shift gears on vehicle in a non-automatic car can affect emission rates because depending on how the driver presses the pedal, smoothly or excess acceleration can increase emissions.

5.4.7 *Vehicle Humidity, Catalyst and Ambient Temperatures and Emission Control*

According to Wagner and Shao (2015), catalytic convertors and oxygen sensors of a vehicle are effective at low temperatures. However, when it is heated by the vehicle exhaust, the devices can attain very high temperatures required for the operation of the vehicle after 1–4 min of driving. Similarly, ambient temperature has direct effect on the evaporation of HC emission (Ligterink et al. 2013). This explains why very low temperatures for example, below 20 °F or 3 °C can influence emission of gases at ignition and this may cause the catalyst of some vehicles to cool during stops. As a result of this, very high ambient temperatures of the engine can affect vehicle exhaust emission because engine loads can increase due to the prolonged use of vehicle air conditioners. Similarly, this can lead to higher emission of NO_x. Consequently, the amount of water vapour in the air can affect NO_x in aging and malfunctioning vehicles. Although 43% of the respondents did not understand the complexities, vehicle humidity, catalyst and ambient temperature impact on emission

control, 23% were of the opinion that high temperature can increase NO_x and HC emissions.

5.4.8 *Quality of Fuel Used in the Vehicle*

In an article on fuel effects in auto/oil high emitting vehicles, (Nunes & Bennett 2009) postulated that the quality content of fuel in the vehicle can have a substantial impact on tied-pipe and evaporative emissions of the vehicle. For example, in urban areas such as Beijing, the authorities introduced oxygenates in fuel to reduce the quantity of CO emissions during the winter to decrease the volatility as well as reduce evaporative HC emissions during hot seasons. The study in Limpopo province did not go as far as unpacking the evaporative components of the emissions but fuel stations consulted in South Africa showed that, the concern is on the sulphur content of the fuel (Jumadi & Zailani 2011) and (Murphy & Posit 2003). The practice of standardizing fuel quality in South Africa is to make sure that fuel consumption no matter the make of the vehicle, capacity and geographical location have access to the same category of the fuel. This practice is to ensure a year-round gasoline standard across the county with respect to emission control as a strategy. However, it is important to note that the emission of vehicles at the province are difficult to measure. However, with respect to the concerns raised by the respondents on awareness campaign, 86% of them indicated that it is important to determine in the future the relevant policy and regulatory frameworks on the use of hybrid vehicles in South Africa, (Technology Fuels Green Efforts 2003).

5.4.9 *Inspection of Vehicles in Limpopo Province*

Measures to track malfunctioning vehicles in Limpopo Province and in South Africa in general are undertaken by road traffic officers during road inspection of vehicles. However, 83% of the commuters indicated that traffic officers were more concerned with driving offences such as drink-driving, over-speeding, overflowing than checking vehicle emissions. A trajectory of 56 road traffic officers and private car owners were requested to indicate their observations with respect to vehicle inspection in 2016, in line with a similar exercise by (Istrfi & Chico 2013). Their responses are shown in Table 5.4.

The investigation in Limpopo did not deal directly with the measurements of the distribution of vehicle with respect to HC emission because the emphasis was on respondents experiences with categories of testing in the province. In order to ascertain the opinion of traffic officers, private car owners and vehicle repairers were targeted to provide their experience in the last 5 years with vehicle testing in the categories indicated. The same questions were administered to all the respondents to ensure the validity of the answers and to cross-check contradictory answers. What

Table 5.4 Respondents experience with vehicle licensing in Limpopo Province, 2016

Category of respondents	Number of respondents	District	Municipalities	Vehicle test categories				
				Vehicle test category	Meet standard	%	Did not meet standard	%
Traffic Officers	6	Vhembe	Thulamela	No. of vehicles tested for road traffic offenders	30	53.6	26	46.6
Truck Drivers	8	Sekhukhune	Tubatse	Over speeding	46	82	10	17.9
Taxi Drivers	10	Mopani	Greater Giyani	Vehicle emission check	51	91.15	5	8.9
Bus Drivers	6	Waterberg	Polokwane	Number of vehicles observed with exhaust smoke	21	37.5		62.5
Private car owners	10	Capricorn	Mogalakwena	Vehicle road worthiness checks	54	94	3	5.1
Total	56							

Authors field data, 2016

was interesting in the Limpopo field survey was that 53.6% of the respondents as against 46.4% indicated that road traffic officers do conduct checks but without devices by merely undertaking observation inspection of the vehicles. 52% of the traffic officers interviewed in Limpopo province indicated that most of their routine checks on vehicles were mainly for reckless driving, and over-speeding. The most interesting part was when the respondents were requested to indicate whether they have experienced vehicle emission checks by traffic officers and 91.1% of them as against 8.9% indicated none. This means that the priority for road traffic officers were centred on roads accidents avoidance than the inspection of vehicles to determine greenhouse emission levels as indicated by a similar study conducted in China.

5.4.9.1 Enforcement of Traffic Regulations in Limpopo Province

On the enforcement of traffic regulation, 92% of the respondents indicated that to drive a car in South Africa, one must go through a stringent driving test. The study showed that the accumulation of driving distance i.e., per capita km travelled can increase greenhouse emissions. In the rural areas of Limpopo where vehicle checks are less frequent, vehicles older than 10 years were still in use in 2016. 67% of the respondents indicated that they have owned motor-vehicles which were out of their service plans. In a study conducted by (Vashon & Klassen 2006) on vehicle emission and testing it was discovered that 50% of total vehicle emitting CO and HC in rural areas were from vehicles older than 10 years. The study in Limpopo showed that 47% of the respondents were not in favour of scrapping vehicles older than 10 years in Limpopo because according to them it will affect those who earn less than R3500.00 per month and own a car. The reasons they gave for not scrapping old vehicles was that those who spent more than 10% of their disposable income on transport cannot afford to have their vehicle scrapped (Vashon & Klassen 2006). If vehicles older than 10 years were scrapped in Limpopo province, majority of the vehicles in the rural areas will be phased out but carbon emissions will be reduced. In addition to this, most taxis, buses and private vehicle owners depend on such old vehicles to commute and make a means of livelihood in the rural areas (SEPA 1999a, b).

5.5 Recommendations

The literature on vehicular emission shows that the subject is very wide and complex. However, the literature review and the field study results also showed that as a developing country, South Africa should in the nearest future focus on the prospects of green transport technology to ensure that compliance and control over vehicle emission is achieved to reduce greenhouse emission. With respect to the vehicle management, emission control and management in Limpopo province, 82% of the respondents indicated that with respect to green transport economy there is need to re-skill those in the transport industry with respect to hybrid vehicles. This will

Table 5.5 Relevant skills required to upscale the control of emission in a green transport economy

Skills suggested based on the findings	Elements of the skills
Green IT technology (technicians and GIS experts)	To learn new softwares relevant to green transport technology and interpretation of graphics symbols
Emission control handling skills (technical experts: electrical, chemists, safety technicians etc.)	To be able to operate and test equipment such as batteries, bio-fuel, electrical wires etc.
	To be able to identify motor vehicle emission levels and their effects on the environment
Heavy vehicle emission systems repair procedures for biofuel (mechanics/biofuel technicians, electricians etc.)	To be able to repair heavy vehicle that use bio-fuel and undertake post repair testing to ensure control
Skills on moto vehicle emission control legislations and standards setting (legal experts)	Training on new legislations that may be needed when green energy transport technologies are introduced
Moto vehicle green standards skills (greens skills traffic control officers)	To be able to undertake visual inspections of vehicle emission control system such as particulates filters, catalytic converters, crankcase ventilation. In addition to this be able to detect excessive emissions i.e. hydrocarbons, carbon monoxide, oxide of nitrogen and also examine excessive consumption of fuel
Green vehicle component repair skills (general mechanic skills)	To be able to undertake green transport vehicle component repairs skills such as removal of parts, replace and adjustment procedures, dismantle, repair re-assemble and adjustment procedures

require an awareness campaign and the redesign of curriculums in transport related fields of study. Table 5.5 shows some of the relevant skills that may be required in the future.

Table 5.5 shows some of the skills that will be needed to enhance new green transport technologies such as hybrid cars, bio-fuel cars, emission control mechanisms and software etc.

5.6 Conclusions

The study in Limpopo province on vehicle management, emission control and management in South Africa has showed that measuring greenhouse gas emissions is still in its infancy. In addition to this, several issues complicate the subject because new vehicle technologies will be required to ensure stricter fuel quality to gradually improve the situations. The case study in Limpopo province and the desktop review of literature have shown that the quality of existing fuel falls below the hybrid vehicles in terms of emission control. Vehicle emission control in South Africa will require

stricter vehicle emission standards to be implemented step by step taking along all the stakeholders in the transport industry. The study showed that awareness campaigns on emission control need to be emphasised to sensitise people on current emission standard in the province and in South Africa in general. These require re-skilling across the whole value chain in the transport sector. Similarly to enforce vehicle emissions in South Africa will require policies that will carry along the stakeholders in terms of re-skilling.

The advantage with hybrid vehicles is that they have the potential to reduce emission by 25 $MtCO_{2e}$ per amount by 2050 (Mercure & Lam 2015). The cost of savings will account for R385 per ton, CO_{2e} for petrol with the use of plug-in hybrid electric vehicles. It is pertinent to note that more research to explain the concept of green transport to the public is needed i.e., workshops. The introduction of new hybrid cars in the nearest future with respect to management of transportation systems should focus on regulating urban transport via the introduction of the BRT and improvements of road network quality, improving transport operation conditions and enforcing gradually stricter regulations and standards with respect to old vehicles in rural areas of South Africa.

References

Department of Energy Statistics (DES) (2010) http://www.energy.gov.za/files/energyStats_frame.html. Accessed Aug 2016

Department of Environmental Affairs (DEA) (2014) Report on emission on fuel combustion

Foster C, Green K (1999) Greening the innovation process. Best paper proceeding, pp 1–41

ICCT (2009) A policy relevant summary of black carbon climate science and appropriate emission control strategies. http://www.theicct.org/sites/default/files/publications/BCsummary_dec09.pdf

IEA (2015) CO_2 emissions from fuel combustion: highlights. https://www.iea.org/publications/freeoublications/publication/co2Emissionfromfuelcombustionhighlights2015,pdf. Accessed 2016

Istrfi D, Chico B (2013) Fleet management solution (consumption and collision prevention system modules. IRACST Int J Comput Sci Inf Technol Secur (IJCITS) 3:3

Jumadi H, Zailani S (2011) Determinations of green technology innovation adoption among transportation companies in Malaysia. https://www.researchgate.net/publication/269928389

Ligterink N, Patuleia A, Koornneef G (2013) Current state and emission performance of CNG/LNG heavy-duty vehicles. TNO 2013 R10148

Lin CY (2009) Factors affecting innovation in logistics technologies for logistics service providers on china. J Technol Manag China 2(1):22–37. https://doi.org/10.1108/17468770710723604

Lin CY, Ho YH (2008) An empirical study on logistics service providers, intention to adopt green innovations. J Technol Manag Innov 3(1):17–26. ISSN: 0718-2724

Mercure JF, Lam A (2015) The effectiveness of policy on consumer choices for private road passenger transport emissions reductions in six major economies. Environ Res Lett 10(064008). https://doi.org/10.1088/1748-9326/10/6/064008

Minjares R, Hon G (2012) Definition and measurement of marine black carbon emissions. http://www.theicct.org/definition-and-measurement-marine-black-carbon-emissions

Murphy PR, Posit RF (2003) Green perspectives and practices: a comparative logistics. Int J Supply Chain Manag 8(2):3–15. https://doi.org/10.1108/13598540310468724

Nunes B, Bennett D (2009) Green technologies in the automotive industry. International Association for Management of Technology, Brochure, pp 7–8

Roads and Transport Gauteng Province (2014) Promoting sustainable (Green Transport in Gauteng). Gauteng on the move. Johannesburg, South Africa

SEPA standard (GEPBU-1999) Emission standard for exhaust pollutants from light-duty vehicles. Accessed 1 Jan 2006

SEPA Standard (GWPBU-1999) Emission standard for exhaust pollutants from light-duty vehicles. Accessed 1 Jan 2006

South African Petroleum Industry Association (SAPIA) (2008) Petrol and diesel in South Africa and the impact on air quality. www.sapia.co.za/LiteratureRetreave.aspx?ID=43782

Technology fuels green efforts (2003) Environmental challenges practices for food manufacturers and distributors food logistics. Cygnus Business Media, Fort Atkinson, p 38

Vashon S, Klassen RD (2006) Extending green practices across the supply chain: the impact of upstream and downstream integration. Int J Oper Prod Manag 26(7):795–821. https://doi.org/10.1108/01443570610672248

Vosper SJ, Mercure JF (2007) Assess the effectiveness of South Africa's emissions-based purchase tax private passenger vehicles: a consumer choice modelling approach. J Energy South Afr 27(4):25–37. https://doi.org/10.17159/2413-3051/2016/v27i4a1436

Wagner V, Rutherford D (2013) Survey of best practices in emission control of in-use heavy-duty disiel vehicles. International Council on Clean Transportation, August. http://www.theicct.org/sistes/default/files/publications/ICCT_HDV_in-use_20130802.pdf

Wagner D, Shao Z (2015) Costs and benefits of motor vehicle emission control programs in China. Communications 49(30):847129-102

Woolf AD, Goldman R, Bellinger DC (2007) Update on the clinical management of childhood lead poisoning. Pediatr Clin North Am 54(2):271–294. https://doi.org/10.1016/j.pcl.2007.01.008

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Chapter 6
Skills and Knowledge Transfer for Transitioning into the Green Economy

John Ogony Odiyo, Agnes Musyoki, and Rachel Makungo

Abstract This chapter aimed at identifying skills required for transitioning into green economy in the transport sector, preferred careers and institutions, challenges that could hinder transition to green economy in transport sector in addition to suggesting policy recommendations in case study carried out Limpopo Province. Case studies are required to provide insight into the nature of the current situation with respect to transition to green economy in the transport sector and providing knowledge and evidence on skills required transition to green transport. The study followed a qualitative and exploratory methodology involving administering questionnaire to purposively selected participants and stakeholder workshop aimed at discussing and debating on required knowledge and skills for transition to green economy in Limpopo Province, identifying challenges and policy recommendations. A total of twenty questionnaires were completed while 56 delegates from different departments and organisations participated in the workshop. A wide range of specific skills needs within technical, management skills and knowledge on techniques and skills on innovation and management for change categories, in the transport sector and their value chains were identified. Many of the skills required in the transport sector correspond to those required for the general green economy indicating that the transport sector will also benefit through implementation of the green economy in all sectors in the province. Most people chose environmental science as the most suitable career to follow in ensuring green economy. The respondents recognized the importance of mainstreaming the green economy at all levels of study. Challenges that could hinder transition to green economy include inadequate training and awareness programs, lack of existing skills directly related to the green economy at work places and inadequate funding for skills development in the green economy.

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Some of the policy recommendations include green growth capacity building for public administrators and policy makers, knowledge and skills transfer to be identified following the value chain based on the jobs required for each mode of green transport, development of methodology to mainstream green economy in all work places, mainstreaming green economy at all education levels, government to fund policy and legislation, and research and innovation related to green transport.

Keywords Green economy · Knowledge transfer · Skills · Transport sector

6.1 Introduction

Transition to a resource efficient and low carbon green economy is essential in reducing greenhouse gas emissions and mitigating climate change by decoupling future growth from the use of non-renewable fossil fuels and other natural resources (CSIR 2014). In South Africa transition into a green economy has also been identified as a key policy area due to its potential to stimulate economic growth and create sustainable jobs. This will aid in responding to critical development challenges faced by South Africa which include high levels of unemployment, poverty and inequality, energy security and climate change (PAGE 2017). However, shortage of skills shortage in green industries, lack of coordination in training and development, as well as the lack of green skills programmes are challenges that needs to be addressed urgently (ILO 2017), to promote transition to a green economy. In addition, National Skills Development Strategy III (DHET 2011) identified the need to develop skills in support of the green economy as a national priority. Having an increased green skills pool will enable South Africa to proactively implement and up-scale green economy initiatives (PAGE 2017).

Transition to green transport will include creation of additional jobs in new or expanding areas, adaptation of jobs to make them greener, substitution of jobs and elimination of jobs (WHO 2011). With these expectations, specific knowledge and skills are therefore required in order to transition into the green economy. One of the key success factors for transitioning to a low-carbon economy in South Africa include addressing shortages of skills in certain areas, re-skilling and development of specific skills capabilities (IDC 2012). Despite the accepted notion that transition to a low carbon economy can be a source of job growth, there is still lack of evidence from case studies to support this. In addition, understanding what skills are necessary to make the transition to a greener economy is critical since data on skills profiles in the green economy is scarce (Slingenberg et al. 2008).

DEA (2010) recommended development of case studies of greening existing skills by various Sector Education and Training Authorities (SETAs) to demonstrate how environmental skills planning is being mainstreamed into development within the context of green economy. Despite this, there is still shortage of studies on identified skills required for the transition to green economy. PAGE (2016) identified the learning needs of ‘champions’ in government, business, civil society and academia,

who drive the transition towards a green economy in diverse policy contexts at national, provincial or local levels in South Africa. The study did not cover skills required by the broader working population for participating in a green economy. A green economy roundtable discussion by Mpumalanga Provincial Government (2016) noted that there is lack of knowledge transfer and skills development related to green economy at the local community level in Mpumalanga, resulting to limited meaningful participation from local communities. This was attributed to low literacy levels, low economic base and low levels of entrepreneurship. This is likely to be the case in Limpopo Province which has these similar characteristics.

Though, the Limpopo government in its green economy plan (LEDET 2013) sees the green economy as an opportunity for economic growth through creating jobs and eradicating poverty, there is a need to identify the skills required for the green jobs. Musyoki (2012) has identified utilisation of biofuel and solar energy as options for transitioning into green economy in Limpopo Province but there is still a need to profile skills required for jobs that are in these categories and other related ones within the context of green economy. This case study is aimed at identifying skills required for transitioning into green economy in the transport sector in Limpopo Province. In addition, the study ranked preferred careers and institutions and challenges that could hinder transition to green economy in transport sector in addition to suggesting policy recommendations. The study contributed knowledge and evidence on skills required transition to green transport, relevant careers and expected challenges. Such information is essential improve on the transition and develop strategies to address challenges on transition to green transport.

6.2 Methodology

The study followed a qualitative and exploratory methodology. Questionnaires were completed by a key professional green economy researcher, government officials, and an education stakeholder, individuals in the private sector, university students and the general public. A total of twenty questionnaires were completed (Table 6.1). A related study by Brown (2015) also interviewed 20 participants including stakeholders from transport and Logistics Company, medium and small sized businesses, Energy Generation Company, green skills centre, amongst others, in Australia. Brown (2015) emphasized that though the latter study had limited scale and reliability, it provided insight into the nature of the current situation. It is expected that though the current study is also of limited scale, it will also provide insight into the nature of the current situation with respect to transition to green economy in the transport sector in Limpopo Province.

The participants were purposively selected. They were contacted by phone and questionnaires sent to them which they returned by email, others were administered at places of work in August 2016. Some individuals were not willing to participate in the questionnaire survey due to lack of general knowledge on green economy and this limited the number of participants in the study.

Table 6.1 List of participants

Participant type	No. of participants	Profession/organisation
Professional key informant (worked a long time in Limpopo)	1	UNISA (green economy researcher)
Private transport users	3	Accounting professions
Department of transport	2	1 Assistant Director and 1 logistics officer (controls transport booking)
Education (teacher)	1	High school teacher
LEDET	3	Deputy director, Assistant director and an in service trainee
Vhembe district municipality	1	IDP officer
Department of agriculture, forestry & fisheries	1	Limpopo province
University Students	6	Universal greening organization (executive) A green economy project supported by government and private stakeholders)
Department of water and sanitation	1	Community development officer
COGHSTA	1	Chief town and regional planner (Polokwane)

A stakeholder consultation workshop was also conducted to discuss and debate on required knowledge and skills for transition to green economy in Limpopo Province, identifying challenges and policy recommendations. A total of 56 delegates from different departments and organisations including Department of Transport (DoT), University of South Africa (UNISA), Limpopo Department of Economic Development, Environment and Tourism (LEDET), South African National Biodiversity Institute (SANBI), Department of Environmental Affairs (DEA), Gateway Airports Authority Limited (GAAL), Capricorn Technical Vocational Education and Training (TVET), Letaba TVET, Limpopo DoT, Cooperative Governance, Human Settlements and Traditional Affairs (CoGHSTA), AM Consulting Engineers (AMCE), Polokwane Municipality, Limpopo Premier's office, Mapfura Makhura Incubator (a biodiesel organisation), Transport Education and Training Authority (TETA) and University of Venda (UNIVEN) research team.

6.3 Results and Discussions

6.3.1 *Green Jobs and Skills Needs for the Green Economy in Transport Sector*

The respondents identified skills needed for the green economy in general (Table 6.2) which were grouped according to where they best add to the value chains of main categories of green skills outlined in UK Government (2011). These include skills that support low carbon transition, resource efficiency, climate resilience and management of natural resources. The identified generic jobs and skills should be given priority in Limpopo Province to promote transition into the green economy.

Table 6.3 indicates the identified specific skills needs in the transport sector and their value chains with respect to alternative sources of fuel and different transport industries (passenger, freight and logistics, automotive industry (including manufacturing and retail)). The skills were identified through stakeholder participation workshop and interviews. Some of the skills cut across all the categories but were placed where they add most value. The results show that the respondents had a fair

Table 6.2 Generic jobs and skills for the green economy

Support low carbon transition	Support resource efficiency	Support climate resilience	Manage natural resources
• Business and financial accounting (carbon and natural environment accounting) • Fuel saving knowledge (appreciate use of buses and bicycles) • Energy generation skills • Skills to minimise carbon emissions • Interpretation of environmental legislation • Design and technologies, products processes increasing resource efficiency • Legislation • Entrepreneurial skills (business start-ups)	• Water quality waste and pollution management • Environmental management • Skills to adopt technologies • Environmental science • Recycling • Land use planning • Operator level actions to maximise resource efficiency (reduce waste in production) • Marketing and interpersonal skills • Pollution	• Environmental education • Technical skills • Engineering skills • Modelling and interpreting climate change projections • Risk management • Hydrological skills • Communication skills	• Environmental science • Project management • Environmental impacts assessment (quantification of impacts) • Management of natural resources • Indigenous knowledge skills • Policy development

Table 6.3 Skills needs for green transport

Alternative fuel (bio fuel)	Passenger and alternative transport	Automotive industry	Freight and logistics
• Environmental sciences • Chemical engineering • Biofuel production • Power supply technology • Research skills • Education on use of alternative fuel • Air quality • Environmental change detection • Pollution control • Global warming prevention • Value chain analysis • Green procurement • Stakeholder engagements • Accounting for natural environment	• Ability to identify green but economically viable transport alternatives • Understanding of the legislative benefits for moving into the green economy in transport (tax benefits) • Tourism management • Manufacturing of buses • Bicycle maintenance • Use of traditional transport modes (e.g. animals) • Car-pool • Awareness campaign organisation • Efficient driving • Public transport access • Construction of bus stops, train stations and road maintenance • Legal compliance • Operator level actions to maximise resource efficiency (reduce waste in production) • Risk management	• Industrial engineering • Environmental engineering • Mechanical engineering • Chemical engineering • Mining engineering • Technological engineering • Information communication technology • Construction of electric cars • Solar car technology • Skills to minimise carbon emissions • Design and technologies, products processes increasing resource efficiency	• Coordination • Marketing • Interpersonal skills • Communication skills • Communication • Organisational skills • Mobility management and advice • Freight logistics and management • Data management • Refrigerated storage skills • Freight transport management (logistics) • Risk mitigation and adaptation • GIS • Town and regional planning • Modelling and interpreting climate change projections

understanding of specific skills that would be required to transition into a green transport but that many of these skills are still lacking. Many of the skills required in the transport sector correspond to those required for the general green economy. Thus, implementation of the green economy in all sectors of the Limpopo economy will have positive impact in the transport sector.

Maclean et al. (2018) identified specific skills in green transport to include training in infrastructure labour, operation and maintenance, production of more resource-efficient vehicles and their maintenance, research and development in alternative fuel technology, transport infrastructure design and engineering; and public transport network construction, in Asian countries including India, Indonesia, Sri Lanka and Viet Nam. Most of the identified skills are comparable to those identified in this study indicating that skills required for green jobs in the transport sector are likely to be similar in most countries. OECD (2014) reported that in addition to technical skills (for example research or engineering skills), management skills and knowledge on techniques (to become more energy efficient, reduce waste generation and pollution), skills on innovation and management for change (communication skills) are also required to transition to green economy. These are some of the skills that were also identified by respondents in the Limpopo Province case study. Thus, identified skills fit within technical, management skills and knowledge on techniques and skills on innovation and management for change categories.

6.3.2 *Ranking of Preferred Careers and Institutions for Transition to Green Economy in the Transport Sector*

Careers listed in Table 6.4 were found to be relevant to green economy in transport sector in Limpopo Province by the respondents. Most people chose environmental science as the most suitable career to follow in ensuring green economy, followed by engineering. This career choice if pursued will support the Limpopo Province's green economy plan (LEDET 2013) which views green economy as local production and consumption, efficient use of energy and water and care of natural and created resources thereby providing socially and environmentally solutions to

Table 6.4 Preferred career for the green economy in transport sector

Career type	Rank
Environmental science	1
Engineering	2
Computer technology	6
Education (teachers and lecturers)	5
Electronics	10
Bio-technology and biological sciences	3
Management Sciences	4
Legislation	5
Nuclear and renewable energy	9
Drivers and technicians	8

Table 6.5 Preferred institutions

Institution	Rank
University	1
University of technology	3
FET colleges	2
SETA	4

economic exclusion and resource degradation, since all these are issues of concern within the field of environmental sciences.

Education training is important from primary, secondary and tertiary institutions and was considered to be the third choice of preference in ensuring transition to green economy. The need to study law in order to implement policies that will ensure that daily activities will align with the goal to go green was ranked number five. Careers in technology are important for ensuring development of green cars and machinery hence was ranked number six followed by bio-technology and biological sciences. The need to train drivers and technicians though important to green transport was ranked number eight. Any mode of transportation rely on energy input, however respondents find the study of nuclear and renewable energy not that important ranking it at second last number nine. Career in electronics was found least suitable in going green and ranked number ten. One would conclude that as much as all these anticipated career choices have some input with respect to various respondent's perspectives, the idea of going fully green in transport sector will not require just one field of study but the integration of various studies balanced together to achieve the ultimate goal of green economy not just in Limpopo but in South Africa as a whole.

Institutions preferred for accessing knowledge and training in green economy in transport skills are indicated on Table 6.5. Although respondents recognized the importance of all levels of education, universities and FETs were ranked highest while university of technology and SETAs were least. This implies that respondents recognized the importance of mainstreaming the green economy at all levels of study. Lethoko (2014) reported that transition to green economy will require a complete overhaul of the education system from pre-primary up to tertiary level, creating the need to look closely at the training that is being offered within secondary schools, vocational schools and tertiary institutions such as universities and universities of technology in South Africa. Nenngwekhulu (2017) also noted that since green growth requires higher education qualification for both high and low profile positions, it is important to ascertain the teaching gap so that graduates and unskilled unemployed people can be trained to acquire green jobs. This also confirms that mainstreaming the green economy at all levels of study will ensure inclusion people in both high and low profile positions in green transport.

The results indicated the need for a combination of both three to four years degree programmes as well as short courses (Table 6.6). The three to four year degree programmes were preferred by more respondents. This is likely to be due to that

Table 6.6 Training preference

Training preference	% of respondents
Three to four year degree programmes	57.7%
Short courses	42.3%

the majority of the respondents (Table 6.1) were university students and government officials who would aspire to acquire university qualifications.

6.3.3 Challenges that Could Hinder Transition to Green Economy in Transport Sector and Suggested Policy Recommendations

Identified challenges that could hinder transition to green economy include inadequate training and awareness programs, lack of existing skills directly related to the green economy at work places and inadequate funding for skills development in the green economy (Fig. 6.1). The study in Limpopo Province found that most organisations (70%) did not have training and awareness programmes on green transport (Fig. 6.1). Environmental issues are not considered seriously in most organisations while a few respondents indicated that driving skills and use of fuel with low sulphur content are encouraged at their organisations. Workshops are concentrated on safety and misuse of avoidance initiatives, though conducting such programs is limited by lack of funds.

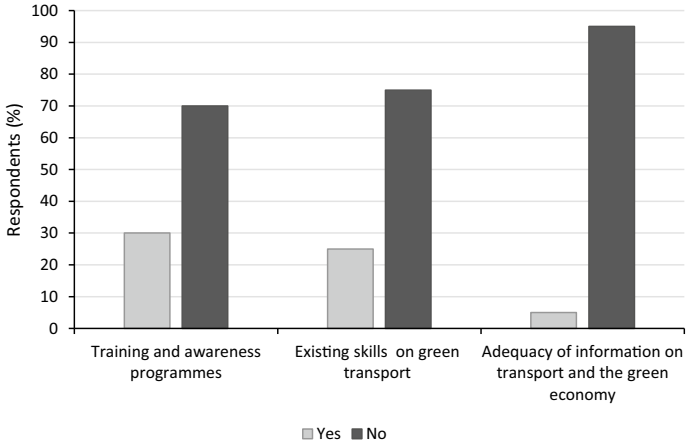

Fig. 6.1 Responses on training and awareness, existing skills on green transport and adequacy of information on transport and the green economy in Limpopo Province

Most of the respondents (75%) indicated that they did not have any skills directly related to green transport but the skills that they have could be improved through re-training and short courses. Nenngwekhulu (2017) also noted that the major limiting factor in the development of a green economy in Gauteng Province is the availability of the appropriate skills and policies to enable such developments. Thus, lack of skills is also expected to affect transition to green economy in transport sector within Limpopo Province. A few (25%) respondents indicated that they had skills in driving to minimise emissions and save petrol. An example is that 'cars must be driven in the right gear and at the right speed' as they noted. They felt that more environmental education was necessary at various businesses and establishments. A few respondents (especially students) felt that their training was relevant to the green economy especially courses taken in botany, chemistry, biological sciences, environmental sciences, ecology and resource management, pollution prevention. They, however, raised the need to mainstream the green economy in the curriculum. Hence, the need to develop tailor made training to the needs of various organisations was identified.

The study found that most organisations (95%) are struggling in raising funding to support programmes to transition into the green economy. A key stakeholder strongly felt that the transition should primarily be funded through existing budgetary allocations without further burdening the fiscus. It was felt that private and government entities should seek to redirect funding to promote green alternatives throughout their operations. The respondents' view was that only limited tax incentives should be granted to entities to support investments in the green economy. Nhemachena et al. (2015) indicated that barriers constraining the implementation of green economy initiatives in the municipalities within in Limpopo Province include lack of information, shortage of workers with full knowledge on green economy, shortage of training programmes on green economy and costs of implementation. This challenges are similar to those identified in this study.

Table 6.7 indicates policy recommendations to be considered for implementation in Limpopo Province to promote transitioning into the green economy in transport sector. These were obtained from questionnaire findings and discussions with stakeholders. In comparison with findings from related studies, Nhemachena et al. (2015) recommended improve awareness of green economy activities across all levels in Limpopo Province. Amis et al. (2018) also noted that there is a great need for increased awareness, shift in practice, and skilling and re-skilling to follow through the commitments made in government strategies and policies in South Africa. ILO (2011) reported that a lot of public policies are inadequate in addressing the skills component of adaptation and mitigation policies. Thus, the identified policy recommendations can be used to fill this gap in Limpopo Province in South Africa.

6.4 Conclusions

Skills required for transitioning into green economy in the transport sector preferred careers and institutions, challenges that could hinder transition to green economy

Table 6.7 Short, medium and long term policy recommendations

Short and medium term	Long term
• Making use of existing institutions such as University of Venda, University of Limpopo, TVETs, FET Colleges • Green growth capacity building for public administrators and policy makers • Knowledge and skills transfer to be identified following the value chain based on the jobs required for each mode of green transport: – Bicycle repairs, manufacturing of batteries for green cars, trains with green lighting and security – Transforming jobs: a mechanic who used to repair petrol buses maybe trained to become an electrical mechanic – Drivers should be reskilled to become train drivers, security conductors, ticket sellers, for example, within the rail system • Polokwane City's strategies to uplift local skills as a means of investing in local knowledge should be replicated in other areas of Limpopo • Taxi recapitalization for example, provides regulatory framework for knowledge and skills transfer • Public education for car owners • University students to be supported and encouraged to promote green awareness • Enforce adherence to environmental ethics • Public transport usage be encouraged • Training shop stewards to disseminate information to their members • A budget is needed for awareness activities of union members • Methodology to be developed on mainstreaming green economy in all work places • Mandatory training should be provided to staff. The implementation of green initiatives should be added to performance agreements of employees with points awarded for skills obtained and initiatives supported	• Mainstreaming green economy in university, college and school curriculum • Tax incentives should be provided to companies that invest in green economy initiatives and training • Skills developed at all levels on sustainable public transportation • Government to fund policy and legislation, and research and innovation related to green transport • National land transport act to include green economy considerations • Non-motorized transport usage and infrastructure development in all major towns • National transport policy in which training is a standing item • Providing transport service providers and their users with monetary incentives to encourage them to use transport alternatives which promote green economy • Implement policy on use of biogas • Enforce transport and climate change policies • Corporations in the transport industry should be the main funders of such initiatives. The training programs should form part of industries' Corporate Social Investment (CSI) initiatives • Businesses to make donation to support training which tax is deductible

in transport sector in addition to suggesting policy recommendations in Limpopo Province were identified in this study. A wide range of specific skills needs in the transport sector and their value chains with respect to alternative sources of fuel and different transport industries (passenger, freight and logistics, automotive industry (including manufacturing and retail)) were identified. The identified skills were within technical, management skills and knowledge on techniques and skills

on innovation and management for change categories, which are equally important for transition to green economy in the transport sector. The study found that many of the skills required in the transport sector correspond to those required for the general green economy. Thus, implementation of the green economy in all sectors of the Limpopo economy will have positive impact in the transport sector.

Most people chose environmental science as the most suitable career to follow in ensuring green economy, followed by engineering. Although respondents recognized the importance of all levels of education, universities and FETs were ranked highest while university of technology and SETAs were least. This implies that respondents recognized the importance of mainstreaming the green economy at all levels of study. Identified challenges that could hinder transition to green economy include inadequate training and awareness programs, lack of existing skills directly related to the green economy at work places and inadequate funding for skills development in the green economy. Some of the identified policy recommendations include green growth capacity building for public administrators and policy makers, knowledge and skills transfer should be identified following the value chain based on the jobs required for each mode of green transport, development of methodology on mainstreaming green economy in all work places, mainstreaming green economy in university, college and school curriculum, government to fund policy and legislation, and research and innovation related to green transport.

References

Amis A, Montmasson-Clair G, Lugogo S, Benson E (2018) The green economy barometer 2018 South Africa. Cape Town/Pretoria, South Africa, 25 pp. www.greeneconomycoalition.org

Brown M (2015) Developing and using green skills for the transition to a low carbon economy. Aust J Adult Learn 55(2):182–203. https://doi.org/10.3316/informit.328559312611572

CSIR (2014) Steering towards a green economy, a quick reference guide. CSIR report number: GWDMS StelGen 13604 v2, 78 pp

DEA (2010) Environmental sector skills plan for South Africa. Department of Environmental Affairs, Pretoria, South Africa, 44 pp

DHET (2011) National skills development strategy III, progress report 2011–2013. Department of Higher Education and Training, Pretoria, South Africa, 149 pp

IDC (2012) Transitioning to a low-carbon economy. Presentation to the forum on the impact of the implementation of response measure, Doha

ILO (2011) Skills for green jobs a global view. International Labour Organisation. https://www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/@publ/documents/publication/wcms_159585.pdf

ILO (2017) Skills for green jobs: South Africa, an updated country report. OneWorld Sustainable Investments. https://oneworldgroup.co.za/wp-content/uploads/2018/10/20170915-ILO-Skills-for-Green-Jobs.pdf

LEDET (2013) Limpopo green economy plan including provincial climate change response. Department of Economic Development and Tourism, Polokwane, South Africa, 54 pp

Lethoko M (2014) Green Economy job projections vs green skills: is there a link between present skills base and the projected numbers in South Africa? Int J Afr Renaiss Stud Multi Inter Transdiscipl 9(2):113–132. https://doi.org/10.1080/18186874.2014.987959

Maclean R, Jagannathan S, Panth B (2018) Education and skills for inclusive growth, green jobs and the greening of economies in Asia: case study summaries of India, Indonesia, Sri Lanka and Viet Nam. Technical and vocational education and training: issues, concerns and prospects, vol 27. Springer Nature Singapore, 198 pp. https://doi.org/10.1007/978-981-10-6559-0

Mpumalanga Provincial Government (2016) Mpumalanga green economy roundtable. In: Roundtable proceedings report, 31 pp

Musyoki A (2012) The emerging policy for green economy and social development in Limpopo, South Africa. Occasional Paper Eight: Social dimensions of green economy and sustainable development. United Nations Research Institute for Social Development, Geneva, Switzerland, 17 pp

Nenngwekhulu N (2017) Development towards green growth in Gauteng province: opportunities and challenges. In: TIPS annual forum 2017, 13 pp

Nhemachena C, Jonas S, Karuaihe S (2015) Understanding of the current practices, challenges and opportunities of the green economy in Limpopo Province. J Public Adm 50(1):6–31. https://hdl.handle.net/10520/EJC175619

OECD (2014) Job creation and local economic development. OECD Publishing. https://doi.org/10.1787/9789264215009-en

PAGE (2016) Green economy learning assessment South Africa: critical competencies for driving a green transition. DEA, DHET, UNITAR and Rhodes University, Pretoria, South Africa, 51 pp

PAGE (2017) Green economy inventory for South Africa: an overview. DEA, ILO and UN Environment, Pretoria, South Africa, 90 pp

Slingenberg A, Rademaekers K, Sincer E, van der Aa R (2008) Environment and labour force skills: overview of the links between the skills profile of the labour force and environmental factors. European Commission, DG Environment, Rotterdam, The Netherlands, 77 pp

UK Government (2011) Skills for a green economy, a report on the evidence. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/32373/11-1315-skills-for-a-green-economy.pdf

WHO (2011) Green and healthy jobs in transport: launching a new partnership under THE PEP. https://www.unece.org/fileadmin/DAM/thepep/en/publications/THE.PEP.Green.Jobs.e.pdf

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Chapter 7
Regulatory Frameworks, Policies, Norms and Standards

James Chakwizira

Abstract This chapter provides a review of policies, strategies, and regulations in the transport sector. The narrative plays out in terms of outlining national, provincial, and local application dimensions and impacts of transport using green transport lenses. The different application scales for transport policies, strategies and regulations as enunciated through different spheres of government constitutes the main thread of the discussion. In any case, the impact and outcomes of government and non-governmental transport intervention are discussed from a green transport perspective. Complementary to this, the role and scope for norms and standards in promoting green transport policy, innovation and activities is outlined. A thematic approach is used in unpacking green transport issues with respect to transport in Limpopo province. The analysis is anchored within the green transport systems theory of innovation framework.

Keywords Green transport · Norms and standards · Policies · Strategies · Regulations · Systems

7.1 Introduction

Literature review corroborates that transport has long been acknowledged as being the heartbeat of South Africa's economic growth and social development (Dewar and Todeschini 2017; Dimitrov 2012; Plan 2010; Walters 2013). Thus, transport is a proven structuring element and instrument for building and developing local, regional, and international markets, facilitates inter and intra-trade, linking and connecting people, places, spaces with communities across the world. However, at the same time, the transport sector is heavily reliant on conventional, fossil-based fuels and therefore, contributes to the problem of not only climate change but poor

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urban quality, given that the road sub-sector is the fastest growing in developing countries like South Africa (Broto and Bulkeley 2013; Creutzig et al. 2015; Jennings 2015a, b; Turner 2017). Greenhouse gas emissions from the transport sector are said to be the fastest growing but, at the same time, the sector as a whole also offers the highest climate change mitigation potential, estimated at around 34% if appropriate mitigation interventions are to be made (Borel-Saladin and Turok 2013; Bulkeley 2013; Chakwizira et al. 2011; Davoudi et al. 2009; Farid 2016; Meyer et al. 2007; Wilbanks et al. 2012). A green transport strategy is necessary in the transport sector as part and parcel of contributing to the "National Climate Change Response Policy and the Green Economy Accord, but also implementation of Chapter 5 of the National Development Plan" (Gupta and Laubscher 2017; Jennings 2015a, b; Labuschagne and Ribbens 2014). Under commitment 9 of the Green Economy Accord, the Department of Transport has committed to reducing carbon emissions on national roads. However, the transport sector makes contributions that cut across other Accord commitments, such as commitment 4 on energy efficiency and commitment 6 on biofuels (Borel-Saladin and Turok 2013; Brent 2016; Death 2014; Mohamed et al. 2014). Exploring the implications of policies, strategies, regulations, norms, and standards in the transport sector is therefore an important aspect in the quest to transition to a low carbon economy in South Africa.

7.2 Literature Review

Addressing climate change through a transport lense requires cooperation by government and non-government sectors operating at different spatial scales (Bobbins and Culwick 2015, Broto and Bulkeley 2013, Cilliers and Camp 2013; National Planning Commission 2013b; Oranje and Merrifield 2010). The issue of transport justice and equity has increasingly gained prominence in literature emphasising the cardinal role that transport interventions can contribute towards spatial transformation aimed at tackling spatial fragmentation and automobile dependent high energy consumption systems and spatial set-up, typical of the post-apartheid South African settlement system (Davoudi et al. 2009; Jennings 2015a, b; Schalekamp and Behrens 2010; Venter 2013). The need to address spatial mismatches between job density and opportunities with location of residential areas especially for low-income earners remain a stubborn matter requiring decisive measures in post-apartheid South Africa (Farid 2016; Musyoki 2012; Rogerson 2017). At the same time spatial fragmentation continues to manifest in the form of social exclusion, deprivation and perpetuated disadvantages for marginal and low-income settlement residents in South Africa (Chakwizira et al. 2011; Dimitrov 2012; Van Wyk 2015; Walters 2014). The fractured and splintered nature of settlements encourages spatial and housing settlement gentrification which reinforces inherited inequities, encourages continued growth, and use of private motors cars (Bruwer and Andersen 2015; Chakwizira 2015, 2016; Dewar and Todeschini 2017; Turok 2012). The automobile dependent economy places a high premium on energy consumption as well as generation of green-house gases

in the atmosphere leading to climate change (Banister 2011; Bulkeley 2013; Dickey 2017; Viitanen and Kingston 2014; Wilbanks et al. 2012). The impact of climate changes entails the need to rethink spatial and settlement planning, infrastructure, and mobility systems in both urban and rural areas (Creutzig et al. 2015; Dulal et al. 2011; Hickman et al. 2010; Marsden and Rye 2010; Meyer et al. 2007; Stanley et al. 2011; Turner 2017; Wilbanks et al. 2012). While transport policies, framework, legislation, norms and standards, surveys and studies have been conducted at international and national level, similar studies have not been cascaded and implemented at provincial and local level to the same degree with particular reference to South Africa (Koma 2010; Montmasson-Clair 2012; Mtembu and Pillay 2017; Nhemachena et al. 2015; Economic Policy Reforms 2010; Wentworth 2014). A study that therefore focuses on green transport economy in Limpopo becomes instructional as it seeks to unravel the nuances and subtle matters linked to transport policies, framework, legislation, norms, and standards at the provincial, district and local level within the purview of a predominantly rural province in South Africa. Understanding the implications that appropriate and adequate transport policies, framework, legislation, norms, and standards, play in anchoring a low carbon economy is therefore of fundamental importance.

7.3 Research Methodology

The empirical research approach employed involved interviews with Key Informants (KI). The chapter utilizes a case study approach of Limpopo province to unpack the green transport policies, framework, legislation, norms and standards matters. Case studies have been argued to be an appropriate methodology for gaining in-depth insights of a phenomena and process through the application of the attitudes, knowledge, awareness and practices (AKAP) tool or methodology as exercised in this instance (Casey and Houghton 2010; Mahlatji 2013; Montmasson-Clair 2012). Case studies also arise from the need to understand complex socio-economic dynamic matters such as the link and implications that green transport policies, framework, legislation, norms, and standards pose within the transport governance framework and system (Geels 2011; Lawhon and Murphy 2012; Yin 2003).

7.3.1 Questionnaire Survey

A research questionnaire with 26 close and open-ended questions was developed to guide the interview process. Researcher assistants were drawn from the Transport, Education and Training Authority (TETA) Sponsored project master's student cohort. The researchers were trained in the questionnaire survey methodology and administration by the Senior researcher responsible for the theme. The questionnaire was pilot tested within the project team at the University prior to being tested

at the TETA Workshop with participants held at Polokwane Ranch Hotel. During the workshop the questionnaire was shared with delegates for feedback and input aimed at further strengthening the questionnaire format, questioning style, format, organisation, general flow, and relevance of questions for the subject under investigation. Through these exercises, combined questions that needed to be open ended and those that required being coded and close ended questions were identified and developed. The final outcome of the series of internal and external peer review of the questionnaire instrument was the final questionnaire that was used in executing the research project. In any case, the Client (TETA) was also consulted for approval prior to administering questionnaire interviews in the field. Overall, the methodology for data collection employed was purposive random sampling focusing on selected key stakeholders in the province.

7.3.2 Stakeholder Mapping and Consultation

A list of key transport and green transportation related database was generated in consultation with TETA. Table 7.1 presents the transportation stakeholder list which was consulted to gain insights and knowledge on green transport issues in Limpopo province.

7.3.3 Secondary Data Analysis

Studies that deal with legislation requires document analysis of policy, strategy, and legislative documents available in the public domain. Table 7.2 presents the list of documents consulted and analysed for gaps, opportunities, and issues regarding transition towards a green transport in Limpopo province.

From Tables 7.1 and 7.2 we can deduce that a mixed research method was used. Central to the operationalization of the mixed method was the use of the snowball technique in assisting to address key issues. Techniques such as gap analysis and strength, weakness, opportunities, and threats (SWOT) analysis were utilised in identifying the challenges that existing policy, legal and strategic transport and transport related documents present in the context of Limpopo Province.

7.3.4 Analytical Framework

Thematic analysis of policy, strategy and legislative documents covering green transport was conducted within the purview of the green transport systems theory of innovation framework. The spatial and human settlement planning and management models of polycentric and monocentric nodes/hubs, central place theory, transplant

Table 7.1 Sample list of stakeholders consulted in the Green Transport Project in Limpopo province

Government departments	Universities and educational institutions	Research institutions	Members of professional bodies consulted
"Department of Transport (DoT)"	University of Venda	Council for Scientific & Industrial Research (CSIR)	South African Planning Institute (SAPI)
"Limpopo Department of Roads and Transport"	University of Limpopo		South African Council of Planners (SACPLAN)
"Department of Roads, Public Infrastructure and Planning"	University of Johannesburg		Engineering Council of South Africa (ECSA)
"Limpopo Department of Economic Development and Tourism (LEDET)"	TVET Vhembe		South African Institution of Civil Engineering (SAICE)
"Department of Economic Affairs"			Council on Built Environment (CBE)
"The Department of Cooperative Governance, Human Settlements and Traditional Affairs (CoGHSTA)"			
"South African Local Government Association (SALGA)"			

cities and rural areas, industrial satellite cities, cluster cities and regions, hub and spoke urban and rural areas, university towns, resource and tourism based cities, functional settlement and regions as well as transport governance and innovation systems are the building blocks in unpacking green transport policies, framework, legislation, norms and standards in Limpopo province (Chakwizira and Mashiri 2009, 2017; Geels 2011; Lember et al. 2011).

Table 7.2 Sample list of legal, policy and strategic documents consulted for the Green Transport Project in Limpopo province

Legal document	Policy documents	Strategic documents
Spatial Planning, Land use and Management (SPLUMA) (2013)	Rural Transport Policy (2007)	Limpopo Provincial Growth and Development Plan (2009–2014)
National Environmental Management Act (NEMA) (2008)	Public Transport Strategy & Policy (2007)	Limpopo Land Transport Framework (2009)
Municipal Structures Act (MSA) (1998)	National Development Plan (2030)	Limpopo Freight Databank & Policy (2011)
Municipal Systems Act (MSA) (2003)	New Growth Path (2011)	Limpopo Spatial Development Plan (2016)
National Land Transport Act (NLTA) (2009)	Sustainable Development Goals (2016)	Limpopo Spatial Development Plan (2007)
	Limpopo Green Economy Plan (2013)	Integrated Development Plans (IDPs)—All Municipalities in Limpopo
	The Moving South Africa (MSA) study (1998)	Integrated Transport Plans (ITPs)—All Municipalities in Limpopo Province
	"National Freight Strategy (2005)"	National Master Plan (2050)
	"The National Land Transport Strategic Framework (2012–2017)"	Limpopo Rural Transport Plan (2009)
	The Industrial Policy Action Plan (2011/12–2013/14)	Energy Efficiency Strategy (2005)
	National Strategy for Sustainable Development 2011–2014 (NSSD1)	White Paper on National Transport Policy (1996)
	National Climate Change Response Policy (NCCRP), 2011	National Climate Change Response White Paper (2011)
	"Draft Policy and Strategy Framework for Green Economy in the Context of Sustainable Development: Towards Implementation of the National Development Plan, 2014"	

7.4 Discussion of Research Findings and Results

7.4.1 Status Quo of South Africa's Transport Policy and Legislative Framework with Respect to Green Transport

The status quo within "South Africa's transport sector has been informed by a number of legislative and policy documents, most of which have been developed since the advent of a new democratic dispensation, and some of which have been inherited from previous dispensations" (Walters 2013, 2014). "The Constitution Act 108 of 1996 mandates the President and other members of Cabinet with the responsibility to develop national policy" (McKay et al. 2017). "This mandate places responsibility on the Minister of Transport to ensure that any development and implementation of national transport policy by the DoT addresses the mobility needs of all citizens" (Chakwizira 2016; Goetz and Schaeffler 2015). "The Constitution assigns different roles and responsibilities to each sphere of Government. With specific reference to transport matters, Schedule 4 Part A of the Constitution assigns Public Transport as a functional area over which both the National and Provincial governments have concurrent jurisdiction, whilst Local Government has a responsibility for Municipal Public Transport" (Marsay and Seobi 2010; Schalekamp and Behrens 2010). The Constitution does not, however, define Public Transport nor does it make reference to green transport. Table 7.3 presents a high-level summary of instructive national policy frameworks and strategic documents supporting the green economy.

In short, Table 7.3 presents that South Africa's short, medium and long-term national spatial and transportation vision includes the need to plan for environmentally sustainable, climate-change resilience, and a transition to a low-carbon economy and just society (National Planning Commission 2013a). Pursuant to the need to monitor and evaluate progress with respect to moving "*towards a green economy*" strategy, green economy indicators were identified, which also cover the transport domain (Goetz and Schaeffler 2015; Mtembu and Pillay 2017). However, to date finding data for the measurement of the green economy indicators has however proved to be a challenge and in particular for the various sub-sectors in the transport industry (Bobbins and Culwick 2015). Inclusive green transport thus entails the robust deployment of fuel efficiency for public and private vehicles as a critical part of both the energy and transport policies (Pasquini et al. 2015). Efforts in the energy sector to move toward green transport also include the use of clean fuels to minimize pollution (Labuschagne and Ribbens 2014). As a result, the use of natural gas is an alternate fuel to gasoline and diesel which is being actively explored—for public transport fleets in the short term and for private vehicles in the longer term.

7.4.2 Green Transport Strategy

In the interim, the current Mid-Term Strategic Framework period, the Department of Transport has finalised and approved the Green Transport Strategy (GTS) and Implementation Plan, 2018. The GTS is a strategic document that complements

Table 7.3 National policy frameworks and strategy documents supporting green economy and transport in South Africa

Policy framework	Provision	Implications for the transport sector and green transport
"National Strategy for Sustainable Development 2011–2014 (NSSD1)"	"The NSSD1 identifies "towards a green economy" as being one of the five key priorities for the transition towards a green economy encompassing green transport sector growth and management"	"The need to transit to low transport technologies"
"National Development Plan (NDP), 2011"	"Green economy discussion is largely orientated around the promotion of renewable energy, application of energy efficient technologies, developing a resource efficient low carbon economy in which clear strategies for both adapting and reducing the carbon emissions from the transport sector are clearly articulated"	"The need to explore alternative sources of fuel for the transport sector" "The need to move towards public transport systems rather than retain a motorised approach to development" "The need for compact, smart and integrated urban and rural settlements"
"2020 New Growth Plan (Accord 4: Green Economy Accord), 2011"	"The 2020 New Growth Plan identifies the Green Economy as being one of the key sectors for growth. The Green Economy Accord prioritises green industries and manufacturing through a localised strategy that uses the enormous spending on climate change-induced technologies to create local industrial capacity, local jobs and local technological innovation. The opportunities in the green economy are described as varied and include energy efficiency, recycling, green buildings and biofuels"	"Implications regarding transport sector green industries and value chain promotion and development" "The need to anchor transport sector green procurement systems in the industry and beyond" "Provision and deployment of transport sector green infrastructure investment and incentives" "Transport sector green road, rail, aviation and maritime construction and building materials"

(continued)

Table 7.3 (continued)

Policy framework	Provision	Implications for the transport sector and green transport
"National Climate Change Response Policy (NCCRP), 2011"	"The NCCRP aims to promote investment in human and productive resources that will facilitate the growth of the green economy and that government will have to increase the mobility of labour and capital out of carbon intensive sectors and industries and move towards greener productive sectors and industries"	"Transport sector green skills, capacity building and training" "Transport sector knowledge economy" "Transport sector creative and innovation economy"
"Industrial Policy Action Plan (IPAP), 2013"	"The IPAP identifies green industries as being a priority area and supports the state's comprehensive and integrated drive to scale up industrial policy by developing and designing sector-specific incentives for strategic areas, including the green industry area"	"Transport sector green industry development roadmap implementation plan"
"Draft Policy and Strategy Framework for Green Economy in the Context of Sustainable Development: Towards Implementation of the National Development Plan, 2014"	"The Draft Policy and Strategy Framework states that in terms of the 2010 green economy deliberations, South Africa views a green economy as a sustainable development path based on addressing the interdependence between economic growth, social protection and natural ecosystem"	"Green transport is part of the wider green economy enabling and intervention framework"
"Medium Term Strategic Framework for 2014 to 2019"	"The framework defines the strategic objectives and targets of government with respect to key green economy issues such as job creation; skills development and infrastructure; sustainable human settlements; and rural development"	The Department of Transport developed a Green Transport Strategy and Implementation Plan, 2018 to guide the sector response

(continued)

Table 7.3 (continued)

Policy framework	Provision	Implications for the transport sector and green transport
"NATMAP, 2050"	"Long term efforts towards transitioning to a green economy in the immediate and long term, way beyond year 2050"	"Implement low carbon transportation systems i. Mass transport ii. Electric vehicles Remove subsidies for fossil fuel and penalise inefficiency (high fuel consumption)" "Engage in a long-term strategic shift away from private car use and support for mass transit, public transport, rail, etc." Explore ways to work closely with Transnet to significantly improve Spoornet so that freight is moved much more by rail than road transport"

Sources Black (2010), National Planning Commission (2013b), Emeran et al. (2013), Giles-Corti et al. (2016), Letsoalo (2013), Masson et al. (2017), McKay et al. (2017), Musyoki (2012), Nhemachena et al. (2015), Pasquini et al. (2015), Schoeman (2015)

the National Climate Change Response Policy (NCCRP) of 2011, and sets out the environmental directive of the DoT. It is envisaged to be an all-encompassing document, covering all modes of transport; and packaged in such a way that it includes *all economically viable climate change mitigation measures and options across the modes, based on their peculiarities, to avoid a "one-size-fits-all" approach*, which may be inappropriate and impractical to implement for some transport sub-sectors. The goal of the GTS is to promote transport that reduces emissions and associated with transport systems while supporting the contribution of the transport sector to the social and economic development of the country.

From the innovation and technology development point of view, it is envisaged that the strategy is all encompassing, and also investigates other transport-related mitigation options such as electric vehicles and promotion of cleaner or alternative fuels for the sector. To this end, the Department is working closely with the Department of Energy on exploring possible options to make electric vehicles more affordable so as to promote their uptake and remove any market barriers related to the uptake of cleaner fuels such as "*Compressed Natural Gas, or BioGas*". The Department of Transport is thus committed to the reduction of Greenhouse Gasses through several climate change mitigation partnerships such as the "*Nationally Appropriate Mitigation Actions*", or NAMAS. NAMA's are emissions reduction measures by the United Nations Framework Convention on Climate Change (UNFCCC) Parties that are reported by national governments. They can also be referred to as a set of policies and actions that countries undertake as part of their commitment to reduce their

Greenhouse Gas emissions. NAMAs also emphasises financial assistance from developed countries to developing countries to reduce emissions. Furthermore, developing countries NAMAs can be tailored to suit their national circumstances. In 2011 the Department, in partnership with the Department of Environmental Affairs, initiated the transport NAMAs through the project "*Establishing Transport NAMAs in South Africa*", these projects include:

- The up-scaling of the Bus Rapid Transit (BRT) systems;
- The shift from "Road to Rail"
- The promotion of Non-Motorised Transport; and
- The Cleaner Fuels Initiative.

7.4.3 The Intersection of the Transport Policy and Legislative Framework with Energy Dimensions

A review of the regulatory requirements relating to alternative low carbon fuels such as gas and biofuels yields exciting findings. The Gas Act (No. 48 of 2001) stipulates certain licensing requirements that apply to commercial transmission, storage, distribution, liquefaction or re-gasification facilities or to trade in gas, but these do not represent an unnecessary burden to stakeholders. Similarly, consulted stakeholders in Limpopo do not regard the more extensive regulations covering biodiesel and ethanol under the Petroleum Products Act (No. 120 of 1977) and subsequent amendments, to be obstacles to the take-up of these transport fuels. The energy policy framework comprises various key development-based policies and integrated plans, which together indicate that the government considers natural gas and biogas as central to South Africa's energy mix. Table 7.4, presents a tabular illustration linking the transport policy and energy nexus dimension in South Africa.

From Table 7.4, we can deduce that a strong nexus exists between transport and energy in South Africa. The relationship has ramifications regarding the need for full cycle analysis and implementation in the transport and energy planning sectors, transportation manufacturing, construction and infrastructure maintenance and rehabilitation value chain. Consequently, in consultation with various industry stakeholders, the National Planning Commission (NPC), departments of energy and trade and industry, and National Treasury are in the process of drafting the Gas Utilisation Master Plan (GUMP), which will take a 30-year view of the industry from a regulatory, economic, and social perspective. Initially commissioned to diversify South Africa's energy production mix with conventional and unconventional gas, GUMP has developed to include industry and infrastructure planning models and acknowledges that it should also inform the gas IPPs. The latter development directly affects the downstream petroleum sector. The NPC recognises that, for gas exploration and production to remain viable, suitable downstream entities will need to provide the demand. Gas Independent Power Producers (IPPs) are expected to provide the initial demand but, for sustainability purposes, other downstream players will also need to

Table 7.4 Linking the transport policy and energy nexus dimension in South Africa

Policy	Content
Competitive Supplier Development Programme (CSDP)	The CSDP aims to improve the capacity and competitiveness of the local supply base and contribution to growth, employment creation, poverty reduction, skills development, and Broad Based Black Economic Empowerment (B-BBEE) imperatives. These aims are to be achieved primarily through the requirement for local manufacturing
National Industrial Participation Programme (NIPP) and Industrial Policy Action Plan 2012–2015 (IPAP)	The NIPP and IPAP consider transportation to be a key multiplier for economic development. An important development sector identified is fleet programmes and products, albeit in the context of supply chains and local manufacturing, rather than the provision of a municipal service IPAP also considers biofuels development to have significant economic development potential because of its strong linkages to agriculture, manufacturing and distribution, and its ability to create substantial numbers of labour-intensive jobs in the agriculture sector. Government has committed to a 2% blend target for including biofuels in the national fuel supply but is looking to increase this to 10%, which would create approximately 125 000 direct jobs

contribute to demand. This offers scope for downstream petroleum sector players, such as municipalities intending to switch municipal bus fleets to gas, to introduce BRT system as well as the need to transition public transport buses and minibus taxi buses (MBTs) to benefit immensely from the GUMP process. The need to provide viable alternatives, such as "*Alternative Cleaner Fuels and Efficient Vehicle Technologies*", programs to reduce private car usage by providing efficient, safe and reliable public transport as well as non-motorised transport infrastructure is therefore a central recommendation for the green transport agenda in Limpopo.

7.4.4 South Africa's Transport Policy and Legislative Framework Implications for Green Transport Innovation and Technologies

Historically, South Africa's success in the automotive industry has been the driver behind efforts to develop an electric vehicle industry. The Department of Trade and Institute (DTI's) second Industrial Policy Action Plan (IPAP2) includes the commercialisation of electric vehicles, and appropriate support to encourage local manufacture of Electric Vehicles (EVs) and related components, installation of infrastructure

for such EVs, creation of testing facilities, provision of demand-stimulation mechanisms, and public education on the use and benefits of alternative-energy vehicles. Led by the DTI, the plan was supported by the DoT, the Department of Science and Technology, provincial governments. The need for such policy expression to become a reality in Limpopo Province is critical as currently no green car manufacturing plant is in the province.

7.4.5 Norms and Standards in the Transport Sector of South Africa

Another critical dimension of the green transport discourse is the role and scope for transport norms and standards in making green transport transition easier in Limpopo province. A clear norms and standards set-up will entail that green transport transition will happen with minimum challenges. Norms and standards for the green economy and transport sector in South Africa can be deduced from legislation, policies and strategies. Key legislation, policies and strategies including the associated norms and standards are presented in Table 7.5.

Table 7.5 Derives norms and standards in the transport sector of South Africa

Legislation	Norms and standards	Implications for transport sector
NLTA (2009)	Integrated transport planning Joined up transport governance	Integrated land use and transportation planning Developmental local government Cooperative local governance
SPLUMA (2013)	Spatial resilience Spatial economy Spatial efficiency Good administration Mixed housing Compact settlements Integrated housing and settlements Spatial integration	Inclusive green transport economy Transport sector resilience Transport technology efficiency Transport systems and governance Sustainable human settlements Adaptive and green transport infrastructure and services
NEMA (2008)	Environmental sustainability Environmental impact assessments Traffic impact studies Environmental mitigation and Adaptation	Sustainable transportation and services Transportation mitigation and adaptation Emissions standards
NATMAP (2050)	Low carbon economy Compact settlements Integrated settlements Appropriate transport technologies Public transit systems Bio-fuels and alternative energy sources	Green transportation Transit Orientated Developments (ToDS) Efficient energy vehicles Efficient transport technologies Alternative fuel types and combustion engine types

Table 7.5 presents norms and standards that exist for measuring transformation towards a green economy and transport sector in South Africa. The challenge though is the lack of adequate datasets and information on indicators or measuring criteria. In addition, achieving the norms and standards in the transport sector is hamstrung by financial, technical and human skills constraints.

7.4.6 *Green Economy and Transport Initiatives in South Africa*

Table 7.6 presents some examples of green economy and transport initiatives in the South African provinces. What stands out from the table is that all provinces in South Africa including Limpopo which is the case study of this project have virtually developed green economy strategies and frameworks meant to assist in implementing "towards a green economy" national plan.

Table 7.6 Examples of green economy and transport initiatives in South African provinces

Province	Green economy and transport initiate
Gauteng	"In 2010 Gauteng Province's Department of Economic Development finalised its provincial strategy for a developmental green economy. The strategy responded to international trends, as many cities, city-regions and other similar areas had begun investing heavily in green technologies and creating green jobs in a post-economic crisis environment where sustainable growth becomes the norm. A further incentive is the need to avoid environmental taxes and penalties. The overall goal of the strategy is sustainable growth and job creation for Gauteng"
Kwa-Zulu Natal	"In 2012 KwaZulu-Natal's Department of Economic Development and Tourism published its green economy strategy with the principal aim of supporting and directing the re-orientation and growth of the province's economy to become increasingly competitive and resilient, and to reduce poverty, create sustainable jobs for local citizens, and address social equity throughout the province. There are three specific goals listed in the strategy: *Goal 1*: Leverage the green economy through greening provincial government investments, activities and operations *Goal 2*: Create "enabling conditions" for the development of the green economy; and *Goal 3*: Unlock the green economy through turnkey/pilot projects in the green economy"
Limpopo	"In June 2013 the Limpopo Province's Department of Economic Development, Environment and Tourism published the province's Green Economy Plan—Including Provincial Climate Response. The plan identifies short, medium and long-term green economy goals for the province: *Short-term*: Generate jobs; Improve environmental quality *Medium term*: Create enabling conditions for green growth; Change behavioural and production patterns, and *Long-term*: Build a new economic/environmental paradigm for Limpopo"

From Table 7.6 we also identify that green economy and transport is an inclusive rather than exclusive concept and approach. Interventions and programmes aimed at promoting green economy and transport are predicated on the need to create jobs, alleviate poverty and encourage greater economic diversification and growth patterns in the economy.

However, while green growth and green economy discussions at a metro level are not yet fully developed, there are initiatives within the major metropolitan cities of South Africa aimed at anchoring green transport interventions much more strongly. Examples include the Cape Town's *MyCiti* Integrated Rapid Public Transport System, Johannesburg BRT *Rea Vaya*; Tshwane's *Areyeng*, Ekurhuleni's *Harambee* and Gautrain. These are public transport integrated bus rapid systems aimed at encouraging a modal shift from the less energy and fuel efficient private transport system towards a more efficient urban mass transit system. Table 7.7 presents a sample of green transport initiatives in South Africa.

From Table 7.7, we can deduce that there are several existing platforms that can be used to promote strategic environmental protection and sustainable economic development making use of a green economy and transport approach, such as the Climate Change Municipal Support Programme. In this envisaged approach, onward feedback loops into local Integrated Development Plans (IDPs); Comprehensive Integrated Transport Plans (CITPs) etc. as practised in the city of Cape Town are pronounced. The green economy and by extension green transport dimensions presents opportunities to address service delivery challenges with new and more sustainable solutions that are more resource and cost efficient and more resilient over the longer term. Many municipalities have recognised over time the need to invest in greener infrastructure and related climate change projects. The Municipal Finance Management Act 56 of 2003 allows for this investment, but there are some constraints, such as inadequate budgetary allocations particularly with respect to the capital outlay infrastructure and transport (including road and rail) requirements and investments projects with longer-term payback periods. Lack of capacity and skills is a further aspect, which can be mitigated through inter-governmental partnerships as well as partnerships with non-profit organisations and private companies. In Limpopo province there is need to appreciate the key role that public –private partnerships can play in helping to facilitate knowledge sharing and unlocking shared barriers for municipalities.

7.4.7 Sustainable and Safe Transport Policies and Programmes in Limpopo Province, South Africa

The Limpopo green economy plan highlights key interventions and considerations necessary to encourage the transition to a low carbon economy. Nationally, it is important to acknowledge that the transport industry has taken several steps to reduce CO_2 emissions and other environmental impacts, notably those associated with fossil-fuel combustion. Combined with growing demands for mobility, many

Table 7.7 A sample selection of green transport initiatives in South Africa

Area	Type of green transport intervention/program
Cape Town	"The City of Cape Town has adopted a UNEP-based definition of the green economy, emphasising low-carbon, resource efficient, socially inclusive solutions. The desired outcomes include identification of new economic opportunities, environmental risk-reduction and job creation. Within the broader green economy, the City has identified key roles for itself: • Ensure that the city remains attractive to investment by using appropriate regulations, incentives, and planning tools • Develop and market economic opportunities with competitive advantage, e.g. eco-tourism and renewable energy • Stimulate private sector growth through green procurement, green building, water and energy efficient technologies • Ensure greened and climate-resilient infrastructure, and • Build on Expanded Public Works Programme job creation to unlock longer-term job opportunities that reduce environmental risk and offer the opportunity for alternative methods of service delivery"
Greening infrastructure	"The Western Cape Infrastructure Framework (WCIF) aims to align all infrastructure development in the Western Cape to the province's strategic agenda, described in the One Cape 2040 Vision. It also has links to the Green is Smart Strategy Framework. The WCIF outlines a fundamental shift towards greening infrastructure in the Western Cape with key transitions in energy, water, transport, settlements and information, communication technology (ICT), including plans to: • Introduce natural gas processing and transport infrastructure to make gas available as a transition fuel • Promote the development of renewable energy plants in the province and associated manufacturing capability • Have more stringent water conservation and demand-management initiatives • Adopt more widely the reuse of wastewater effluent as standard practice • Adopt large-scale desalination once it becomes the "next best" option • Invest in public transport and non-motorised transport infrastructure, particularly in larger urban centres • Prioritise general rail freight over bulk rail freight • Shift freight traffic from road to rail along major routes • Diversify the housing programme, with greater emphasis on incremental options • Integrate settlement development, prioritising public service facilities in previously neglected areas, and • Increase the speed and functionality of existing ICT networks and supply new technology as it becomes available" "Implementation guidelines for the WCIF that incorporate measuring green transport have clear monitoring and evaluation indicators that have been prepared"

(continued)

Table 7.7 (continued)

Area	Type of green transport intervention/program
South African Green Economy Modelling Report (SAGEM)	"The SAGEM study was undertaken in 2013 at the request of the Department of Environmental Affairs (DEA) to assess potential opportunities to promote a green economy as set out by the National Development Plan—Vision 2030. Commissioned by UNEP, the assessment was led by Stellenbosch University and the Sustainability Institute of South Africa. It utilised the Threshold 21 framework developed by the Millennium Institute, customized for the South African context" "The SAGEM study comprised of a modelling exercise comparing a 'business-as-usual' investment scenario with other scenarios in which investments were allocated in various configurations to four critical green economy sectors, namely, natural resource management, agriculture, transport and energy" "Considering economic growth, poverty, employment, resource efficiency and climate change, the research showed that the strengthening of natural resource management and environmental protection is fundamental for sustained economic growth and wellbeing. Reducing emissions and conserving natural capital stocks in the short-term to profit from their healthier state in the future, benefitted both sustainable growth and wellbeing" "Overall, the model suggested that driving green economy investment was better for the economy than not. Concentrating investment in the energy sector was shown to maximize employment creation potential overall. This is due to additional infrastructure requirements in the sector. However, given an equal allocation of investment across the four sectors, agriculture showed the highest employment creation potential" "This work fed into the development of Green Accord, which forms part of the New Growth Path"

Sources Antal and Van Den Bergh (2016), Graichen et al. (2017), Mazzucato et al. (2018), Munang et al. (2013), Olhoff and Christensen (2018), Pasquini et al. (2015), Williams (2013)

eco-innovation initiatives have focused on increasing the energy efficiency of vehicles and other forms of transportation, while at the same time improving safety. Table 7.8 summarizes the transport sector green economy challenges with respect to Limpopo province. These challenges operate at all scales, spheres and sectors of government and non-governmental sectors. Table 7.8 presents highlights of some transport sector major challenges in Limpopo Province.

Letsoalo (2013, pp. 33–34) indicates that to promote faster development in transport sector as highlighted by the Table 7.8, there is a need for a more user-friendly policy and government intervention to enhance competition for new innovations, business ideas and strategies to manage the environmental impact on the transportation system. Some of the issues requiring the intervention is:

- Consideration of subsidising cost to convert a vehicle to an aftermarket alternative fuel system;
- Consideration of exempting taxis and buses powered by alternative fuels from paying road tax;

Table 7.8 Highlights of some transport sector major challenges in Limpopo province, South Africa

Identified issue	Challenge	Opportunity for action
Spatial planning	Land fragmentation	Bring people closer to work opportunities to reduce need for transport, align land-uses with public transport and pedestrian routes Review land regulations and operations Compile an updated Green House Gas inventory and Atlas for Limpopo province Enhance the use of existing infrastructure like the natural gas pipelines, existing distribution channels of LPG, existing petrol/diesel stations for biodiesel/bioethanol blends, including charging EVs at home or shopping malls or airports Promotion of modal shifts, favouring transport modes with high transport and fuel efficiency, e.g. high-speed passenger trains or rail such as the Johannesburg to Durban high speed passenger train as well as shifting freight from road to rail
Taxi industry	Transformation of taxi industry Disgruntlement with new arrangements such as BRT	Corporatization of taxi industry opportunity to move operators from second to first economy (i.e. from taxi owners to bus owners/operators
IRPTN projects—Polokwane	Integrated ticketing system Branding of public transport Roll-out and implementation of BRT project	New jobs created through bus operation like maintenance, fare collection, security can be quite sustainable moving into the future Develop comprehensive rail policy and programmes aimed at addressing inefficiencies in the rail sector thus promoting it as viable option for transportation of both goods and passengers

(continued)

Table 7.8 (continued)

Identified issue	Challenge	Opportunity for action
Alternative green technology and innovation	Deployment, cost, access, affordability and acceptability of new transport technologies in transit systems and for private vehicles	Testing next generation climate friendly buses including ethanol, CNG, and biodiesel buses in order to gain operational, environmental, and financial data on their impact Putting more emphasis on the introduction of electric and hybrid vehicles to mitigate climate change Synchronize the traffic lights Urban design for energy efficiency (bicycle roads, no car zones) Solar traffic lights Solar street lights Alternative energy vehicles Cars: Hybrid or electric Bus retrofitting (gas) Electric bikes Hybrid buses Gas fuel technology Biodiesel Hydrogen fuel cell Solar production of hydrogen for rail and public transport Biofuel Roads upgrading programme using environmentally responsible technologies (green roads)
Expanded public works programme	Upgrading EPWP to be compliant to green procurement and green job profiling requirements	Opportunity to secure funding to create green jobs within these projects
Building on momentum of the 2010 World Cup NMT initiatives	Development of NMT infrastructure and green jobs around 2010 roads projects	Utilise and development of NMT infrastructure and green jobs around 2010 roads projects and beyond
Shifts in policy direction	Take advantage of reviews of IDPs, ITPs, SDFs etc. to infuse and incorporate green transport components	Development of new policy direction around issues like climate response strategy for the transport sector, energy efficiency framework for the transport sector including cleaner fuel technologies and alternative fuels

Sources Broto and Bulkeley (2013), Giordano (2014), Letsoalo (2013), Rivett-Carnac et al. (2016)

- Consideration of exempting import duties and encouraging the setting up of manufacturing facilities in South Africa for products like toolkit development, dispensers, cylinders, batteries, etc.;

7.5 Transport, Policy, Norms and Standards in Limpopo Province: Case Study Findings

Transport, policy, norms and standards in Limpopo province are an extension of the national transport, policy, norms and standards. The issues, gaps, opportunities and challenges mirror those reflected at the national level. However, differentiated nuances emerge in the context of Limpopo province informed by unique geographical realities, context and the interplay of various development dynamics in the country.

7.5.1 Lack or Absence of a Provincial Green Transport Policy

Limpopo province does not have an explicit green transport policy that addresses the emergent green transport issues. Consequent to this, green transport initiatives and policy directions are approached by default and implicitly. It is for this reason among others that green transport is either addressed as a sentence, a few sentences, a paragraph or section in various policy documents. In this policy findings and recommendations, we thus argue that transport and by extension green transport is a specialised domain and field that requires undivided and indivisible attention if green transport matters are to occupy the rightful place in development debates. Table 7.9 presents selected highlights of a transport and related policy documents opinions from a provincial green transport perspective as indicated by surveyed stakeholders. While the Constitution (i.e. 28.5%) and the NDP (28.5%) are key national policy pronouncements, these are not enough in themselves for purposes of realizing a green transport compliant Limpopo province. Transport sector strategies and plans such as public transport strategy (14.28%), National Transport Master Plan (NATMAP) (14.28%) etc. do not provide structured green transport transitional measures to facilitate a seamless shift from a high carbon emitting economy to a low carbon emitting economy. Other complementary green transport policies, guidelines and regulations will need to be developed at the provincial and local level if green transport is to become a success.

From Table 7.9, we can further deduce that while transport policy documents exist at national level, these are not enough in themselves to ensure green transport implementation at the provincial and local level. In order to implement robust, flexible and resilient green transport policy provisions, there will be need to supplement and complement them with provincial green transport policy and guidelines attuned to Limpopo's local needs and requirements.

Table 7.9 Selected highlights of transport and related policy document shortcomings from a provincial green transport perspective

Name of policy document	Identified policy shortcoming	Frequency	%
Constitution of Republic of South Africa	Is generic and does not provides specifics to respond to new issues such as green transport	6	28.5
NATMAP, 2050	Was crafted prior to Climate change and green transport becoming topical issues and hence is silent on the matters	3	14.28
Public Transport Strategy, 2007	Addresses green transport by default and does not provide adequate guidance regarding green transport manufacturing, procurement and implementation guidelines for use at local or municipal level	3	14.28
National Development Plan (2030)	Identifies transition to a low carbon economy as essential and presents some broad-brush measures such as compact development and integrated spatial planning. However, this picture is illustrative and inadequate for local-level interventions needs	6	28.5
National Land Transport Framework (2014–2019)	Incorporates the need for low carbon transition in the transport sector but does not provide a province specific road-map and strategy for implementing low carbon transitions in each of South Africa's provinces	2	9.52
Others		1	4.76
Total		21	100

Sample size N = 21
Source Research Findings, 2016

7.5.2 Lack of or Absence or Inadequate Green Transport Budgeting and Accounting

While in the province, specific Departments such as Limpopo Department of Economic Development and Tourism (LEDET) and Limpopo Department of Roads and Transport (LDoR&A) have been charged with the responsibility to oversee green economy initiatives, budgeting and accounting systems beyond these main Departments is not clear. While Departments can and do indeed reflect and comment on green transport contributions and impact, this is as an addendum or after thought. At the same time, when budgets are being disbursed from Treasury, be it provincial or national there is no explicit budgetary line that indicates that such an amount is meant to promote exclusively green transport initiatives. As a result of this, beyond

Table 7.10 Suggested drivers for integrating green transportation and logistics initiatives in Limpopo province, South Africa

Options	Scale 1–5 (1 lowest and 5 highest)				
	1	2	3	4	5
Partnerships			6		
Decreasing CO_2				2	
Implement policies related to green transportation					4
Decrease conventional fuel consumption for bio-fuel				2	
Provide green transport (BRT)		4			
Incentives for individuals and companies towards a green transport economy			3		
Total	0	8	27	16	20
Rank	5	4	1	3	2

Sample size N = 21
Source Research Findings, 2016

LEDET and LDoR&T, green transport actions and measures are not explicitly tied to budgeting and funding flows but finds themselves expressed by implication. The need to develop a clear framework for provisioning green transport budgeting and accounting becomes critical.

Table 7.10 presents the ranking of suggested drivers for integrating green transportation and logistics in Limpopo Province. In terms of ranking establishing partnerships (27) with individuals, companies and sectors aimed at promoting green transportation is crucial. As an example partnership with schools and Universities regarding green projects, innovations and competitions would be one way of strongly anchoring the green economy and transport project in Limpopo Province.

From Table 7.10 we can deduce that implementing policies (20) related to green transportation came second, suggesting that the value of policies lies in their implementation and uptake. Decreasing carbon emissions (16) through using cleaner fuels and better transport was also important and is therefore a critical element in actions and measures meant to reverse and reduce the carbon footprint of transport and the economy in Limpopo Province.

7.5.3 *Inadequate Research and Innovation Think-Tank on Green Transport in Limpopo Province*

Granted that there is the existence of the Limpopo research commission which is made up of all stakeholders in Limpopo including research and university community, green economy and by extension green transport interventions still remain largely inadequate. Even when one factors the efforts of the National Transport Forum (NTF) that includes all provinces and stakeholders involved in the transport sector, at the provincial operational level, transport research and by extension green transport research is inadequately covered. In order to overcome this challenge, it is suggested that the Limpopo Transport Forum (which was quite vibrant at some reference point in terms of the Limpopo Freight Transport Forum) be revived and used as a springboard for sharper and heightened focus on green transport matters covering all transportation sectors in the province such as roads, railways, air etc. Figure 7.1 presents an overview of the importance of green issues in the transport sector in Limpopo Province.

From Fig. 7.1 we can deduce that most interviewed stakeholders identified that green issues are very important (61.9%) for and in the transport sector. However, the challenge they raised related to the need to address "*green transport adoption*" owing to perception, opinion and behaviour or lifestyle issues. It was argued that a significant proportion of people in the province believe that they are "i*ncomplete*" if they are not driving. However, at the same time the impact of decentralisation of services between areas for example Louis Trichardt (LTT) and Thohoyandou was viewed as one practical way of reducing emissions by eliminating trips through bringing services closer to people. This was viewed in the context of densifying

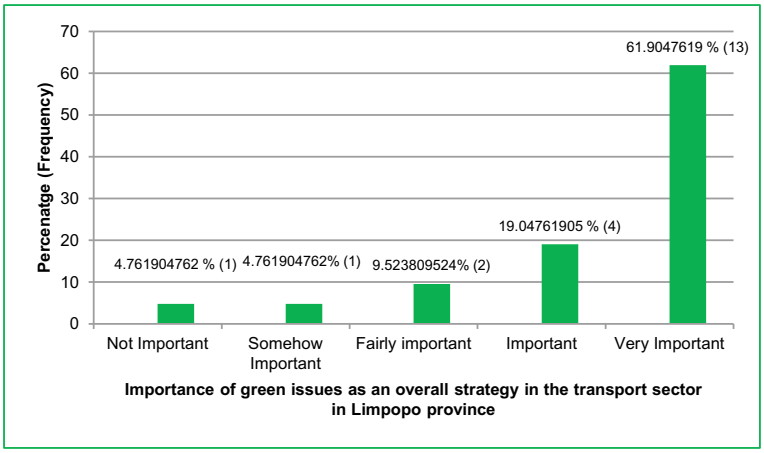

Fig. 7.1 Importance of green issues as an overall strategy in the transport sector of Limpopo province. Sample size N = 21. *Source* Research Findings, 2016

and diversifying services offered in Thohoyandou so that the need to travel to Louis Trichardt is minimized.

7.5.4 *Existing Spatial Patterns of Settlements in Limpopo Province Present Green Transport Implementation Challenges and Opportunities*

The fragmented and scattered nature of settlements overlaid on a difficult geographical and challenging climatic zone make it difficult to engage in alternative and green transport interventions such as cycling and walking given the terrain (i.e. slopes), long distances between home areas, work area and facilities of interest. However, at the same time opportunities for pooling transport resources together and engaging in car—pooling, car sharing, lift-clubs and use of buses including BRTs present an opportunity to reduce the carbon footprint of traffic in the Province. It is however critical to realise that the province has different types of towns which will require differentiated green transport interventions. For example, the province has mining towns, agricultural towns as well as border towns all presenting different nuances of green transport needs. If one also includes the strong eco-tourism component of the province, this brings another dimension of the green transport relevant to the tourism sector as an example. Recognition that no one size fits all for green transport interventions is one central theme that green transport policy and recommendations in Limpopo Province will need to be sensitive to. Table 7.11 presents the results of the opinion survey from stakeholders indicating which plans they view as providing leadership to tackling green transport issues in the Province.

From Table 7.11, we can deduce that currently the provincial green economy plan is viewed as the document providing clear direction to the green transport sector (33.33%) than anything else. While respondents argued that the provincial land transport plan (14.28%) should provide leadership, it was argued that the existing document is outdated and required urgent review. Given that the last provincial land transport plan (PLTF) did not incorporate green issues, the plan was criticized as

Table 7.11 Provincial long-term plan viewed as providing direction for green transport in Limpopo province

Provincial long term green plan portrait	Frequency	%
Provincial growth and development plan	4	19.04
Provincial green economy plan	7	33.33
Provincial spatial development plan	4	19.04
Provincial land transport plan	3	14.28
Provincial infrastructure master plan	2	9.52
Others	1	4.76

Sample size N = 21
Source Research Findings, 2016

providing little value in addressing green transport challenges. The provincial infrastructure plan (9.25%) (i.e. currently under preparation) was viewed as an opportunity that should not be missed in seeking to craft and strongly infuse the green economy and by extension green transport matters in the province.

7.5.5 *Existence of a Conducive National Transport Policy, Regulations, Norms and Standards to Act as Platforms for Implementing Provincial Customized Green Transport Solutions*

The review and discussions with stakeholders yielded the outcome that overall national frameworks and regulations exist. However, the downside of it, is that as framework legislation, they were never crafted to address the provincial peculiarities and dynamics of implementation that vary from one province to the next. As such it is critical that the province of Limpopo develops its own refinement and improvement of the broad-based national frameworks, policies and norms adapted to the case of Limpopo. Table 7.12 presents some of the innovative ways that the province can introduce to move away from conventional energy sources.

From Table 7.12 we can deduce that no stand-alone intervention exist that can single-handedly address fully green transport requirements in Limpopo province. This strongly suggests that a balanced implementation approach that considers the need for promoting BRT (23.8%) were appropriate, promoting NMT (28.57%) as far as practical as well as fostering enhanced smart and integrated planning (38.09%) are important. However, others (19.04%) suggest that innovation and thinking beyond the current approaches is also an important ingredient for sustainable green transport development and implementation in Limpopo Province.

Table 7.12 Some innovative ways that the province can introduce to move from conventional energy sources of supply

Innovative option	Frequency	%
Bus Rapid Transport (BRT)	5	23.8
Promote non-motorised transport (NMT) such as cycling, walking etc	6	28.57
Smart and integrated planning e.g. compact development, Transit Orientated development (ToDs etc.)	8	38.09
Others	4	19.04
Total	21	100

Sample size N = 21
Source Research Findings, 2016

7.5.6 *Lack or Absence or Inadequate Coverage of Green Transport Qualifications or Programme Offering in Limpopo Province*

While different types of educational institutions ranging from Universities, Technical Vocational and Educational Training (TVET) colleges, Schools and private institutions exist offering different programmes which have resonates in green transport, the challenge is that the actions are ad-hoc, not streamlined and integrated. The focus is not clearly structured to address green transport needs in the province and by extension in the country. While it can be argued that graduates from these institutions will adapt and learn the green skills, knowledge and needs once at work, it is also true that challenges will abound under such a model. Indeed, academic institutions touch on green economy and green transport challenges in courses on environment, tourism, agriculture, geography, urban and regional planning, engineering, etc. However, the problem is that the focus of the programs is not green transport and hence inadequate attention is paid to in-calculating knowledge, skills and techniques relevant to green transport. The TVET colleges do not have dedicated programmes on green infrastructure designing and manufacturing as an example. Table 7.13 presents the state of planned and current green transportation and logistics initiatives in Limpopo Province.

Table 7.13 Planned and current green transportation and logistics initiatives in Limpopo province, South Africa

Options	Scale 1–5 (1 lowest and 5 highest)				
	1	2	3	4	5
Emissions measuring and reduction		1			
Improving energy efficiency in motor vehicles		1			
Trail or use of alternative green fuels			1		
Moving freight away from air, road to rail					6
Strategic warehousing and distribution centres after peak hours				1	
Vehicles routing to reduce mileage and carbon emission					
Green procurement			2		
Green materials usage		1			
Sustainable transport policies and green thinking					6
Hybrid and alternative energy vehicle development and usage				1	
Others					1
Total	0	6	9	8	61
Rank	5	5	2	3	1

Sample size N = 21
Source Research Findings, 2016

From Table 7.13 we can deduce that high and middle income people own cars. For them to switch to green transport modes there is need for incentives in terms of providing a standard BRT service or incentives for car sharing and pooling or making it affordable to acquire green cars. Sustainable transport policies and green thinking (6) will result in improved spatial outcomes and spatial transformation that leads to green resilient settlements. Spatial planning, land use and management act (SPLUMA, 2013) is expected to play a leading role in making this contribution a reality. Moving freight from air and road to rail (6) was a strategic move to reduce emissions especially given the high volume of trucks on the N1 road that traverses Limpopo Province.

7.5.7 *Lack of a One Transport Governance Approach in (Re)solving Issues*

While institutions and actors exist covering different components of the transport sector such as infrastructure, construction, planning, policy, financing and sustainability as examples, the efforts are disjointed, fragmented and incoherent. There is therefore need for a one governance approach to enable integrated land use and transportation planning which is at the core of green transport interventions. Table 7.14 presents the results of the opinion survey from stakeholders interviewed. While challenges exist, the "*silver lining*" is that public–private partnerships (PPP) can offer a window to implement a raft of interventions that would assist in green transport transformation in the province. Establishing a green fund initiative (i.e. 47.61%) was argued as a practical way to ensuring green budgeting, accounting and monitoring as well as supporting science and technology (S&T) work aimed at upscaling, retrofitting and acquiring green manufacturing equipment aimed at reducing the carbon footprint of industries and sectors that support and promote green transport in Limpopo Province.

Table 7.14 How policy makers can promote PPP in the green transport sector

PPP intervention measures and option	Frequency	%
Green transport industrial fund	10	47.61
Green transport corridors	5	23.8
Eco-mobility initiatives	3	14.28
Carbon tax policy	2	9.52
Tax rebates for individuals who use public transport, car sharing, car-pooling or lift clubs etc.	1	4.76
Others	0	0
Total	21	100

Sample size N = 21
Source Research Findings, 2016

From Table 7.14, we can deduce that achieving a sustainable green transport policy direction in Limpopo province will require multi-faceted and diverse implementation models. No one approach will provide an inclusive, integrated and comprehensive solution. The need to apply different strategies fit for different scales that consider different dynamics and realities of individuals, institutions and sectors is therefore fundamental. While eco-mobility (i.e. 14.28%) was mentioned, the respondents indicated that this solution required initiatives that predate to implementing awareness campaigns to children starting at the Crèche or kindergarten level. In this thinking the slogan "*catch them young*" was touted as one practical way of developing and building a "green transport" generation of citizens, essential in promoting green interventions throughout their life-cycles. The carbon tax policy (i.e. 9.25%) although hailed as a move in the right direction was questioned regarding its implementation practicalities. It was cautioned that given the rural nature of the province and the reality that certain marginalised and deep rural areas are only saved by the "*bakkie*" transport, implementing a carbon tax model may be pricing the transport service out of the reach of peripheral and poor people in the province. In this regard, solution and policy direction must strike a differentiated balance between promoting green transport and ensuring that the intervention bring a "*value add*" dimensions to all sectors of the society and economy without disempowering others sectors unconsciously.

7.5.8 Overcoming Constraints to Implementing Green Transport in Limpopo Province

Stakeholders discussed and identified that different forms and types of constraints exist in seeking to promote the transition to green transport in Limpopo. These range from financial, structural or spatial, policy or legislative as well as behavioural or institutional constraints. In seeking to propagate a suitable green transport agenda for Limpopo province, it was suggested that all areas and sectors required attention if an inclusive, resilient, integrated and sustainable green transport agenda is to be realised. Figure 7.2 presents suggested key issues in developing a green economy in Limpopo Province.

From Fig. 7.2 we can deduce that technological innovations (33%) running the gamut of vehicle manufacturing, infrastructure manufacturing and transportation construction materials and technologies are at the centre of a green transport turnaround strategy and policy. For this to happen, a supportive policy and legislative environment (29%) that will enable the "*painless transition*" is fundamental. Implementation of a carbon policy on emissions such as car retirement policies, enforcing carbon emission certificates and standards (19%) is also a critical dimension of a broad-based pathway towards a low carbon economy in Limpopo Province.

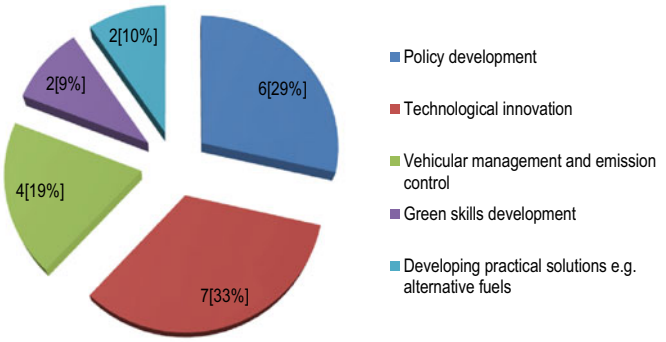

Fig. 7.2 Suggested key issues in developing a green economy in Limpopo province. Sample size N = 21. *Source* Research Findings, 2016

7.5.9 Synthesis of Green Transport in Limpopo Province

A synthesis of the policies, strategies, regulations, norms and standards in the transport sector highlights a strong narrative replete with low carbon transition gaps (Benson et al. 2014). At the same time these existing gaps represent an opportunity to convert them in value adding and transformation green transport levers and platforms for charting a low carbon transition roadmap and implementation in Limpopo province. Figure 7.3 presents a schematic diagrammatic illustration summarising the critical Highlights of Regulatory Framework, Policies, Norms and Standards Research Findings.

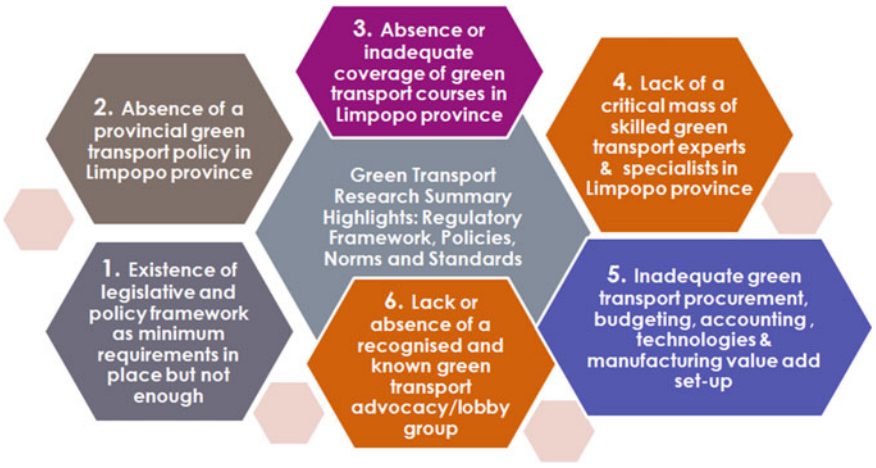

Fig. 7.3 Summary highlights of regulatory framework, policies, norms and standards research findings. *Source* Authors own conceptualization, 2021

From Fig. 7.3 we can deduce that to transition towards a low carbon economy in Limpopo, there is need for the implementation of a raft of interventions and measures covering the full gamut of regulatory framework, policies, norms and standards in the transport sector. It is heartening to realise that minimum conditions and a framework regime for implementing and engaging in a green transport inclusive and green induced and focused growth and economy exist (Montmasson-Clair 2012). However, the need to upscale, update and align the Regulatory Framework, Policies, Norms and Standards to be compliant to a green transport growth and development approach requires further investment in innovation, training and skills transfer and knowledge development also taking into account the 4th Industrial Revolution (Aoyi et al. 2016; Gumbo and Letlape 2016).

7.6 Chapter Recommendations

i. **Short and medium term**
In the short to medium term, several high impact and practical policy measures are recommended for development, implementation and management. The recommendations are based on principles and values aimed at strengthening and improving existing systems and mechanism in line with the need to promote the green economy and by extension green transport initiatives. These are as follows, namely:

- Generation of a 10-year provincial short-medium term green transport policy in Limpopo that is aligned with the National Development Plan (NDP) 2030;
- The development, implementation and management of green transport budgeting and accounting guidelines for use by Government departments and sectors in promoting the "transition to a green economy in Limpopo province" (Letsoalo 2013);
- The development, implementation and review of short term (i.e. refresher courses, certificate and diploma courses) in transportation with a clear emphasis on green transport by Universities in Limpopo such as "University of Venda", "University of Limpopo" etc. aimed at (re)training current and future green transport stakeholders such as practitioners, policy-makers, decision-makers etc. (Musyoki 2012);
- Implementing a robust and flexible training, capacity building and awareness raising programmes, projects, campaigns and roadshows covering the need, importance and relevance of green transport budgeting and accounting for all government departments, sectors and non-governmental sectors in Limpopo province;
- Development and support of green transport non-governmental organisations (NGOs), civil groups and or incorporation of green transport activists

in existing and future NGOs, civil groups to create multiple lobby and advocate groups in promoting green transport and by extension green economic development;

- Revival of the Limpopo transport forum with a special chapter or sub-group or reference working group focusing on green transport and the green economy. The aim of the special chapter or sub-group or reference working group is to "facilitate information sharing and coordination, including organising seminars and site visits to different municipal green transport initiatives" (Nhemachena et al. 2015);
- The University of Venda to establish a transportation research unit which focuses among other themes on green transport as a niche area;
- Utilise Limpopo's Polokwane's bus rapid transport (BRT) project to showcase the need and advantages of green transport in the growth and development of secondary cities and small-medium sized cities.
- "Successes and lessons learned in implementing green transport initiatives need to be effectively disseminated between cities, small to medium sized towns, communities, farms and villages in the Province" (Mahlatji 2013);
- Update existing provincial, district and local level transport, land use, infrastructure, economic and closely related policy documents to incorporate green economy in general and green transport in particular interventions explicitly. This should be implemented during the next rounds of reviews for the different documents, namely in the next 5 years for the integrated transport plan (ITP) review, local economic development (LED) policy document and next integrated development policy (IDP) cycle for all municipalities etc. respectively;
- Establish green economy desks or green transport desks in departments and sectors either individually or in clusters depending with need and budgetary provision to assist in expanding and aligning green transport portfolios and footprints of interventions between and across sectors;
- Employing the October transport month to pilot, demonstrate and show-case eco-mobility interventions such as cycling, car free days etc.;
- Identification, implementation and management of green transport high impact corridors of interventions in which "green infrastructure and transport interventions are consciously implemented as demonstration or pilot projects per each Local municipality or District municipality in the province" (HM Treasury 2011);
- Establishment and development of a green transport manufacturing, procurement requirements, systems and regulations value chain and addition structure aimed at developing a minimum set of skills, knowledge and competencies upon which a green economy rests on;

ii. **Long-term**

- The University of Venda to develop a new programme or a suite of transportation programmes offered at both undergraduate and post-graduate level with green transport as a niche area;
- Departments to transition towards green transport "budgeting and accounting" complete with key performance areas (KPAs) and key performance indicators (KPIs) to facilitate project and programme monitoring of interventions and challenges thereof (HM Treasury 2011);
- Use lessons from the implementation of Polokwane's BRT to implement similar BRT's in other secondary cities such as Mokopane, Lepalale, Tzaneen etc.;
- Explore and investigate how the concept of integrated rapid public transport plan (IRPTN) can be extended to service the needs of rural based transport corridors connecting major towns with villages e.g. Polokwane with Lebowakgomo etc.;
- Develop a 2050 Green Transport Master Plan for the province of Limpopo clearly articulating the green transport transition pathway for the province by department, sectors, non-state sector complete with timelines, budgeting, responsibilities etc. This plan should indicate clearly the green transport infrastructure requirements, options and funding modalities as an example etc.;
- "Streamlining and development of a joined up or one governance transport approach and systems to facilitate better and coordinated green transport interventions and measures" (Chakwizira 2016).

Key Actors

Several key actors exist regarding addressing the critical green transport transition and required development trajectory. The identified key actors include the following, namely:

- **Limpopo Department of Roads and Transport**: The Department's mission and vision is to spearhead, oversee and provide leadership regarding key policy issues in Limpopo, of which the green transport is one such area. The need for the department of Transport to provide structured leadership in this direction can-not be over-emphasised.
- **Limpopo Department of Economic Development (LEDET)**: This department has already provided impetus and is mandated with championing green economy and sustainable environmental interventions and transformation in the province. The need to upscale green economy interventions and make such work more inclusive and complementary to green transport interventions is vital.
- **South African Local Government Association (SALGA)**: SALGA is expected to play a key role in capacity building and training of district and local authorities regarding smart planning, integrated land use and transportation planning, SPLUMA as well as green transport.

- **District and Local Municipalities in Limpopo province**: These play a key role in ensuring policy implementation and filtering into the respective documents including the need to make sure that integrated development plans (IDPs), integrated transport plans (ITPs), Infrastructure Master Plans etc. reflect and incorporate green transport infrastructure and services needs in their proposals and implementation plans.
- **Office of the Premier—Limpopo**: The Office of the Premier through its planning and coordination role provides overall sight leadership and guidance to all policies being implemented in the province. Their role in securing green transport transformation cannot therefore be over-emphasised.
- **University of Venda**: The University offers a Bachelor of Urban and Regional Planning programme which has transportation courses and components. In developing both short-term and long term green transport courses, the Department is expected to explore certificate, diploma, degree and post-graduate qualification in Transportation Engineering, Planning and Logistics using green transport as a niche.

The shift towards green transport is a process. As such available options such as dual-fuel and hybrid-electric vehicles provide a means to manage the risk and transition associated with switching to cleaner technologies. The "*silver-lining*" for green transport transition perhaps lies in the fact that the private sector has innate capacity and willingness to invest in green transport technologies, infrastructure and services needed to accomplish this shift (Graichen et al. 2017). "In light of the public benefits associated with green transport, government needs to assist by creating demand and providing an enabling environment" (Gupta and Laubscher 2017).

7.7 Conclusions

The South African government as well as the international community have over the past decades entered into several commitments related to transport, and in particular the need to curtail the contribution of gaseous emissions by the transport sector to the atmosphere. As an example, the latest sustainable development goals (SDGs) recognize explicitly the central role that sustainable transport will play in climate change adaptation and mitigation measures (Banister 2011; Chevallier 2015; Wilbanks et al. 2012). Both "national and international policies, frameworks, legislation, norms and standards have in common the need and goal of transforming the transport sector albeit among many other sectors to ensure that the future is sustainable" (Schwanen et al. 2011; Viitanen and Kingston 2014). An important message from the chapter is that industry, society and communities all have shared co-responsibility for shaping a modern and post-modern transport agenda in which green economy, growth and transport will play an increasingly influential role (Dewar and Todeschini

2017; Minchener 2012). Indeed, the transport governance sector approach needs to permeate all sectors and areas of the economy so that barriers linked with fragmented spatial and transportation approaches can be dismantled and reversed (Death 2014; Turok 2012). Such new thinking presents exciting opportunities for developing better human settlements and enhanced transportation governance systems that are robust and adept to better guiding global and country decision-making processes and investments towards green focused development in which transportation plays a pivotal role (Hickman et al. 2010; Lawhon and Murphy 2012). Again, it should be re-emphasised that the shift towards green transport is a process and not an event. In this regard, the gained momentum towards green transport friendly interventions in the country require further refinement and promotion through adequate budgetary, financial, evaluation and monitoring systems (Mtembu and Pillay 2017; Wentworth 2014). However, the challenge of developing transport policies, framework, legislation, norms and standards for sustainable development is to orient and adapt the transport sector and allied sectors towards a balanced approach to sustainable transport development. Many of the measures required to achieve this balance are not new, the main difficulty is effective implementation (Aoyi et al. 2016; Schäffler and Swilling 2013). The approach to achieving sustainable development of the climate change resilient and competitive transport sector requires a combination of solutions (Brent 2016; Gupta and Laubscher 2017; Lember et al. 2011; Zikhali et al. 2016).

References

Antal M, Van Den Bergh JC (2016) Green growth and climate change: conceptual and empirical considerations. Clim Policy 16(2):165–177. https://doi.org/10.1080/14693062.2014.992003

Aoyi O, Seodigeng T, Modiba E, Otieno B, Mabuza J, Masedisho B (2016) Project no: SSP/Green economy research/2012//201516. Vaal University of Technology, Vanderbijlpark, South Africa

Banister D (2011) Cities, mobility and climate change. J Transp Geogr 19(6):1538–1546. https://doi.org/10.1016/j.jtrangeo.2011.03.009

Benson E, Bass S, Greenfield O (2014) Green economy barometer: who is doing what where, and why? In: London: Green Economy Coalition. IIED, London

Black WR (2010) Sustainable transportation: problems and solutions. Guilford Press. ISBN 978-1-60623-485-3

Bobbins K, Culwick C (2015) Green growth transitions through a green infrastructure approach at the local government level: case study for the Gauteng City-Region. J Public Adm 50(1):32–49. https://hdl.handle.net/10520/EJC175618

Borel-Saladin JM, Turok IN (2013) The impact of the green economy on jobs in South Africa. S Afr J Sci 109(9–10):01–04. https://doi.org/10.1590/sajs.2013/a0033

Brent A (2016) Unlocking the potential of energy efficiency and renewable energy. In: Greening the South African economy: scoping the issues, challenges and opportunities. ISBN (Paperback) 978-77582-069-7, ISBN (Web pdf) 978-1-77582-086-4

Broto VC, Bulkeley H (2013) A survey of urban climate change experiments in 100 cities. Glob Environ Change 23(1):92–102. https://doi.org/10.1016/j.gloenvcha.2012.07.005

Bruwer M, Andersen J (2015) Moving towards smart mobility in Stellenbosch: transportation engineering. Civ Eng = Siviele Ingenieurswese 2015(v23i8):44–47. https://hdl.handle.net/10520/EJC177739

Bulkeley H (2013) Cities and climate change. Routledge. ISBN 0-203-21925-2 Master e-book ISBN

Casey D, Houghton C (2010) Clarifying case study research: examples from practice. Nurse Res 17(3). https://doi.org/10.7748/nr2010.04.17.3.41.c7745
Chakwizira J (2015) The urban and regional economy directing land use and transportation planning and development. WIT Trans State-of-the-Art Sci Eng 86:199–225. https://doi.org/10.2495/978-1-84566-077-2/009
Chakwizira J (2016) Access and constraints to commuting in Gauteng province, South Africa. Doctoral dissertation, University of Venda
Chakwizira J, Bikam P, Dayomi M, Adeboyejo T (2011) Some missing dimensions of urban public transport in Africa: insights and perspectives from South Africa. Built Hum Environ Rev 4(2):56–84
Chakwizira J, Mashiri M (2009) Contribution of transport governance to socio-economic development in South Africa. In: 28th annual Southern African Transport Conference (SATC) 2009, Pretoria, South Africa, 6–9 July 2009, pp 1–18. http://hdl.handle.net/10204/3696
Chakwizira J, Mashiri M (2017) Re-imaging rural transport transitions and futures in South Africa. J Eng Archit 5(2):66–83. https://doi.org/10.15640/jea.v5n2a6
Chevallier R (2015) Aligning sustainable development goals with climate-resilient growth. SAIIA (South African Institute of International Affairs) 2015. Braamfontein, Johannesburg, South Africa
Cilliers J, Camp H (2013) Highway or byway? The National Development Plan 2030. Inst Secur Stud Pap 2013(6):1–16 (Hanns Seidel Foundation, South Africa)
Creutzig F, Jochem P, Edelenbosch OY, Mattauch L, van Vuuren DP, McCollum D, Minx J (2015) Transport: a roadblock to climate change mitigation? Science 350(6263):911–912. https://doi.org/10.1126/science.aac8033
Davoudi S, Crawford J, Mehmood A (2009) Planning for climate change: strategies for mitigation and adaptation for spatial planners. Earthscan. ISBN 978-1-84407-662-8
Death C (2014) The green economy in South Africa: global discourses and local politics. Politikon 41(1):1–22. https://doi.org/10.1080/02589346.2014.885668
Dewar D, Todeschini F (2017) Rethinking urban transport after modernism: lessons from South Africa. Routledge. ISBN 13: 978-0-5746-4169-8 (hbk)
Dickey JW (2017) Metropolitan transportation planning. Routledge
Dimitrov L (2012) The link between transport, social exclusion and energy issues in the South African context. Doctoral dissertation, University of Johannesburg
Dulal HB, Brodnig G, Onoriose CG (2011) Climate change mitigation in the transport sector through urban planning: a review. Habitat Int 35(3):494–500. https://doi.org/10.1016/j.habitatint.2011.02.001
Economic Policy Reforms (2010) Going for growth in Brazil, China, India, Indonesia and South Africa. OECD Gen Econ Future Stud 2010(1):194–230(37). ISSN 1681-5378
Emeran H, Heyns W, Dyer R (2013) PRASA and a new National Strategic Plan: transportation engineering. Civ Eng = Siviele Ingenieurswese 2013(v21i8):12–15
Farid SM (2016) Green economy in South Africa and its impact on sustainable economic development. Int J Res Bus Manag Account 2(3):77–94. ISSN 2455-6114. https://gnpublication.org/index.php/bma/article/view/586
Geels FW (2011) The multi-level perspective on sustainability transitions: responses to seven criticisms. Environ Innov Soc Trans 1(1):24–40. https://doi.org/10.1016/j.eist.2011.02.002
Giles-Corti B, Sugiyama T, Badland H, Koohsari MJ, Owen N (2016) Discussion of "How to have sustainable transportation without making people drive less or give up suburban living" by Mark Delucchi and Kenneth S. Kurani. J Urban Plan Dev 142(2):07016001. https://doi.org/10.1061/(ACSE)UP.1943-5444.0000172
Giordano T (2014) Multi-level integrated planning and greening of public infrastructure in South Africa. Plan Theory Pract 15(4):480–504. https://doi.org/10.1080/14649357.2014.963651
Goetz G, Schaeffler A (2015) Conundrums in implementing a green economy in the Gauteng City-Region. Curr Opin Environ Sustain 13:79–87. https://doi.org/10.1016/j.cosust.2015.02.005
Graichen J, Healy S, Siemons A, Höhne N, Kuramochi T, Gonzales-Zuñiga S, Sterl S, Kersting J, Wachsmuth J (2017) International climate initiatives. A way forward to close the emissions gap?

Initiatives' potential and role under the Paris agreement. Final report. UBA-FB-002551-ENG, Dessau-Roßlau, Germany. ISSN 1862-4359
Gumbo T, Letlape B (2016) Urban sustainability transformative effects of green energy infrastructural technologies in the African continent. J Constr Proj Manag Innov 6(Supplement 1):1633–1650. https://doi.org/10.36615/jcpmi.v6iSupplement.115
Gupta K, Laubscher R (2017) South African government initiatives towards a transition to green economy. In: Industrial policy and sustainable growth, pp 1–14
Hickman R, Ashiru O, Banister D (2010) Transport and climate change: simulating the options for carbon reduction in London. Transp Policy 17(2):110–125. https://doi.org/10.1016/j.tranpol.2009.12.002
HM Treasury (2011) National infrastructure plan 2011. Infrastructure UK, UK Treasury Department (HM Treasury). http://cdn.hm-treasury.gov.uk/national_infrastructure_plan291111.pdf
Jennings G (2015a) A bicycling renaissance in South Africa? Policies, programmes & trends in Cape Town. In: 34th annual Southern African transport conference, 6–9 July 2015, "Working Together to Deliver—Sakha Sonke". CSIR International Convention Centre, Pretoria, South Africa. http://hdl.handle.net/2263/57762
Jennings G (2015b) Public transport interventions and transport justice in South Africa: a literature and policy review. In: 34th annual Southern African transport conference, 6–9 July 2015, "Working Together to Deliver—Sakha Sonke". CSIR International Convention Centre, Pretoria, South Africa. http://hdl.handle.net/2263/57779
Koma SB (2010) The state of local government in South Africa: issues, trends and options. J Public Adm 45(Special issue 1):111–120. https://hdl.handle.net/10520/EJC51773
Labuschagne F, Ribbens H (2014) Walk the talk on the mainstreaming of non-motorised transport in South Africa. Paper presented at the 33rd annual Southern African transport conference 2014, CSIR ICC, Pretoria. http://hdl.handle.net/2263/45524
Lawhon M, Murphy JT (2012) Socio-technical regimes and sustainability transitions: insights from political ecology. Prog Hum Geogr 36(3):354–378. https://doi.org/10.1177/0309132511427960
Lember V, Kalvet T, Kattel R (2011) Urban competitiveness and public procurement for innovation. Urban Stud 48(7):1373–1395. https://doi.org/10.1177/0042098010374512
Letsoalo (2013) Limpopo green plan, Polokwane, Limpopo, South Africa
Mahlatji ES (2013) Challenges in the planning and implementation of government strategy by government departments: a case study of the Limpopo Department of Economic Development, Environment and Tourism (LEDET). MPA thesis. http://hdl.handle.net/10386/1039
Marsay A, Seobi M (2010) How to achieve a sustainable increase in transport infrastructure investment. In: Proceedings of the Southern African transport conference 2010. ISBN 978-1-920017-47-7
Marsden G, Rye T (2010) The governance of transport and climate change. J Transp Geogr 18(6):669–678. https://doi.org/10.1016/j.jtrangeo.2009.09.014
Masson R, Trentini A, Lehuédé F, Malhéné N, Péton O, Tlahig H (2017) Optimization of a city logistics transportation system with mixed passengers and goods. EURO J Transp Logist 6(1):81–109. https://doi.org/10.1007/s13676-015-0085-5
Mazzucato M, Semeniuk G, Geddes A, Huang P, Polzin F, Gallagher K S, Shakya C, Steffen B, Tribukait H (2018) Bridging the gap: the role of innovation policy and market creation. In: Emissions gap report 2018. United Nations Environment Programme (UNEP), pp 52–59
McKay T, Simpson Z, Patel N (2017) Spatial politics and infrastructure development: analysis of historical transportation data in Gauteng-South Africa (1975–2003). Misc Geogr 21(1):35–43. https://doi.org/10.1515/mgrsd-2017-0003
Meyer I, Leimbach M, Jaeger C (2007) International passenger transport and climate change: a sector analysis in car demand and associated CO_2 emissions from 2000 to 2050. Energy Policy 35(12):6332–6345. https://doi.org/10.1016/j.enpol.2007.07.025
Minchener A (2012) Carbon mitigation technologies for emerging economies. IEA, Clean Coal Centre, London, United Kingdom. ISBN 978-92-9029-518-1

Mohamed N, Maitho E, Masvikeni E, Fourie R, Tilly M, Zondi N (2014) The green fund of South Africa: origins, establishment and first lessons. Dev South Afr 31(5):658–674. https://doi.org/10.1080/0376835X.2014.935295

Montmasson-Clair G (2012) Green economy policy framework and employment opportunity: a South African case study. Trade and Industrial Policy Strategies (TIPS), Working Paper Series 2012-02. https://doi.org/10.2139/ssrn.2748491

Mtembu V, Pillay M (2017) A contextual review of South Africa's socio-economic content of green economy and green growth indexes. J Public Adm 52(3):614–624. https://hdl.handle.net/10520/EJC-de8686471

Munang R, Thiaw I, Alverson K, Mumba M, Liu J, Rivington M (2013) Climate change and ecosystem-based adaptation: a new pragmatic approach to buffering climate change impacts. Curr Opin Environ Sustain 5(1):67–71. https://doi.org/10.1016/j.cosust.2012.12.001

Musyoki A (2012) The emerging policy for green economy and social development in Limpopo, South Africa. UNRISD Occasional Paper: Social Dimensions of Green Economy and Sustainable Development No. 8. United Nations Research Institute for Social Development. Geneva, Switzerland. ISBN 978-92-9085-090-8. Version is available at: http://hdl.handle.net/10419/148789

National Planning Commission (2013a) National development plan vision 2030. Pretoria, Government Printers, South Africa. ISBN 978-0-621-40475-3 RP270/2011

National Planning Commission (2013b) National development plan vision 2030. Pretoria, Government Printers, South Africa

Nhemachena C, Jonas S, Karuaihe S (2015) Understanding of the current practices, challenges and opportunities of the green economy in Limpopo Province. J Public Adm 50(1):6–31

Olhoff A, Christensen JM (2018) Emissions gap report 2018. UNEP DTU Partnership. Nairobi, Kenya. https://www.unep.org/emissions-gap-report-2020. ISBN 978-92-807-3812-4. Job number: DEW/2310/NA

Oranje, M, Merrifield A (2010) National spatial development planning in South Africa 1930–2010: an introductory comparative analysis. Stads- en Streeksbeplanning = Town Reg Plan 2010(56):29–45

Pasquini L, Ziervogel G, Cowling RM, Shearing C (2015) What enables local governments to mainstream climate change adaptation? Lessons learned from two municipal case studies in the Western Cape, South Africa. Clim Dev 7(1):60–70. https://doi.org/10.1080/17565529.2014.886994

Plan PTA (2010) Phase 1 (2007–2010): catalytic integrated rapid public transport network projects. Public transport action plans and strategy. Government Printers, Pretoria, South Africa

Rivett-Carnac K, Swilling M, Giordano T (2016) Greening the national infrastructure plan. In: Greening the South African economy: scoping the issues, challenges and opportunities. UCT Press, Cape Town, South Africa. ISBN (paperback) 978-1-77582-069-7, ISBN (web pdf) 978-1-77582-086-4

Rogerson CM (2017) Geography and economy in South Africa and its neighbours. Routledge

Schäffler A, Swilling M (2013) Valuing green infrastructure in an urban environment under pressure—the Johannesburg case. Ecol Econ 86:246–257. https://doi.org/10.1016/j.ecolecon.2012.05.008

Schalekamp H, Behrens R (2010) Engaging paratransit on public transport reform initiatives in South Africa: a critique of policy and an investigation of appropriate engagement approaches. Res Transp Econ 29(1):371–378. https://doi.org/10.1016/j.retrec.2010.07.047

Schoeman CB (2015) The alignment between spatial planning, transportation planning and environmental management within the new spatial systems in South Africa. Stads- en Streeksbeplanning = Town Reg Plan 2015(67):42–57. eISSN 2415-0495, print ISSN 1012-280X

Schwanen T, Banister D, Anable J (2011) Scientific research about climate change mitigation in transport: a critical review. Transp Res Part A: Policy Pract 45(10):993–1006. https://doi.org/10.1016/j.tra.2011.09.005

Stanley JK, Hensher DA, Loader C (2011) Road transport and climate change: stepping off the greenhouse gas. Transp Res Part a: Policy Pract 45(10):1020–1030. https://doi.org/10.1016/j.tra.2009.04.005

Turner A (2017) Is clean air possible? A critical analysis of China's intended nationally determined contributions for the United Nations climate change conference 2015

Turok I (2012) Urbanisation and development in South Africa: economic imperatives, spatial distortions and strategic responses. Human Settlements Group, International Institute for Environment and Development, IIED 2012, London, UK. ISBN 978-1-84369-890-6

Van Wyk J (2015) Can SPLUMA play a role in transforming spatial injustice to spatial justice in housing in South Africa? South Afr Public Law 30(1):26–41. https://hdl.handle.net/10520/EJC197706

Venter C (2013) The lurch towards formalisation: lessons from the implementation of BRT in Johannesburg, South Africa. Res Transp Econ 39(1):114–120. https://doi.org/10.1016/j.retrec.2012.06.003

Viitanen J, Kingston R (2014) Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector. Environ Plan A 46(4):803–819. https://doi.org/10.1068/a46242

Walters J (2013) Overview of public transport policy developments in South Africa. Res Transp Econ 39(1):34–45. https://doi.org/10.1016/j.retrec.2012.05.021

Walters J (2014) Public transport policy implementation in South Africa: Quo vadis? J Transp Supply Chain Manag 8(1):1–10. https://hdl.handle.net/10520/EJC157866

Wentworth L (2014) Creating incentives for green economic growth: green energy in South Africa. South African Institute of International Affairs, Braamfontein, Johannesburg, South Africa

Wilbanks T, Fernandez S, Backus G, Garcia P, Jonietz K, Kirshen P, Savonis M, Solecki B, Toole L, Allen M (2012) Climate change and infrastructure, urban systems and vulnerabilities: technical report for the US Department of Energy in support of the national climate assessment. Island Press, Washington, DC, USA. ISBN 10 987654321

Williams J (2013) Carbon dioxide, climate and society: proceedings of a IIASA workshop cosponsored by WMO, UNEP, and SCOPE. Elsevier, 21–24 Feb 1978

Yin R (2003) Designing case studies. In: Qualitative research methods, pp 359–386. ISBN 978-1-78973-692-2 (print)

Zikhali P, Gulati M, Ngwenya P (2016) Financing the green economy. In: Greening the South African economy: scoping the issues, challenges and opportunities. https://doi.org/10.17159/assaf/0025

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Chapter 8
Conclusion

John Ogony Odiyo, Peter Bitta Bikam, and James Chakwizira

Abstract Transition to green economy and transport is crucial to reduce environmental problems such as greenhouse gas emissions and climate change in South Africa. However, the challenges associated with the transition present opportunities for innovation and mitigation within the green economy and transport sector. Green economy and transport sector initiatives have the potential to address economic and environmental challenges and open new sources of growth.

Keywords Transition · Green economy · Transport sector · Environmental problems · Climate change

8.1 Introduction

The green economy in the transport sector theme is an opportune theme within the context of the SDGs, national, provincial and local growth and development imperatives. This chapter provides a synthesis to the book while also engaging in reflexive thinking with respect to the future of the green economy and transport sector generally. Through this approach, the authors seek to stimulate further engagement and conversations beyond this book publication. The intention is to sustain the conversation and build further work and projects that advance the green economy and transport sector theme contextually and holistically.

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8.2 Synthesis

The transition to green economy and transport is crucial to reduce environmental problems such as greenhouse gas emissions and climate change in South Africa. However, there are multiple, interconnected, and complex challenges associated with the transition. These complexities and interdependencies present opportunities for innovation and mitigation within the green economy and transport sector. According to (see p. 10 in Kanianska 2017) in order to advance green economy and transport transition paradigms, action and measures, the following should be in place:

- Implement and manage innovations and solutions that support economic prosperity and human well-being;
- Stimulate resource-efficient, low-carbon economic and social development;
- Safeguard people from environmental health risks.

The chapters of this book by situating the green economy and transport sector in the context of South Africa and in particular, Limpopo Province have explored the impacts of growth and development on the green economy and transport sector. Invariably, the green economy and transport sector initiatives have the potential to address economic and environmental challenges while at the same time opening new sources of growth.

Generally, growth and development efforts that are anchored on the foundations of the green economy and green growth strategy, indicators and tools have innate potential to respond to the SDGs as well as a raft of national, provincial and local development initiatives. While these green economy and strategy compliant systems have origins that can be traced from the United Kingdom, Asian, Pacific Region as well as further work that was crystallised through Organisation for Economic Co-operation and Development (OECD) (Morgera and Savaresi, 2013 p. 14–16), over time these concepts have assumed global and glocal relevance that makes them applicable worldwide. In this regard, the green economy and transport green strategy approach provides a *'lens'* for re-examining the current economic growth paradigm whilst at the same time offering an actionable policy framework for policy and decision makers, practitioners, researchers and academics in developed, emerging and developing economies.

Acknowledging that there is no *"one-size-fits-all"* prescription for implementing strategies and interventions for green economy and transport sector growth, the chapters in the book have utilized a thematic focus that provide mechanism for actions and fulcrum movement in steering green economy and transport transition further. Indeed, greening the growth path of an economy and the transport sector depends on policy and institutional settings, transportation modes and technologies, level of development, skills and knowledge transfer, resource endowments and environmental pressure points (see p. 4 in Meadowcroft 2012). Given the unique and differentiated South African apartheid driven historical legacy, the chapters have portrayed how the emerging green economy and transport sector faces different challenges and opportunities, with implications for livelihoods, climate change, environmental

sustainability, and economic diversification opportunities. This suggests that contextual green economy and transport sector solutions are strategic in measures aimed at addressing growth and development realities of any setting.

The book is anchored on a multi-disciplinary approach as a practical way to tackling the green economy and transport sector. Considering that sustainable development and transportation is broad as argued by proponents such as Sauvé, Bernard and Sloan (2016), see p. 40 in Vigar (2017), see p. 28 in Lang et al. (2012) the book has therefore focused on different themes in sustainable development and transportation in South Africa that include:

- Conceptualization of green economy and transport sector,
- Environment, climate change and the green economy,
- Transport modes and the green economy,
- Technology innovation in the green economy,
- Vehicle management, emission control and maintenance,
- Regulatory framework in the transport sector, policies and standards, and
- Skills and knowledge transfer.

Consequently, the chapters in this book have highlighted the numerous changes and the wide range of influences that impact and are impacted by the green economy and transport sector. The adopted framework of analysis was anchored on a sectoral and case study based approach that identified the challenges, opportunities and prospects for climate change, sustainable development and transportation which may enable South Africa to advance and develop in a sustainable, inclusive and resilient manner. It is against this background that this book sought to explore the issues articulated above and contributed chapters demonstrate how such matters have influenced the green economy and transport sector of South Africa. Reflecting on the post-apartheid South Africa from a climate change, sustainable development and transportation perspective, the following key objectives were answered by the chapters in the book:

- Identification of existing and emerging paradigms relating to the transition towards a green economy in the transport sector.
- Exploration of how paradigms in green economy and transport sector impact on human settlements, livelihoods and skills development in the quest of creating inclusive, resilient and sustainable development.
- Analysing the opportunities and challenges that are associated with the transition towards a green economy in the transport sector making use of Limpopo province as a case study.
- Theorizing the green economy and transport sector transition in post-apartheid South Africa.
- Advancing proposals on a national green economy and transport sector agenda and policies that will contribute to the creation of inclusive, resilience and sustainable communities in South Africa.

8.3 Research and Policy Directions

Attuning practice and theory through applied research that provides pathways for anchoring the green economy and transport sector strongly is important. This can be approached from multiple perspectives considering multiple dimensions to the green economy and transport sector theme. Indeed, a multi-lever and governance over-arching approach that brings together government, non-governmental sectors, industry, and academia is one way of furthering growth and development in any area. The impact of the 4th Industrial revolution as well as digital movement impacting on the transport sector as well as green economy cannot be under-estimated. A triad approach in which academia, industry and community co-investigate, co-develop and manage projects and programmes for enhanced green economy and transport sector development is fundamental. Research and policy directions in general should focus on efficacy with respect to developing transport sector specific and non-specific transport complementary skills in some areas of the under-listed topics, namely:

- Environment, climate change and the green economy,
- Transport modes and the green economy,
- Technology innovations in green transport,
- Vehicle management and emission control and maintenance,
- Skills and knowledge transfer for transitioning into the green economy, and
- Regulatory frameworks, policies, norms and standards.

However, while the chapters in the book highlight the importance of a skills and development strategy for the transport sector, it is critical to highlight that balance between and among other non-transport sectors of the economy is vital. This is to ensure that the value add of the skills development work in the green economy and transport sector is not compromised by the lack of readiness and structural alignment from the sectors whose growth and development is enabled by the transport sector service function.

8.4 Future Thoughts

Green economy in the transport sector provides both an approach and framework for analysing growth and development strategies and policies in any setting. The movement towards circular economies, connected and digital systems are all predicated on low carbon economies. Finding space for strongly embedding green economy and transport value chains through innovation and shifts in production and consumption systems is vital. The role that multi-disciplinary and transdisciplinary research and development partnership and collaboration between state and non-state sectors can play is immense. Future thinking and agenda should seek to better align, (re)structure and (co)locate the green economy and transport sector theme within the wider context

of industry, academia, community and the wider development practitioners landscape research and development agenda for improved efficiencies and effectiveness.

References

Kanianska R (2017) Green growth and green economy, vol 2016. Banská Bystrica, Blianum, pp. 11–20

Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) Transdisciplinary research in sustainability science: practice, principles, and challenges. Sustain Sci 7(1):25–43. https://doi.org/10.1007/s11625-011-0149-x

Meadowcroft J (2012) Greening the state. Comparative environmental politics: Theory, practice, and prospects, 63–87

Morgera E, Savaresi A (2013) A conceptual and legal perspective on the green economy. Review of European, Comparative & International Environmental Law 22(1):14–28. https://doi.org/10.1111/reel.12016

Sauvé S, Bernard S, Sloan P (2016) Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. Environmental Development 17:48–56. https://doi.org/10.1016/j.envdev.2015.09.002

Vigar G (2017) The four knowledges of transport planning: Enacting a more communicative, trans-disciplinary policy and decision-making. Transp Policy 58:39–45. https://doi.org/10.1016/j.tranpol.2017.04.013

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