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WITS SCHOOL OF GOVERNANCE

Impact of mega astronomy infrastructure projects on development in the rural Northern Cape, South Africa

Daniel Manama Mokhohlane

WITS School of Governance

The thesis presented in fulfilment for the PhD to the Faculty of Commerce, Law, and Management, University of the Witwatersrand

November 2023

WITS UNIVERSITY

Declaration

I, **Daniel Manama Mokhohlane** declare that this thesis entitled 'Impact of mega astronomy infrastructure projects on development in the rural Northern Cape, South Africa' is my unaided work. I have acknowledged, attributed, and referenced all ideas sourced elsewhere. I am hereby submitting it in fulfilment of the requirements of the degree of PhD at the University of the Witwatersrand, Johannesburg. I have not submitted this report before for any other degree or examination to any other institution.



Daniel Manama Mokhohlane

Signed at Johannesburg on 06 November 2023

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Abstract

This study investigates the impact of mega astronomy infrastructure projects on development in rural Northern Cape, South Africa. The Northern Cape province especially Kareeberg Local and Karoo Hoogland Local Municipalities has become a hub for astronomy research due to its clear skies and low light pollution, attracting significant investments in mega astronomy infrastructure projects such as the MeerKAT and the Southern African Large Telescope among others. There is also an expectation from local communities that these projects should assist in improving development in those communities. This is the paradox the study investigates. That is so because those communities earmarked for mega astronomy infrastructure projects are preserved and protected by legislation against polluting activities i.e., too much lighting, a lot of radio frequency, too much dust, and smoke, which could be detrimental to radio and optical astronomy. Therefore, this research assesses the development impact of these projects with respect to infrastructure development, job creation, education, tourism and perceptions of people living around those projects. The study discusses the paradox of using mega astronomy infrastructure projects for rural and socioeconomic development. A mixed-methods approach was employed, including surveys, interviews, observations and data analysis, to gather, analyse and synthesise data from residents, project stakeholders, and government officials. A new framework for the Impact of Mega Astronomy Infrastructure projects for the Development of Rural Areas was developed. This framework could be useful in dealing with the persisting dissonance and paradox in assessing mega astronomy infrastructure projects' impact on rural development. The findings of this study provide valuable insights into the role of mega astronomy infrastructure projects in assessing and promoting sustainable development in rural areas and informing future policy decisions and investment strategies in the rural Northern Cape in South Africa.

Keywords: *astronomy, development, dissonances, impact, paradox, and rural*

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List of Abbreviations

AGA	Astronomy Geographical Advantage
CSIR	Council for Scientific Industrial Research
DRDLR	Department of Rural Development and Land Reform
DSI	Department of Science and Innovation
FIM-DR	Framework for Impact of MAIPs on Development in Rural Areas
IDP	Integrated Development Plan
KAT 7	Seven-dish Karoo Array of Telescope
MAIP	Mega Astronomy Infrastructure project
MeerKAT	More Karoo Array Telescope
MoU	Memorandum of Understanding
NDoH	National Department of Health
NASSP	National Astrophysics and Space Science Programme
NICIS	National Integrated Cyber Infrastructure System
NRF	National Research Foundation
NSI	National System of Innovation
OECD	Organisation for Economic Co-operation and Development
PKSD	Pixley Ka Seme District Municipality
RFQ	Request for Quotation
SAAO	South African Astronomical Observatory
SALT	Southern African Large Telescope
SANReN	South Africa National Research Network
SANSA	South African National Space Agency
SARAO	South African Radio Astronomy Observatory
SEFA	Small Enterprise Financial Agency

SEDA	Small Enterprise Development Agency
SKA	Square Kilometre Array
SMMEs	Small, Medium, and Micro enterprises
Stats SA	Statistics South Africa
STI	Science, Technology and Innovation
Wits	University of the Witwatersrand

Chapter 1

Introduction to the Research

1.1 Introduction

This study assessed the impact of mega astronomy infrastructure projects on development in the rural Northern Cape in South Africa. The Northern Cape due to less development, low density and dispersed population, its clear skies most of the time, less light pollution, and low radio frequency, attracted significant investments in mega astronomy infrastructure projects (MAIPs). There is also an expectation from local communities that MAIPs should assist in improving socioeconomic development in those communities which is highly paradoxical. The prevailing paradox is so because the local communities preserved for the MAIPs are protected by legislation against activities that are detrimental to astronomy such as too much lighting, a lot of radio frequency, too much dust, and smoke, which could be detrimental to radio and optical astronomy. Therefore, this study assessed the development impact of these projects in terms of four themes which are economic infrastructure development, job creation, education, and tourism. In addition, the study further assessed the perceptions of people living around those projects.

A parallel mixed-methods approach was used which included collection of primary data through surveys, interviews and observations. Secondary data was collected through document analysis using reports and other available documents such as presentations and speeches. Primary data was collected from residents, project stakeholders, and government officials whereas, secondary data was collected from 'grey' literature. 'Grey' literature is information produced outside of traditional publishing and distribution channels and can include reports, policy literature, working papers, newspapers, newsletters, government

documents, speeches, white papers, plans, etc. The reason for literature classification was because of the arising dissonance and synergies picked from data analysis.

In data analysis, location, methodology, and data triangulation were considered, while there were synergies in data analysis, however in some instances, data dissonances also emerged. Dissonance in research refers to the presence of conflicting, contradictory or divergent findings, interpretations, or perspectives within the body of research literature (Jonas et al., 2001; Madsen, 2015; Ross-Hellauer et al., 2023). Dissonance can arise from differences in research methodologies, sample populations, data analysis techniques, or theoretical frameworks used by researchers (Ward et al., 2010). Addressing dissonance in research is crucial for ensuring the validity and reliability of research findings (Ross-Hellauer et al., 2023). Therefore, researchers are advised to critically evaluate and reconcile conflicting evidence, identify potential sources of bias or error, and strive to reach a consensus on the most plausible explanations or acknowledging and addressing dissonance in research, researchers can enhance the robustness and credibility of their findings, contributing to the advancement of knowledge in their field.

While the opposite of dissonance is synergy, literature and data synergies refer to a state of agreement, unity, and coherence among various literature (especially between ‘grey’ literature and peer-reviewed literature) or between primary and secondary data (Tavera Romero et al., 2021; Weibl & Hess, 2020). When there is synergy in the data collected and the literature reviewed, it is when all the components such as primary and secondary data are convergent or peer-reviewed and ‘grey’ literature in the same field is convergent (Campos & Vazquez-Brust, 2016). From the 1996, 2001, and 2011 censuses analysis, the results could not give a conclusive response to the research questions. Kareeberg and Karoo Hoogland's results were the same as the results from Joe Morolong.

There was synergy in analysing primary qualitative and quantitative data because they both responded negatively to all research questions. In analysing secondary data from 'grey' literature, all the research questions were positively responded meaning that there was development taking place in Kareeberg and Karoo Hoogland as the result of the MAIPs. There was synergy in all the 'grey' literature but dissonance between primary data and secondary data. In reviewing scholarly literature about the topic that is being studied we could find synergies with some literature and as well as dissonances with other literature.

The Theory of Change Framework with the African Renaissance Movement Theory and the Gandhian Philosophy were used to develop a new framework for the impact of MAIPs on the development of rural areas to find the solution to raised paradox and emerging dissonance in data analysis. Therefore, the findings of this study provided valuable insights into the role of MAIPs in assessing and promoting sustainable development in rural areas, informing future policy decisions and investment strategies in South Africa, particularly in the two local municipalities, Kareeberg and Karoo Hoogland in the Northern Cape. This introductory chapter consists of six sections which are the introductory section, the background and context of the study, the conceptualisation of the research, research delimitation and assumptions, the justification of the study and lastly the preface to this document.

1.2 Background and Context

As discussed in the introductory section of this chapter, this thesis discusses the role mega astronomy infrastructure projects played in advancing economic development through the example of two MAIPs in two different South African municipalities. The two MAIPs are the More Karoo Array Telescope (MeerKAT) in Kareeberg Local Municipality and the Southern African Large Telescope (SALT) in Karoo Hoogland Local Municipality. In the

case of bringing these MAIPs to South Africa, it has been politically argued that the intervention is essential to deal with long-standing developmental challenges in rural communities (Department of Science and Innovation, 2020b, 2021; Department of Science and Technology, 2016). Rural communities are communities on the margins of the mainstream economy (Allen et al., 1992). South Africa has been grappling with what I term the 'quadruple development' challenges of underdevelopment, high unemployment, inequality, and poverty for quite some time. These 'quadruple development' challenges are worse in the rural part of the country (Department of Science and Technology, 2012; Nkoane & Dichaba, 2017). Through the MAIPs, South Africa's government advocates using science, technology, and innovation (STI) to solve these development challenges.

South Africa's vast area is rural, peri-urban, underdeveloped, and riddled with high poverty and unemployment rates. According to the World Bank (2020) and Stats SA (2021), South Africa has the highest inequality globally, with a Gini coefficient of 0.63. Seventy-one per cent of net wealth in 2015 was in the hands of 10% of the population, while the bottom 60% held 7% of the net wealth (World Bank, 2020). Ownership of commercial land in South Africa corroborated the issue of inequality because South Africa's government land audit revealed that 72% of the land is in the hands of only 8% (which are Whites) of the population whereas 81% of the population (which Africans, in particular Blacks) own approximately 4% of the commercial land (Ndhlovu, 2024). This status quo does not seem to have improved, according to Statistics South Africa (Stats SA), even after numerous government interventions, such as the Reconstruction Development Programme, the Comprehensive Rural Development Programme, and the Rural Campus Connectivity Projects, among others (Jacobs & Hart, 2014.; Stats SA, 2021; Ndhlovu & Shangase, 2018). Stats SA (2021) reported that South Africa's unemployment rate increased to over 34.4% in the third quarter

of 2021/22. The situation was worse in the country's rural part because the unemployment rate was over 51% (Stats SA, 2021).

According to Rittel and Webber (1973, p.155), many social ills, referred to as 'wicked problems' such as but are not limited to lack of development, high rate of poverty, rampant drug abuse, teenage pregnancy, high school dropout, high illiteracy, lack of service delivery, high rate of unemployment, and few economic opportunities, riddled rural areas. Nonetheless, some rural parts of South Africa, i.e., Kareeberg and Karoo Hoogland, with numerous 'wicked problems', are deemed environmentally conducive for MAIPs. These MAIPs' conduciveness is due to less radio and light wave interference, referred to as radio and light pollution in astronomy terms (Lazio, 2008; Peng, 2010). Therefore, South Africa's government considered STI, particularly astronomy, as a driver for the country's development agenda in line with the National Research and Development Strategy of 2002 and, recently, the 2030 South African National Development Plan (Department of Science and Technology, 2002; South Africa & National Planning Commission, 2012).

South Africa's government, through the Department of Science and Innovation (DSI), developed legislation and policies such as the National Strategy for Multi-wavelength Astronomy, a National Astrotourism Strategy for South Africa and the Astronomy Geographic Advantage (AGA) Act no. 21 of 2007 to guide the holistic growth of the astronomy discipline and preservation of the areas earmarked for astronomy (Department of Science and Innovation, 2019, 2021; The Astronomy Geographic Advantage Act of 2007).

Astronomy is a unique science discipline envisaged to provide mega infrastructure projects, technological innovations, and spin-offs, as well as human capacity development, community development and socio-economic development (Department of Science and Technology, 2015a; Velho et al., 2024). Consequently, South Africa's government has significantly invested over R10 billion between 2001 and 2021 in astronomy (Department of

Science and Innovation, 2020a; National Treasury, 2021). Making a compelling case for developing countries such as South Africa to avail funding for mega STI infrastructure projects seemed a challenging political task. However, South Africa's astronomers convinced politicians that MAIPs would facilitate development in the country for public funding to be provided for such projects. This made sense because these MAIPs are based in deep, and underdeveloped rural areas.

Another important element according to Velho et al. (2024) is that South Africa is unique compared to its counterparts pursuing mega astronomy infrastructure in other countries, for example, China, India, Chile, Australia, and the United States, etc., mega astronomy projects are situated in areas where there is nothing, far away from where people reside but still classified as rural. In South Africa, these conducive astronomy areas are close to where people reside; for example, SALT is approximately 18.9 km outside Sutherland and MeerKAT is around 92 km outside Carnarvon.

Therefore, this study investigated the impact of these instruments on those people residing in their nearby vicinity. This study provides insights into whether development practitioners could use MAIPs for rural development or not. There is also a strong sense that if these MAIPs are not well managed, the accrued developmental benefits, if any, might be coincidental, spillovers, unplanned and not deliberate (Velho et al., 2024). The following sections and subsections outline the research's physical setting and its context analysis, the conceptualisation of the research, the research problem statement, the research purpose statement, as well as the main research question, and four secondary research questions.

1.2.1 Research Physical Setting

The physical setting of the current study was Kareeberg and Karoo Hoogland in the Northern Cape province. As stated previously, the study aimed to assess the impact of

MAIPs on rural development in those areas. The MeerKAT project, a precursor to the SKA giant international radio telescope, is in the Kareeberg. Also, Karoo Hoogland is the home to the largest giant optical telescope in the Southern Hemisphere, the SALT. For this research, I considered both municipalities (Kareeberg and Karoo Hoogland Local Munincipalities) as rural because they have small towns with one main street surrounded by farming communities. These towns have few essential amenities, and people still need to travel to big cities for more advanced services or medical care, such as surgeries and jobs. In these small towns, it is rare to find tertiary institutions. In most cases, students travel to the big cities to further their education beyond Grade 12. However, this issue of rural areas or towns is still in contention, and there is no clear definition in the literature of a rural town. In Chapter 2, there will be more discussion on the phenomenon of rurality of Kareeberg and Karoo Hoogland Local Municipalities for this research is discussed further. The paragraphs below discuss the Northern Cape province and areas within the province, especially where the research was conducted.

1.2.1.1 The Northern Cape province

The Northern Cape is one of the nine South African provinces, it is the largest with an arid desert landscape. It is 372889 km^2, equal to approximately one-third of the rest of the country, sparsely populated, and predominantly rural. According to the 2019 General Household Survey, 1246000 people lived in the Northern Cape, which is 2.2% of South Africa's population (Stats SA, 2021). The provincial capital of the Northern Cape is Kimberly, famous for the diamond rush in 1870 and consequently, the Big Hole mine as one of the province's tourist attractions. The other tourist attractions in the area are star gazing due to clear night skies, San rock art, 4x4 safaris, wild daisies, spring flowers, and wildlife in the Kgalagadi Transfrontier Park.

The northern part of the province borders Botswana and the northwest borders Namibia. The Atlantic Ocean bounds the area towards the west side of the province. The dominant language is Afrikaans (53.75%), followed by Tshwana (33.08%). Xhosa and English are spoken to a small extent. The Northern Cape province has five municipal districts: John Taolo Gaetsewe (formerly Kgalagadi), Frances Baard, Namakwa, Pixley Ka Seme District Municipality and ZK Mgcawu (formerly Siyanda). Refer to the Northern Cape in Figure 1 shows the five Northern Cape District Municipalities and 26 Local Municipalities. The next three sub-sections discuss the District and Local Municipalities where the research was conducted.

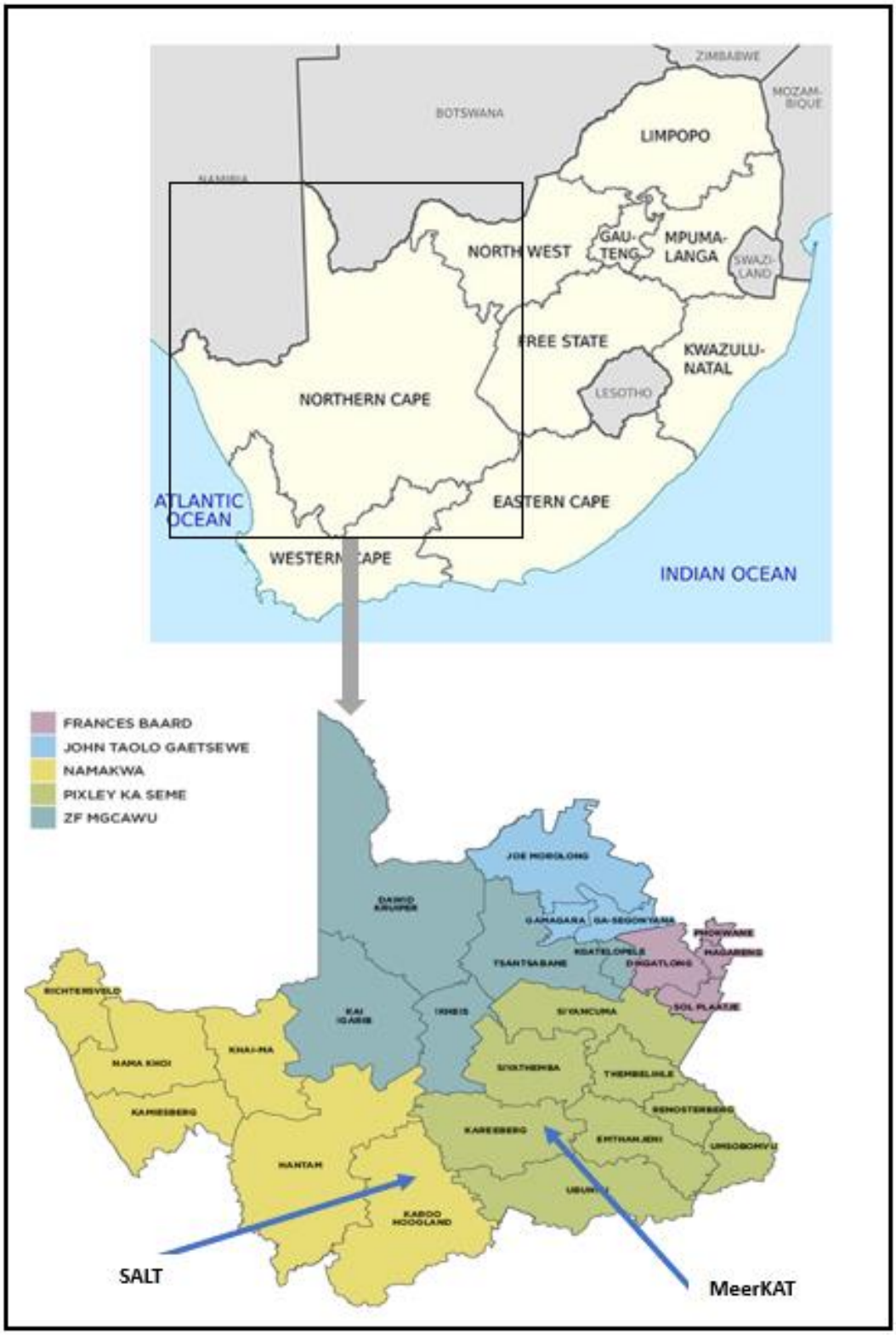

Figure 1. Map of Five Northern Cape Districts and 26 Local Municipality
Source (Yes Media, n.d.).

1.2.1.2 Pixley Ka Seme District Municipality

MeerKAT is in the Kareeberg Local Municipality and is in the Pixley Ka Seme District Municipality. According to the Kareeberg Integrated Development Plan IDP of 2020/21 (Kareeberg Local Municipality, 2020) and the baseline report by the University of the Free State (University of Free State, 2009), the Municipality has a usual annual average rainfall of 260 mm with a high average evaporation of 2300mm. The average temperatures are 15.9 degrees Celsius to 23.5 degrees Celsius during the day and -2.0 degrees Celsius to 8.2 degrees Celsius at night. Due to these climatic conditions, sheep farming is dominant, and the potential to go beyond sheep farming is limited. However, the area can cultivate indigenous Karoo plants, which may have economic value. Such products are already part of the ecosystem and could increase the agricultural intensity if explored (Kareeberg Local Municipality, 2020). The Namakwa District Municipality and Karoo Hoogland Local Municipality are discussed in the following sub-section.

1.2.1.3 Namakwa District Municipality

The SALT is in Sutherland, a small part of the Karoo Hoogland Local Municipality in the southern part of Namakwa District Municipality, Northern Cape province. The Karoo Hoogland is an amalgamation of Williston, Fraserburg and Sutherland. According to the Karoo Hoogland Local Municipality Final Annual Report 2018/19 (Karoo Hoogland Municipality, 2020), Sutherland started as a church and market town for the local sheep farmers in 1858. Sutherland has an arid climate. It is 1450m above sea level and the coldest place in South Africa, with an annual average temperature of 11.3 degrees Celsius. It boasts an area of 35.98 km^2, and the skies are amongst the world's darkest ideal for optical astronomy. John Taolo Gaetsewe District Municipality and Joe Morolong Local Municipality within the District Municipality are discussed in the paragraph below.

1.2.1.4 John Taolo Gaetsewe District Municipality

The Joe Morolong Local Municipality in the John Taolo Gaetsewe District Municipality was selected as a comparison group municipality for this study. John Taolo Gaetsetse District Municipality is in the northern part of the Northern Cape province. It shares a border with Botswana on the northern side of with North West province on the northeastern side (Figure 1). Apart from Joe Morolong Local Municipality, John Taolo Gaetsetse District Municipality has two other local municipalities: Gamagara and Ga-Sekhonyana Local Municipalities. The Joe Morolong Local Munincipality IDP for the 2020/21 financial year (Joe Morolong Local Municipality, 2020) indicates that it is the biggest and yet the poorest of the three, with more than 100 villages and approximately 20172 km^2.

The Joe Morolong Local Municipality IDP (Joe Morolong Local Municipality, 2020) estimates that almost 95% of the road infrastructure is not tarred. Its economic activities are agriculture, manufacturing, mining, quarrying, energy, construction, wholesale and retail, transport, and business and community services. Unemployment in the Local Municipality is over 70% (Joe Morolong Local Municipality, 2020). I chose Joe Morolong Local Municipality as a comparison municipality because it is far from the Municipalities where mega astronomy infrastructure occurs. The assumption is that astronomy activities in Kareeberg and Karoo Hoogland do not impact the proximity of Joe Morolong.

This section concerns the physical research context's history, description, and attributes for connecting it to the research problem under study. The research study used two MAIPs, the SALT, and the MeerKAT, to determine if these projects impact rural development in Kareeberg and Karoo Hoogland, respectively. The Kareeberg, in the western part of the Pixley Ka Seme District Municipality in the Northern Cape province, consists of three towns: Carnarvon - the administrative centre, Vosburg, and Van Wyksvlei. This part of

the Karoo is called the Orange River Nama Karoo. Mixed Karoo veld is variable, and rain can fall in any season, but autumn is usually the best growing season. The veld combines bossies and summer-growing grasses with succulent plants (University of Free State, 2009).

Most people in Kareeberg, Karoo Hoogland and Joe Morolong Local Municipalities are highly impoverished. These regions have high illiteracy and unemployment rates (Department of Rural Development and Land Reform, 2015; Joe Morolong Local Municipality, 2020; Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020). These are the attributes of most rural areas in South Africa, primarily poor people residing in those areas. The two Local Municipalities' economies (Kareeberg and Karoo Hoogland), to some extent, are dependent on sheep farming, which is declining, as reported in the IDPs (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020). More people in these two local municipalities are becoming reliant on state social security grants. Therefore, this study aimed to determine how these MAIPs could impact aspects related to rural development that could assist in poverty alleviation in the Municipalities. The following section deals with the conceptualisation of the research, the research problem, the research statement, and the research questions.

1.3 Research Conceptualisation

1.3.1 The Research Problem Statement

South Africa's post-apartheid government identified astronomy as a niche research area for development. The government has gone to some lengths to protect and preserve rural areas against anti-astronomy bias, using legislative measures to achieve this (Department of Science and Innovation, n.d., 2019; Department of Science and Technology, 2002, 2007, 2015, 2016; Square Kilometre Array, 2012). South Africa has a competitive geographic advantage due to clear, dark skies and low radio and light interference

(Department of Science and Technology, 2002, 2007, 2015). Consequently, from 2005 to 2021, more than R10 billion of public funds were spent constructing and operating mega astronomy infrastructure projects in South Africa and other African country partners (Department of Science and Innovation, 2020a; National Treasury, 2021). This study assessed the extent to which astronomy could be considered a niche research area for development; that is, it analysed the efficacy of astronomy for rural area development. This frames the research's questions.

Fayos-Solá et al. (2014) and Velho et al. (2024) indicate that developers use tourism for development in rural areas; this is truer for those areas suitable for astronomy, including - astrotourism, conservation, ecotourism, and archaeology, and archaeotourism, among others. The focus of this study is on tourism-based astronomy – astrotourism. Astrotourism comprises two terminologies: tourism and astronomy. Astrotourism grows on the back of astronomy that is happening in an area. The conditions for astronomy to flourish include scarcity of rain, clear skies, dark, low radio interference, and the availability of astronomy infrastructures in the area. These conditions are primarily in rural spaces that are not usually part of the modernisation paradigm that considers advanced development. There are vast benefits for astrotourism: it could contribute to technological spin-offs, human capacity development, education, school improvement, and rural development. Further, it offers a critical contribution to the tourism sector, particularly in areas where MAIPs are situated, the rural parts of South Africa. As argued in this thesis, astrotourism could be a powerful instrument for rural area development. Given its technological intensity, astrotourism could disseminate knowledge and human capital development in the host rural communities. Against this backdrop, South Africa's government has continued investing significantly to build MAIPs. These are explored in this thesis.

Former Africa's SKA Project Director, Dr Bernie Fanaroff, pointed out that the SKA project should be taken not as an end-in-itself but as the means for poverty alleviation and development (Square Kilometre Array, n.d.). Given the unevenness development patterns in South Africa, between the rural and urban spaces, the role of astronomy is, therefore, progressive. Fanaroff further emphasised that the SKA project should be an opportunity to put South Africa on a developmental trajectory because scientific and technological developments are drivers of economic growth (Hauptfleisch & Singlé, 2012; Martin & Tang, 2007; Molas-Gallart & Tang, 2011; Simmonds et al., 2013; Stimson et al., 2022). There tends to be urban bias in much of the literature on modernisation or development (Rostow, 1960; Schuurman, 1993; Singh & Shishodia, 2016). There is, however, a paradox in using the MAIPs for rural development. As much as there is a need for development in South Africa's rural areas, South African legislation protects the astronomy sites and their surroundings from activities that can lead to modern development (The Astronomy Geographic Advantage Act of 2007, 2008).

The AGA Act seeks to conserve the place where astronomers erect mega astronomy infrastructure instruments from modern development that can negatively impact the scientific endeavours of mega astronomy instruments. Developers and astronomers are at loggerheads over this legislation because the popular understanding of development is according to modernisation theory: the more there are lights in the area, the more the site is developed. The easier the access to connectivity for telecommunication, the more modern the place is. Astronomers, on the other hand, perceive those activities often associated with modern development as restricting astronomy because they increase light and radio pollution due to skyglow and telecom transmitters in the areas. The cosmic radio source signals received on Earth are extremely weaker than the signals used by the telecom systems; therefore, they are easily masked by man-made interference which contaminates the data collected by radio

telescopes and leads to erroneous interpretations of data (Crawford, 1991; Thompson et al., 1991). Skyglow is a result of the use of artificial light sources, such as electrical or rare gases used for illumination, advertisement boards and gas flares, mostly in modernised areas (Thompson et al., 1991; Thompson, et al., 2017). Some of the factors astronomers consider in choosing a site to erect their instruments relate to the remoteness of the location, their underdevelopment, and the absence of radio and light pollution; essentially, the astronomer's wish is for the area to remain in the same state for astronomy to thrive (Bhogal, 2018; Slotegraaf & Glass, 2018; Smorenburg, 2016). In this sense, its logic diverges from the modernisation paradigm.

The other conflicting reason is that the MAIPs' proponents proclaim that these projects bring about scientific and economic benefits in the host country (Department of Science and Technology, 2002; Smorenburg, 2016). Those opposed to these expensive mega-science projects regard them as unaffordable luxurious ventures for only the few science and engineering elites – 'big toys for big boys'. Their gripe is that the government should not allocate funding for such expensive ventures in a highly unequal country riddled with high poverty, vast underdeveloped areas, and high unemployment rates (Bhogal, 2018; Gastrow, 2017; Smorenburg, 2016).

1.3.2 The Research Purpose Statement

This research assesses the extent of the contribution of mega astronomy infrastructure to development in the rural Northern Cape province in South Africa. At the start of the research, I had no assumption about whether such an effect would be positive or negative. At its crux, this study grapples with the tensions between the imperatives of development along the lines of modernisation and mega astronomy infrastructure and the preservation legislation, which is about preserving rural areas against modern development that is

associated with increased lights and radio waves within those rural areas earmarked for astronomy. To determine their impact, I studied two MAIPs, MeerKAT and SALT on development in Kareeberg and Karoo Hoogland Local Municipalities, respectively. Since the study period was from 2001 to 2021, the 1996 Census is the baseline for SALT, and the 2001 Census and 2009 Socio-economic Baseline Study by the University of the Free State are the baseline for MeerKAT (Stats SA, 1998, 2003; University of Free State, 2009).

I formulated four primary objectives for this research study to attain the research aim, and the study was based on the four secondary research questions listed in Section 1.2.2. The first research objective assessed if the economic infrastructure developed in Kareeberg and Karoo Hoogland because of MeerKAT and SALT, respectively. The second objective is to evaluate if employment rates in Kareeberg and Karoo Hoogland improved from 2001 to 2021 and ascertain whether the increase resulted from MeeKAT and SALT. The third objective determined if education prospects have improved within Kareeberg and Karoo Hoogland and to what extent such improvements were attributable to MeerKAT and SALT. The fourth objective determined if astrotourism – the branch of tourism resulting from astronomy was introduced and developed within the Kareeberg and Karoo Hoogland, and with what outcomes. The baseline was what had been there pre-2001 as measured by the 1996 and 2001 Censuses and 2009 Socio-economic Baseline Study by the University of the Free State (Stats SA, 1998, 2003; University of Free State, 2009).

The additional objective assessed Kareeberg and Karoo Hoogland residents' perceptions of the MeerKAT and SALT. Perceptions were measured both qualitatively and quantitatively. It is crucial to study and understand how these projects affect development in the rural areas where they are situated, considering the opposing views and the high costs of implementing MAIPs. Also, it is important to research how these projects shape evolving behaviour and opinions of the people in areas earmarked for these projects. This study adds

to our knowledge and understanding of MAIPs in rural areas through the lens of development. The impact of mega astronomy on rural people's lives has significance for academic study. As the projects in both Kareeberg and Karoo Hoogland evolve, the current study's results could provide valuable data that may lead to new scientific knowledge on changing livelihoods in rural areas.

1.3.3 The Main Research and Secondary Research Questions

This study assessed two MAIPs on socio-economic development in Kareeberg and Karoo Hoogland. There is one main research question, Question 1, and this study responded to the main research question through four secondary research questions, Question 1.1, 1.2, 1.3, and 1.4 listed in Table 1 below. The secondary research questions supported the main question and further investigated specific issues that assisted in responding to the main question. These secondary research questions examined rural Northern Cape development due to the SALT and MeerKAT projects. The main research question was divided into secondary research questions to which I could collect data and respond efficiently*: eating an elephant piece by piece until it is all consumed*, so to speak.

According to Leedy and Ormrod (2010), a researcher can divide the main question into several secondary research questions to efficiently resolve the main question. These provided secondary research questions clarify responding to the main question. The secondary research questions pertain to part/s of the issues assessed in forming a complete response to the main research question. These secondary research questions deal with aspects of development in Kareeberg and Karoo Hoogland Local Municipalities. The secondary research questions contain key research variables such as economic infrastructure, employment rates, education prospects, and astrotourism development. As this research is mixed method research last secondary research question is descriptive, i.e., people's

perceptions of mega astronomy projects. I cascaded those research variables and attributes into the data collection instruments, i.e., questionnaires, interview schedules and observations.

Table 1. Main Research Question and Four Secondary Research Questions

Main research question	
1. How have the Local municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs?	
Secondary research questions	
1.1	How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?
1.2	How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?
1.3.	How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?
1.4.	How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?

Kareeberg: Kareeberg Local Municipality; Karoo Hoogland: Karoo Hoogland Local Municipality; MAIPs: Mega Astronomy Infrastructure Project; MeerKAT: More Karoo Array Telescope; SALT: Southern African Large Telescope.

1.4 Delimitations and Assumptions of the Research Study

1.4.1 Delimitations of the Research Study

This research assessed socio-economic development in Kareeberg and Karoo Hoogland due to MeerKAT and SALT implementation from 2001 to 2021. This study focuses on economic infrastructures, improved education, increased employment rates, astrotourism development, and economic participation through the growth of small, medium, and micro enterprises (SMMEs) in the astrotourism sector. Economic infrastructures involve paved roads, reliable energy sources, and connectivity. Enhanced education is associated with the increased number of students taking natural sciences and mathematics subjects at the high school level and the increased number of students going to school up to high school. The study also assessed people's feelings about these projects, hoping to address the imaging

themes. This study did not deal with land reforms and agricultural development issues but rather mega astronomy infrastructure and their role in rural economic development.

The research results were reported using secondary and primary data. I collected data from interviews and surveys involving respondents from stratified samples, from business representatives, community leaders, ordinary community members, and employees to senior managers of the SALT and the MeerKAT projects. The study assumed all the input data on the SALT and MeerKAT projects would be readily available. Methods for assessing the impact of MAIPs on rural development were adopted. Another fundamental limitation is that I, as the primary researcher and data collector work for the Department of Science and Innovation (DSI). The DSI is the custodian of the MeerKAT and SALT MAIPs. Development studies such as community development, social entrepreneurship development, technology and inclusive innovation development, and land reform issues are also essential but beyond the scope of this study.

1.4.2 Assumptions of the Study

According to Leedy and Ormrod (2010), two assumptions form the basis of every study. First, the investigation of the phenomenon should be comprised of random events that are predictable and lawful, and second, some cause-and-effect relationships might have accounted for observed patterns in the spectacle. These two assumptions apply to the current study. We should avoid making assumptions and instead provide readers with explicit details in this research report.

I collected primary data from participants in Kareeberg and Karoo Hoogland, dominantly Afrikaans-speaking areas. I committed to draft data collection tools, i.e., interview schedules and questionnaires in English, the language in which I am competent. I then acquired the services of a professional translator to translate the English data collection

tools into Afrikaans. I employed two assistant researchers to assist with the translations and, in some instances conducting interviews in Afrikaans and interpreting them in English. The two research assistants' minimum qualifications were Grade 12 certificates, and they were conversant in English and Afrikaans and resided in the same communities. I assumed the language interpreters did not lose the participants' intended meaning while translating from one language to another.

Furthermore, I assumed that the data and information collected were not defective. There was a change in local government during the study period. I was granted permission to conduct research by the incumbent's predecessors. It was hoped that the incumbents would honour the agreement. The researcher assumed that the local government authority within the community would also honour the agreement and allow data collection to proceed.

1.5 Research Justification

This study is worth pursuing because there is a gap in scholarship, especially on the uses of MAIPs to achieve development outcomes in rural areas. The study also casts light on the contention about developing rural areas for MAIPs while preserving such sites to remain as original as possible. The preservation potentially restricts astronomy from thriving as an instrument of development. Under these conditions, it is challenging for MAIPs to facilitate or bring modern development to rural areas. A contention of modern development by these projects in rural areas arises due to legislative conditions to preserve the same rural regions from modern activity development. Therefore, it is paradoxical to expect the MAIPs to facilitate modern development in rural areas and preserve them through legislation against modern development. The study envisaged disentangling the paradox and explaining how development practitioners could navigate such.

The AGA Act limits or prevents modern development activities that produce radio waves, light waves, dust, and smoke. In contemporary society, development means ease of communication and access to the World Wide Web services through connectivity using radio waves. Any infrastructure or gadgets that transmit radio waves are prohibited in Kareeberg to avoid radio wave interference with the area's radio astronomy. It is common knowledge that good connectivity to the World Wide Web is paramount in modern-day development. Therefore, the question is how Karebeerg can be developed through MAIPs if some essential ingredients for modern development are prohibited. This research is crucial because it attempts to respond to this question.

People might recognise the developed, modern, and civilised cities by the bright night lighting, which is perceived as unsuitable for optical astronomy. To achieve good science through SALT, optical astronomers in Karoo Hoogland prefer clear night skies at all times. The Local Municipality should not improve the Karoo Hoogland, especially Sutherland night lighting to the extent that Sutherland loses its originality to remain an ideal place for optical astronomers worldwide. The AGA Act prohibits industries such as mining prone to heavy dust and smoke in Sutherland and Carnarvon for astronomy to thrive. Still, these industries could provide development opportunities in surrounding communities. The other question this research should respond to is how astronomy can help develop rural areas since other development activities that can assist are prohibited – redefining rural development using MAIPs. Even heavy contemporary constructions (economic infrastructures such as roads, wind towers, open cast mining, etc.) in Kareeberg and Karoo Hoogland may not be allowed because they are prone to heavy dust and smoke production, which could interfere with optical astronomy. Heavy construction and modern area development go together. If one is not allowed, the other does not thrive. Hence, practising world-class astronomy and simultaneously pursuing rural development is paradoxical. The current study gives insight

into whether the expectation of MAIPs facilitating development in rural areas is reasonable, especially given the association of high-tech development with modern urban areas. At a conceptual level, the study challenges some of the conceptions of development that assume linearity.

This thesis aims to examine the extent to which MAIPs impact rural development in South Africa. There is substantial literature on rural development through land reform, local economic growth, tourism, rural-urban migration, socio-economic, agriculture, community-based organisations, game farming, rural electrification, education, ICT, and many other government-initiated development projects, mostly unsuccessful (Azimoh et al., 2016; Binns et al., 1997; Binns, 1998; Binns & Nel, 2002; Department of Rural Development and Land Reform, n.d.; Henley, 2012; Mamba & Isabirye, 2015; Nel et al., 2001; Nel & Hill, 1996; Pasmas & Hebinck, 2017; Rosenberg et al., 2014). The others, such as Qobo (2022), Mugabe (2021, 2021), the African Academy of Science (2018), and the African Union (2014), looked at sustainable development in general through STI. However, there is not much recorded on rural development through astronomy; hence, this study is crucial.

Therefore, this thesis aims to close this research gap because this study used a combination of quantitative and qualitative research strategies (mixed method research approach). I adopted the pragmatic paradigm in this research, which is associated with situations, actions, and consequences (Creswell, 2014; Lather, 1992; Merriam & Simpson, 2000; Mills, 2017; Morgan, 2014; Neuman, 2006; Stringer & Dwyer, 2005). In a pragmatic worldview, the researcher focuses on applications - what is working and solutions to the problems that need to be solved instead of focusing on research methods; what happened before and used all available approaches to understand the problem vividly? (Čížek, 2009; Creswell, 2014; Morgan, 2014). Chapter 3 discusses the mixed-method research strategy and pragmatism in detail.

The current study used stratified sampling in the case of qualitative data and purposive random sampling as I understood the characteristics of the population in Kareeberg and Karoo Hoogland. The sample was ordinary community members consisting of youth aged between 18 and 35 years old; adults, people over the age of 35 years; disabled persons over the age of 18; community leaders such as chiefs and political leaders; farming communities around Kareeberg and Karoo Hoogland; managers of the MeerKAT and SALT projects; ordinary workers for the MeerKAT and SALT projects; business people or entrepreneurs (e.g. from guest houses; hotels; shops; construction companies) in Kareeberg and Karoo Hoogland. The study used a combination of structured and non-structured questionnaires to collect quantitative data.

The significance of this study is its value in contributing to the literature on rural development and deconstructing linear paradigms about development. This research is even more important given the paucity of studies on the impact of MAIPs on development in rural areas, which goes against the grain of how development in rural areas is often conceived. I provided valuable insights into changing lifestyles and environments through MAIPs in rural areas. In addition, I developed a conceptual model for MAIPs. Importantly, this study deals with the expectation of MAIPs to impact development in ways that diverge from modernist perspectives. The study will assist in responding to whether these projects should be used for rural development. This study verifies optimistic consultancy studies on development due to those MAIPs in KLM and KHLM.

The study findings could be helpful to the following stakeholders: the Department of Science and Innovation (DSI) as the custodian of the MeerKAT and SALT projects; the National Research Foundation (NRF) as the project implementing agency; the MeerKAT and SALT project implementation teams; the South African National Treasury as the primary funder of the projects in South Africa; the Provincial Government of the Northern Cape as

the host of the projects; the Kareeberg and Karoo Hoogland as the local hosts of the projects; South African taxpayers who have a role to play in evaluating the performance of the projects; the South Africa Government that has a responsibility to justify MAIPs' funding given the country's other basic needs, in particular socio-economic conditions and the policymakers on how MAIPs could be used for development without derailing the projects to not achieve their engineering, science and innovation outputs. Not doing this study leaves a gap in rurality versus development using astronomy. Without this study, there is a gap in investigating rurality versus development using astronomy. The section below is the thesis preface, which is the research chapter layout of this thesis.

1.6 Preface to the Thesis

Rural development in South Africa is crucial because the government prioritised it since the fourth democratic government administration. The Department of Rural Development and Land Reform (DRDLR) was established to focus on and manage rural development issues (Department of Rural Development and Land Reform, 2015; P. Jacobs & Hart, 2014.). In collaboration with the International Astronomical Union, the DSI established the Office of Astronomy for Development to monitor the use of mega astronomy to pursue development and social change in South Africa (International Astronomical Union, n.d.). These are the initiatives to use astronomy for general and rural development. Therefore, the current study aimed to determine if such initiatives have borne fruit by assessing the impact of the MAIPs on rural development.

In responding to the four secondary research questions theoretically and empirically, this thesis comprises seven chapters. Chapters 1 to 4 build the study's theory. Chapters 5 to 6 report on the empirical part of the research. In the concluding chapter, Chapter 7, the theory is synergised with empirical data to develop a new theory or framework for using astronomy

for rural development. Each chapter is divided into sections and sub-sections for document flow, simplicity, and planning, with sub-sections providing easy information management.

Chapter 1 is an introductory chapter divided into five sections. In the first section, the study research background that informed the study and motivated the researcher to undertake the study was outlined. The second section is the research conceptualisation, consisting of the research problem statement, research purpose statement, and research questions. The third section outlined the study's delimitations and assumptions, where I identify potential underlaying causes of the problem and the primary reasons for selecting the ones discussed. The research is justified in the fourth section; why was it essential to do the research and what the consequences had the study not been conducted. A brief thesis overview is provided in this, fifth section.

Chapters 2 and 3 review the literature to derive the study's conceptual framework. It provides the literature review overview in section 2.1, specific literature on rural areas in general in section 2.2, literature on South Africa's rural areas' historical context in section 2.3, and post-colonial and apartheid rural areas context analysis in section 2.4. In section 2.5, the different theories of rural development were discussed including strategies, economic and special statistical models. In section 2.6, the research knowledge gap analysis or impact on the body of knowledge in which development and rurality are defined using MAIPs. In Chapter 3 section 3.2, the research summarises all the literature reviews and derives a conceptual framework based on sections 2.2 to 3.2.

Chapter 4 discusses the research strategy, design, procedures, reliability and validity measures, and limitations. Chapters 5 and 6 present and discuss the findings to interrogate the research questions, while Chapter 7 summarises and concludes the research. Figure 2 illustrates the thesis outline based on the research outputs.

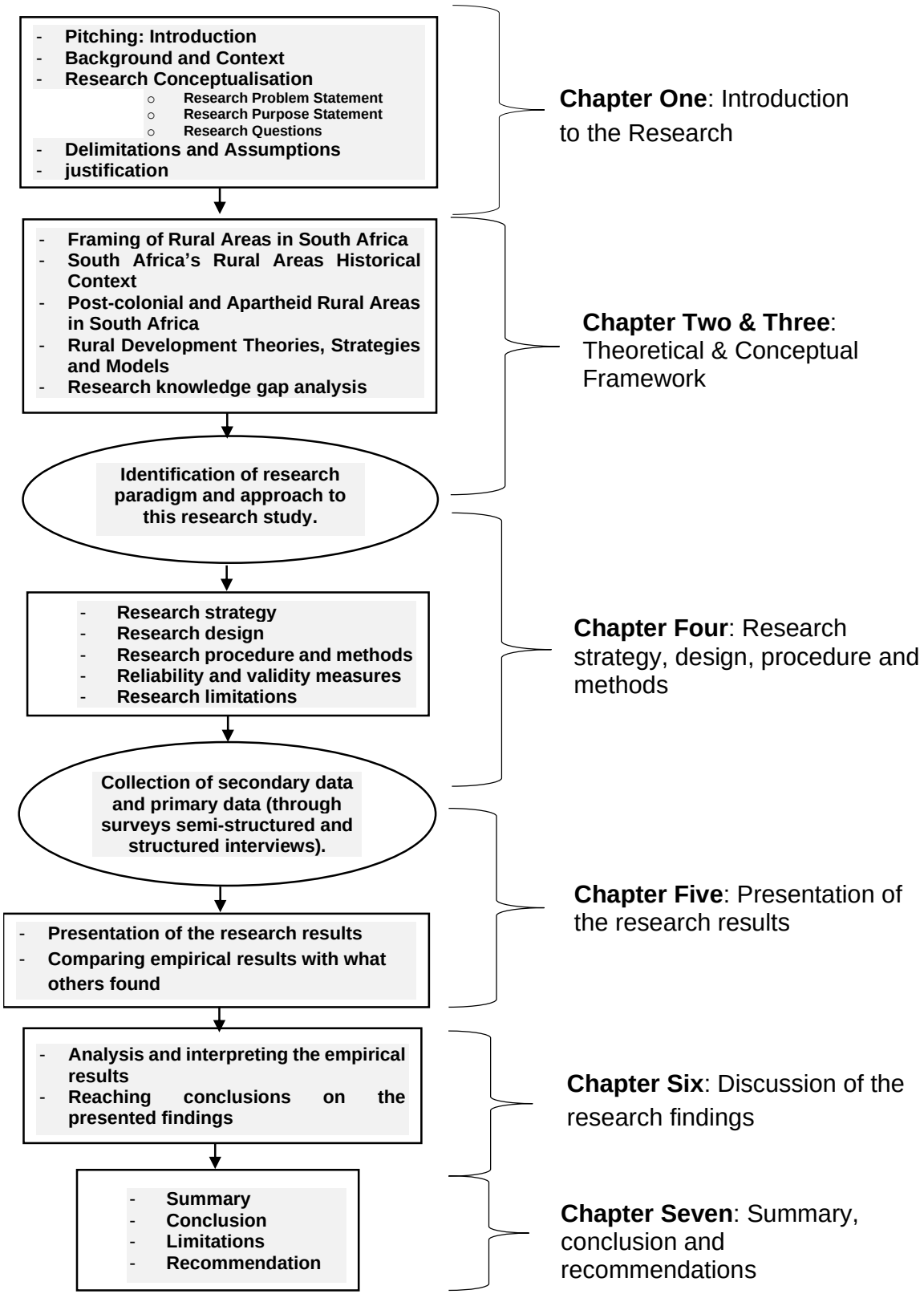

Figure 2. Thesis Outline Based on the Research Outputs

Chapter 2

Rural Development and Inclusion of Mega Astronomy: South Africa

2.1 Introduction

This literature review chapter has three broad objectives: understanding the research problem, identifying the knowledge gap, and developing a framework for interpreting the research findings. Sections 2.2 to 2.4 discuss or framing of rural areas in general and specifically in South Africa in pursuit of understanding the research problem. The sections include South African historical context and post-apartheid rural areas and development initiatives. Section 2.5 deals with rural development theories and strategies, and their applicability to the current study, and is about economic impact models for MAIPs, all in pursuit of identifying the research knowledge gap. Section 2.6 develops the research knowledge gap and identifies the research conceptual framework. Lastly, Section 2.7 summarises the literature review and develops and discusses the research conceptual framework.

As stated, this chapter is to review the literature to derive a conceptual framework for this research. Wotela (2016) defined a conceptual framework as a model informed by literature to frame the empirical component of the research and serves as an explanatory framework. Creswell (2009) and Mills (2017) added that the conceptual framework serves as a critical tool for researchers, providing a theoretical lens through which to approach and understand the research questions and hypotheses. Further, the conceptual framework identifies and operationalises the key variables, attributes, and their relationships and provides a roadmap for data collection and analysis by a systematic and coherent approach to research (Miles et al., 2014). A conceptual framework guides the selection of research methods, data collection techniques, and sampling strategies and ensures that the research

design is aligned with the theoretical underpinnings and research objectives (Creswell, 2014). The conceptual framework also offers an analytical framework for interpreting research findings (Miles et al. 2014). The following section discusses the concept of 'rural areas' to fulfil one of the three objectives of this chapter, which is to understand the research problem.

2.2 Framing of Rural Areas in South Africa

The rural area concept is the state of being, the reality of space and humans at the time of observation (Martinussen, 2004; Ndlovu, 2017). Sociologists and anthropologists elusively considered rural areas as country sites, underdeveloped, or not at all developed areas (Frankema et al., 2013; Martinussen, 2004; Ndlovu, 2017). They are areas where agriculture is a primary industry, and most rural dwellers live and work on ranches or farms (Frankema et al., 2013; Martinussen, 2004). Rural area communities play a vital role in the socio-economic fabric of many nations, especially Africa. Despite the increasing urbanisation trends, rural areas continue to be home to a significant portion of the global population (World Bank, 2019). Therefore, understanding the unique characteristics, challenges, and opportunities of rural communities is crucial for policymakers, researchers, and practitioners to develop effective and efficient strategies for sustainable development.

As stated by the Organisation for Economic Co-operation and Development (OECD) (Organisation for Economic Co-operation and Development, 2018), the World Development Report (World Bank, 2019), and the Conceptual Framework for Sustainable Development of Rural Areas (Sheina & Fedorovskaya, 2018), rural areas are typically characterised by lower population densities, vast land, and a significant proportion of agriculture activities. However, it is paramount to note that the demographic makeup of rural communities could vary greatly across regions and countries. Factors such as cultural, historical, and geographical differences contribute to the diversity within rural spaces, hence, understanding

the demographic composition is crucial for addressing specific challenges and designing targeted interventions.

Food and Agriculture Organisation of the United Nations (2019), Sheina and Fedorovskaya (2018), the United Nations (2014), and the World Bank (2019) agree that agriculture has been traditionally the backbone of rural economies, providing livelihoods for many rural inhabitants. However, rural economies are increasingly diversifying, with the emergence of non-agriculture sectors such as astronomy, tourism, manufacturing, and services. The economic dynamics of rural communities are influenced by factors such as access to markets, availability of infrastructure, technological advancements, and government policies. It is, therefore, imperative to examine the interplay between agriculture and the broader rural economy to promote sustainable development.

The Organisation for Economic Co-operation and Development (2018), and Sheina & Fedorovskaya (2018), amongst others, agree that rural communities often face unique social challenges that can have a significant impact on their well-being. Issues such as poverty, illiteracy, social isolation, digital divide, lack of service delivery, and inadequate social services are prevalent in rural areas. Comprehending these social issues is critical for formulating effective policies and programmes that could address the specific needs of rural communities while there is cognisance of cultural preservation, community engagement, and social capital playing essential roles in fostering a sense of belonging and well-being in those areas.

Access to basic infrastructure and services is a key determinant of the quality of life in rural communities (Sheina & Fedorovskaya, 2018). Challenges related to transportation, healthcare, education, and connectivity infrastructure are often more pronounced in rural areas than urban areas (Manggat et al., 2018; Martin & Tang, 2007; Ndlovu, 2017). Furthermore, the limited or not access whatsoever to adequate employment, health facilities,

educational institutions, and transportation networks keeps rural communities in perpetuity of poverty bondage. Less access or lack of thereof connectivity perpetuates the digital divide between rural and urban communities. Bridging this gap is essential to enhance rural development and improve the well-being of rural residents, hence the importance of undertaking of this study.

Policymakers, development practitioners, and researchers at various levels must develop targeted interventions to address the specific challenges rural communities face. Policies related to astronomy for development, agriculture, rural development, education, infrastructure, and healthcare should be designed to promote inclusive growth and sustainable development in rural areas. Also, evidence-based decision-making, stakeholder engagement, and participatory approaches are critical elements for the successful implementation of policies and interventions in rural areas (Food and Agriculture Organisation of the United Nations, 2019; Organisation for Economic Co-operation and Development, 2018; Sheina & Fedorovskaya, 2018; World Commission on Environment and Development, 1987). The following section discusses the South African historical context of rural development.

2.3 South Africa's Rural Areas Historical Context

Even the Department of Rural Development and Land Reform (DRDLR) defines rural areas as places with a low population density, where many economic activities are centred around agriculture, and where the basic infrastructure and services are to some extent limited (Department of Rural Development and Land Reform, 2013). The South African government also identifies former homeland and farm areas as rural. This is due to the areas' historical marginalisation and underdevelopment. The other recent indicator for the areas to be considered rural is for such areas to be classified as "rural development nodes" by the

DRDLR. The “rural development nodes” are rural targeted areas for focused development intervention.

Colonialism and apartheid perpetuated underdevelopment in rural South Africa because periphery places were intentionally left undeveloped and reserved for Black people. According to the White Paper of Local Government (Provincial Affairs and Constitutional Development, 1998) and Meyiwa et al. (2014), in 1948, Hendrik Verwoerd, the “architect of apartheid”, institutionalised segregation through the apartheid legislation the Group Areas Act No. 41 of 1950. The Group Area Act was central to apartheid legislation, further exacerbating the local level's geographical, institutional, and social separation. The Group Areas Act introduced strict rules on residential segregation and forced removal of Black people to areas termed “own group” areas and the Bantustans. The Act perpetuated local segregation and inequality, leaving a colossal scar on South Africa's rural areas. Apartheid created a legacy of inequality between urban and rural, Black and White, creating two economies within the same country, making South Africa presently the most unequal country globally (Jacobs & Hart, 2014, (Ndhlovu, 2022); Ndinda & Ndhlovu, 2022). The racial classifications in South Africa were used to show the extent to which racism had resulted in privileging Whites and marginalising Blacks (Ndinda & Ndhlovu, 2022). The White Paper of Local Government (Provincial Affairs and Constitutional Development, 1998) posits that the segregation policy did not start in 1948 when the government enacted the apartheid legislation but from the colonial era (Provincial Affairs and Constitutional Development, 1998).

According to the White Paper of Local Government (Provincial Affairs and Constitutional Development, 1998; Ndhlovu & Shangase, 2018), the Group Areas Act disallowed permanent residence and presence of indigenous Africans, particularly Blacks, in urban areas through the pass law system. The apartheid Group Areas Act aimed to limit the

extent to which municipal integration could happen so that affluent White municipalities may not bear the financial burden of supplying service delivery to near and adjacent disadvantaged Black areas. The segregation between Black and White, rural, and urban, was done through spatial segregation, a policy of “own management for own areas”, and influx control. Under the apartheid regime, numerous attempts to introduce the policy of “own management” for specifically Black people were made, partly to compensate for restricted human rights and in another part to strengthen the economic and political privileges of racial exclusion by the Group Area Act. In rural areas, former Bantustans, there was limited local government establishment. Traditional leaders were responsible for land allocation and development matters. Some small rural towns, townships, and villages (referred to as "R293 towns") had administrations without power because power resided in the central government.

The 1998 White Paper of Local Government further states that the Administrative Boards, which removed responsibility for townships from White municipalities, were established through the Bantu Affairs Administration, Act of 1971. The Community Councils, elected bodies, were introduced to the communities in 1977. Councils had no meaningful authority and not enough resources to perform the mandated duties adequately. The Community Councils never gained political traction and credibility. In 1982, the administration abandoned the Community Council's idea. The government replaced the Community Councils with another body, the Black Local Authorities. The Black Local Authorities also had no financial resources, and the people did not accept it. The people perceived the Black Local Authorities as politically illegitimate structures. The rejection of this body in the mid-1980s sparked community mobilisation and at times violent demonstrations. These bodies, Community Councils, and Black Local Authorities failed in their conceptualisation. After all, they were not fit for the purpose because the government of the day did not provide them with the necessary financial resources to perform their intended

mandate, which was to make a real difference in the quality of the livelihood of their constituents. The government designed those bodies to reinforce the segregation policies and economic exclusion of Black people.

The 1998 White Paper of Local Government and Mayiwa et al. (2014) confirm that the local government revenue was self-generated, mainly through property taxes and services to residents and businesses in the area. This arrangement suited the apartheid government and their White municipalities, with small populations, significant economic resources, and a broad tax base. The apartheid laws barred most industrial and retail developments in rural areas where most Black people resided. These Black areas used little revenue from a limited tax base and dealt with non-payment of the rates due to the high poverty rate in those areas, which is the prevailing situation even presently. Massive financial shortfalls gradually accumulated in rural local municipality governments. There was also the conception of development that sought to advance some form of modernisation for one section of the population, Afrikaners in the countryside through commercial agriculture and subsistence farming for Blacks while Blacks earned an income through acting as labour reserves. The paradigm of development that prevailed during this period was anchored in the notion of "separate but equal" development (South African History Online, n.d.). This was a doctrine to justify racial segregation development first established around 1896 in the United States of America (Berry, 1996). Therefore, the current study, the Kareeberg, Karoo Hoogland and Joe Morolong Local Municipalities and their surrounding small towns are considered rural. In continuing with research problem analysis, the next section discusses the post-colonial and apartheid rural areas.

2.4 Post-colonial and Apartheid Rural Areas in South Africa

Earlier in this chapter, I discussed and framed what is meant by rural areas and towns. I classified Kareeberg, Karoo Hoogland and Joe Morolong Local Municipalities as rural. These Local Municipalities consist of klein dorpies [translated from Afrikaans small towns], surrounded by farming communities. However, this is not a conventional description of rural towns. According to Stats SA's (1998) Discussion Document on the investigation into appropriate definitions of urban and rural areas for South Africa, the meaning and classification of urban and rural areas is fluid. The urban vis-á-vis rural is based on a combination of land use and the surveyor's general plans (cadastre). According to the Municipal Demarcation Board (n.d.), the Republic of South Africa's Constitution (Constitution of the Republic of South Africa No. 108 of 1996) and the Municipal Structures Act (Civic Academy, 2018; Municipal Structures Act No. 117, 1998) are silent on defining the urban vis-á-vis rural.

However, the Republic of South Africa's Constitution and the Municipal Structures Act created three categories of Municipalities: Metropolitan Municipalities (category A), District Municipalities (category C), and Local Municipalities (category B). Metropolitan Municipalities exist in the eight big South African cities: Johannesburg, Cape Town, Tshwane, eThekwini, Nelson Mandala Bay, Mangaung, Buffalo City, and Ekurhuleni, each consisting of Wards. Local Municipalities are all areas that fall outside the eight Metropolitan Municipalities. There are 226 Local Municipalities in South Africa, consisting of several Wards similar to the Metropolitan Municipalities. District Municipalities also consist of several Local Municipalities that fall within the district. This study has classified rural municipalities as those in categories B and C; these should be those far from the category A municipalities. Even though most rural municipalities fall in categories B and C, there is still no clear definition of rural towns.

While I can categorically say most categories B and C fit as rural areas, the 1998 White Paper of Local Government disagrees. The White Paper indicates that the segregation of rural regions from towns and cities has imposed artificial administrative and political boundaries between areas that might otherwise be functionally integrated. The White Paper further emphasises that separating rural from urban brings about inequality, exclusion, and inequity for rural dwellers who contribute to the urban economy but do not benefit from it. The White Paper sharply discourages the separation of rural from urban, purporting that such separation can impose administrative and political boundaries between the functionally integrated areas. The White Paper further affirms that integrating rural regions with their adjacent urban areas through the demarcation of category B municipalities is permitted by the legislation and regarded appropriate by the Constitution. This should be done in pursuance of desegregation development and abolishing the notion of "separate but equal" development.

South Africa's Municipal Demarcation Board is mandated to determine municipal boundaries through the Municipal Demarcation Act No. 27, 1998 and relevant legislation enacted in terms of Chapter 7 of the Republic of South Africa's Constitution. The 1988 White Paper of Local Government also clarifies the separation of rural and urban areas. The Municipal Demarcation Act provides for integrating rural areas with adjacent urban regions where the peri-urban areas are defined and perceived as capable of complete urbanisation. Most rural and peri-urban regions suffered the legacy of apartheid-era legislation of displacement. Then, the current study considers the Kareeberg, Karoo Hoogland, and Joe Morolong and their small towns' rural municipalities despite the structured post-apartheid municipalities. The following section deals with rural development theories, strategies, and their applicability in this research in pursuit of identifying the research knowledge gap. Section 2.6 is about economic impact models for MAIPs in identifying the research knowledge gap. Section 2.7 identifies the research knowledge gap from the reviewing of the

literature review and section 2.8 summarises the literature review and develops the research conceptual framework.

2.5 Rural Development Theories, Strategies and Models

Rural development is a complex phenomenon, defined through the lens of the contemporary practice of dualism, as discussed by Heinämaa (2003) and Ndlovu (2017). Heinämaa (2003) posits that rural development can be traced back to Cartesian philosophy, developed in the 17th century by philosopher René Descartes – the father of Western philosophy. Cartesianism produced an ontological dualism of the mind and the body, the process of duality for conceptualising the social phenomenon meaning that rural development could not be conceptualised without considering urban development. In simple terms, the concept of duality is when the presence of a specific social phenomenon provides the basis for the possibility of the existence of another social phenomenon. For example, it is unimaginable to think about the concept of "man" without thinking about concept of "woman." How about thinking of the concept, "day" without thinking of the concept, "night"? Indeed, it is not that easy.

Ndlovu (2017) and Nel at el. (1997) point out that to comprehend the complexity of the rural development phenomenon, one may examine its purpose by dissecting it into two separate bodies of knowledge development, and rurality. The meaning-making process of double social construction is helpful because it can assist in recognising the hidden meaning that the community might miss while looking holistically at the concept of rural development (Ndlovu, 2017). Like the rural development phenomenon, the concept of development is not normative but abstract and difficult to comprehend because no universal definition is accepted. For example, Ndlovu (2017 p45) defines development in isolation and views rurality as the 'state of becoming'. Commonly, the Asian Studies Association of Australia

(n.d.), Frankema et al. (2013) and Martinussen (2004) define development as a concept that signifies progressive change or improvement over time, space, and humans, which is the definition that we adopted for the current study. The rurality concept without development is the 'state of being', the reality of space and humans at that time of observation (Ndlovu, 2017 p45). Sociologists and anthropologists elusively considered rural areas as country sites, underdeveloped, or not at all developed areas. They further defined them as areas where agriculture is a primary industry, and most rural dwellers live and work on ranches or farms (Frankema et al., 2013; Martinussen, 2004).

As a result of the double social construction of the rural development phenomenon, rural becomes an object of development. Hence, when researchers investigate the meaning of rural development, they do not necessarily doubt whether rural spaces exist. However, the question is, what should the rural areas look like after post-development? The other question worth considering is which lens researchers use to judge whether the rural spaces are developed or not in the eyes of those with a preconceived Western idea of development. Development scholars are unsuccessful in reaching an agreement about what rural development entails. Those disagreements are because the researchers' views are, to some extent, impacted by their economic, social, political, spatial, and epistemic locations as they conceptualise rurality and development phenomena. Thus, the topical idea of the definition of development is that the researchers could never reach a consensus, which makes the rural development phenomenon highly contested.

Even the Cartesian philosophy of ontological dualism, as Dika (2020), Ndlovu (2017) and Thibaut (2018) attest, does not make it easy to define rurality without urbanity. Therefore, this difficulty also applies to determining rural development without urban development as direct opposites. The empirical part of the current study provides valuable

clarity on these contentions. The following paragraphs endeavour to discuss rural development theories, strategies, and models.

2.5.1 Rural Development Theories and Strategies

Earlier, in this thesis, rural development was defined as a complex process that involves economic, social, and environmental factors through partnerships and collaboration of various stakeholders i.e., local communities and public and private sectors (van Wyk-Jacobs, 2018). Rural development theories have evolved as a reflection of the global economy and societal values changes (Frankema, 2013; Ndlovu, 2017; Singh & Shishodia, 2016). The current study explored some key rural development theories with their associated models and strategies such as the theories of modernisation, dependency, trickle-down, community-driven development approach, sustainable development approach, human development approach, Gandhian philosophy and finally the African Renaissance Movement.

The associated strategies are top-down strategy, bottom-up strategy, participatory strategy, and integrated strategy in rural areas with the following models: Hauptfleisch and Single production process model, Martin, and Tang's simple linear model, Chain-link Kline and Rosenberg model, Advanced Martin, and Tang time-based benefits assessment, and finally, the Theory of Change (ToC) Framework. All elements of these theories, strategies and models/frameworks are discussed in the following subsections and appropriate ones were selected for the current study's conceptual framework.

2.5.1.1 Modernisation Theory

According to rural development literature (Bebbington, 2000; Lynch, 2013; Goorha, 2010; Rostow, 1960; Schuurman, 1993; Singh & Shishodia, 2016), one of the earliest theories of development is the modernisation theory, of which rural development researchers have

widely debated. The father of modernisation theory is a subject of debate among scholars as multiple influential thinkers have immensely contributed to the development of this theory (Albrow, 2020). However, one widely recognised figure in this regard is Max Weber, a German sociologist, philosopher, and political economist (Magalhães, 2021; Weber, 1945). Other notable scholars who have made significant contributions to modernisation theory, amongst others, include Karl Marx, Emile Durkheim, and Georg Simmel. These thinkers have provided valuable insights into the process and consequences of modernisation, further enriching the modernisation discourse (Albrow, 2020; Magalhães, 2021).

Bebbington (2000) and Goorha (2010) defined classical modernisation theory as a sociological and economic theory that emerged after World War II to explain the process of development in non-Western countries. This classical modernisation theory argues that economic growth, social change, and cultural transformation are all interrelated and that the adoption of Western values and institutions is necessary for development. Further, it attests that the traditional societies are underdeveloped and backward; hence, they must follow a linear path towards Western-style classical modernisation, which is considered urbanization in some instances. The classical modernisation theory suggests that rural development can only occur when modern industrial societies replace traditional rural societies. However, Ndhlovu (2024) disputes the assertions of modernisation by labelling them neoliberal narratives that degrade indigenous knowledge systems, and disempower, and dehumanise the poor rural people. This theory assumes that modernisation will lead to increased economic growth and better living standards for rural populations. Rostow (1960) postulates that modernisation theory involves a series of stages which rural societies must go through to achieve complete modernisation: first, traditional society; second, preconditions for take-off; third, take-off; fourthly, drive to maturity; and lastly, high mass consumption.

Rostow (1960), Schuurman (1993), and Singh and Shishoda (2016) affirm that several strategies should be employed to promote modernisation in rural areas, one of which is the promotion of industrialisation, which is emphasised as a critical component of modernisation. Industrialisation is perceived to increase productivity, employment opportunities and hence promote economic growth. Industrialisation can involve numerous initiatives, such as providing incentives for business investment, intense development of rural area infrastructures, and providing high-quality training and education for the people residing in rural areas. Educating and training people living in rural areas is regarded as an important aspect of modernisation because it may help with necessary skills that could expand employment opportunities. Education and training opportunities can be provided through access to good schools and general and vocational training programme initiatives. Modernisation theory also puts more emphasis on the ability of Science, Technology, and Innovation (STI) to transform economies and societies (Lynch, 2013). The part of training and education for modernisation is directly related to the human development approaches theory, one of the rural development theories discussed later in this chapter.

These strategies for modernisation theory are funnelled through what is referred to by Mosse (2004) and Pranadji et al. (2021), as the top-down approach which involves centralised decision-making and implementation processes, in which regional or national authorities design policies and interventions. This approach provides efficient resource allocation and coordination advantages but overlooks local context and community needs, leading to limited or no project ownership and sustainability.

However, this classical theory, which was popular in the mid-20th century, has been heavily criticised for neglecting the social and environmental impacts of development prevalent in rural spaces (Goorha, 2010). The theory also promotes Western cultural imperialism and ignores the unique historical, cultural, and social contexts of non-Western

societies. It further overlooks the negative consequences such as environmental degradation, social inequality, and political instability. They also point out that Western-style modernisation may not be appropriate or desirable for all societies. Hence, Goorha (2010) suggested that the classical modernisation theory is too old and needs to be reviewed and revised to the contemporary modernisation theory, which should encompass the latest development that ensued within the communities and address issues raised by the critics as deficiencies of the classical theory.

Despite all criticisms, classical modernisation theory seems to profoundly impact development policies globally. It has influenced the strategies of international development agencies and national governments. It has shaped the discourse on development in academic and policy circles. It alleges that rural areas could be developed by adopting modern technologies and practices, such as mechanised agriculture, mining, and industrialisation such as the Fourth Industrial Revolution, which is a purview of technologies such as the Internet of Things, Quantum Computing, Machine Learning, Artificial Intelligence, Robotics, Face Recognition Technology, Big Data Analytics, High-Performance Computing, Blockchain Technologies, Digitisation, 3D Technology, Nano Technology, Precision Medicine, Regenerative Medicine and Stem Cells Technology, and Immunotherapy, amongst others. In the case of the current study, the classical modernisation theory may posit that Kareeberg and Karoo Hoogland could be developed due to astrotourism, connectivity, and technology bought as the results of MAIPs. The other theory of rural development that has some similarities with the modernisation theory but different is the trickle-down theory which is discussed in the paragraph below.

2.5.1.2 Trickle-down Theory

The trickle-down theory is one of several theories of rural development that explain how rural areas can be developed. Like the modernisation theory, the trickle-down theory does not have a single notable "father" because it is a concept that has been discussed and debated by many economists and policymakers, such as Adam Smith, David Ricardo, Jean-Baptiste Say etc., over time, drawing on various classical economic theories (Anderson, 2012; Sowell, 2012). The theory gained prominence during the Reagan era in the United States of America however, it is important to note that the theory predates the era and had been long discussed and critiqued by scholars and economists before the Reagan administration popularising it (Sowell, 2012; Vergara & Salazar, 2021; Wilson, 2022). Ronald Reagan served as the 40th President of the United States of America from 1981 to 1989.

The theory suggests that economic growth in a country or region will eventually benefit all members of society, meaning that economic growth in urban areas will eventually trickle down to rural areas, leading to rural development (Aghion & Bolton, 1997; Basu & Mallick, 2008; Sowell, 2012). The trickle-down theory is an economic concept that suggests that economic growth eventually "trickles down" to the lower classes (Ndhlovu, 2019 p74). For example, trickle-down theory proponents believe that if the government provides tax cuts, subsidies, and other economic benefits to the wealthy, they will invest in businesses and create jobs, leading to economic growth that will benefit everyone. However, this theory has been debated for many years, with some structural economists arguing that it does not work in practice. Neoclassical economists are the leading proponents of the trickle-down theory; however, structuralist theorists have sought to rebut the trickle-down theory's assertions (Okada, 2017). Structuralist theories, also known as structural economics, are economic theories that emerged in the mid-20th century as a critique of neoclassical economics (Yonay,

1998), such as the dependency theory discussed in the next subsection. Structuralist theories focus on the role of economic structures, institutions, and power relations in shaping economic outcomes (Sapkota et al., 2013).

Structuralist theories argue that economic development is influenced by factors beyond supply and demand, such as historical, social, and political factors (Fontana, 2010; Okada, 2017). They emphasise the importance of understanding the underlying structures and institutions that shape economic behaviour and outcomes. One key aspect of structuralist theories is the notion of dualism, which refers to the coexistence of modern and traditional sectors within an economy (Fontana, 2010). Rising inequalities today, including within developed economies, demonstrate the failure of "trickle-down" theories (Ndhlovu, 2019, p.74). Even developed economies engage in state interventionist measures such as providing incentives for businesses or placing local content conditions on companies (Sapkota et al., 2013). The Joe Biden administration's Inflation Reduction Act goes against "trickle-down" growth theories that rely mostly on markets' allocative efficiency (Federal Information, 2023; Fox Business, 2023; Target News Service, 2023).

Aghion and Bolton (1997), Gai and Zhou (2022), and Vergara and Solazar (2021), agree that trickle-down theory is based on the idea that economic growth is necessary for development and suggest that if a country or region can achieve sustained economic growth, this will eventually lead to improved living conditions for all members of society, including those in rural areas. This is because economic growth can lead to the creation of jobs, increased wages, and improved access to services such as healthcare and education. The trickle-down theory recognises the importance of private-sector investment in rural development and suggests that businesses can be encouraged to invest in rural areas, leading to increased economic activity and improved living conditions for rural residents (Ardington

& Lund, 1995; Gai & Zhou, 2022). This is because businesses can create jobs, provide goods and services, and contribute to the local economy.

The mishap of the trickle-down theory is a top-down approach, which assumes that economic growth will automatically lead to improved living conditions for all members of society; however, this is not always the case, particularly in rural areas (Anderson, 2012; Basu & Mallick, 2008; Böhm et al., 2015; Sowell, 2012). In some cases, economic growth may only benefit a small segment of the population, leaving others behind because economic growth can be unevenly distributed, with some regions or sectors benefiting more than others (Basu & Mallick, 2008; Sowell, 2012).

Another mishap of the theory, according to Anderson (2012) is that it assumes that private-sector investment will automatically lead to improved living conditions for rural residents. However, this is not proven to be the case, particularly in areas with little infrastructure or where the business environment is challenging. In some cases, businesses may be reluctant to invest in rural areas due to the high costs of doing business or the lack of a skilled workforce and adequate infrastructure.

Basu and Mallick (2008) and Sowell (2012) also posit that the trickle-down theory has been criticised for neglecting the role of government in rural development. Empirical evidence of the trickle-down theory's effectiveness is mixed because some studies suggest that tax cuts and other benefits to the wealthy do lead to increased investment and job creation, while others suggest that the benefits are minimal or non-existent. For example, a study by the Congressional Research Services (2022) and the Institute for Policy Studies (2020) found that there was little evidence to support the claim that tax cuts for the wealthy lead to increased economic growth and job creation. Similarly, the study by the Institute for Policy Studies (2020) found that the wealth of the top 0.1% increased by 736% between 1980

and 2017, while the wealth of the bottom 90% increased by only 9%. This suggests that the benefits of economic growth are not trickling down as the theory promises. The theory suggests that economic growth and private sector investment are sufficient for rural development, but this overlooks the important role that government could play in promoting rural development. For example, government policies can help to create an enabling environment for business investment, provide infrastructure and services, and promote social inclusion.

Finally, trickle-down theory is a widely debated concept in rural development. While the theory has some strengths, including its recognition of the importance of economic growth and private-sector investment, it also has several weaknesses. The weaknesses include the theory's assumption that economic growth will automatically benefit all members of society, its neglect of the role of government in rural development, and its failure to address the challenges of unevenly distributed economic growth. As such, policymakers should be cautious in relying solely on the trickle-down theory in their efforts to promote rural development. Instead, they should adopt a more comprehensive approach that considers the role of government, the challenges of economic growth, and the needs of rural residents. The other theory used for rural development is dependency theory which is a school of thought within the field of economics, that emerged in the 1950s and 1960s as a response to the failure of modernisation theory in rural development (Bebbington, 2000). Dependency theory is discussed in the paragraphs below.

2.5.1.3 Dependency Theory

Dependency theory argues that third-world countries could achieve development by following the same development trajectory as first-world countries (Agbebi & Virtanen, 2017; Cardoso and Faletto, 1979; Santos, 1970). Dependency theory is a collective body of

work, several key scholars are credited as the founders or major contributors to its development. Among those scholars, the most prominent figure is Raůl Prebisch an Argentine economist and diplomat (Cardoso & Faletto, 1979; Frank, 1969; Prebisch, 1950). Prebisch served as the Executive Secretary of the United Nations Economic Commission for Latin America and the Caribbean from 1950 to 1963 (Cardoso and Faletto, 1980; Santos, 1970).

Another influential scholar in the development of dependency theory is Andre Gunder Frank, a German American economic historian and sociologist. Frank's work, particularly his book "Capitalism and Underdevelopment in Latin America" (1969) expanded on Prebisch's idea and emphasised the role of historical colonialism and imperialism in perpetuating underdevelopment in the global South (Frank, 1969). Other notable contributors to the development of dependency theory include Fernando Henrique Cardoso and Enzo Faletto, who co-authored "Dependency and Development in Latin America" (1979). Their work focused on the political and social dimensions of dependency, exploring how power structures and social relations within and between countries contribute to underdevelopment (Cardoso & Faletto, 1979).

The theory suggests that developing countries are more dependent on developed countries for their economic growth and development (Frank, 1969). Therefore, cascading it down to rural development, according to Bebbington (2000), means that rural areas often depend on urban areas for resources and markets. However, this approach emphasises the need for local control over resources and the development of alternative economic activities, such as eco-tourism, astrotourism, and artisanal production.

Dependence theory's critics strongly criticise the theory that it suggests that the relationship between developed and developing countries is one of exploitation, with developed countries benefiting from the resources and labour of developing countries while

providing little in return (Escobar, 1999). Agbebi and Virtamen (2017), Cardoso and Faletto (1979), and Frank (1969) agree that dependency theory is flawed because it ignores the historical and structural factors that create the unequal relationship between first-world and third-world countries. They further confirm that the theory insinuates that the relationship between the first-world and the third-world countries is characterised by the exporting of raw materials from third-world countries to first-world countries. First-world countries process those raw materials into finished goods and sell them back to third-world countries at a higher price. This relationship is not mutually beneficial and is perpetuated by the control that first-world countries have over international trade and finance, which allows them to set prices and terms of trade that benefit themselves at the expense of third-world countries. The critics confirm that this relationship has negative consequences for third-world countries, including perpetuating poverty, underdevelopment, and political instability.

Regarding development in rural areas, Frank (1969) says the dependency theory suggests that rural areas are too dependent on the global economic systems; therefore, economic development in rural areas is hindered by this dependency. He advises that rural areas must break free from this dependency to achieve economic development and posits that global economic systems exploit rural spaces by extracting resources and using labour (cheap labour) from rural spaces without providing adequate compensation. The exploitation is perpetuated by a system of unequal exchange, in which rural areas are compelled to export their raw materials at a low price and import finished products at high prices.

Cardoso and Faletto (1979) devised a strategy for rural areas to break free from dependency by promoting import substitution. Import substitution involves developing local industries to produce goods that were previously imported, creating skill bases to reduce dependency on foreign goods, and promoting local economic development. Santos's (1970) strategy for rural areas to break free from dependency is land reform, alluding that land

reform could assist in reducing inequality and promoting economic development in rural areas. Land reform could involve initiatives such as land redistribution to emerging farmers, promoting collective land ownership through cooperatives, and providing necessary support to such cooperatives.

One of the demerits of dependency theory is overlooking the potential and importance of global economic integration by emphasising the negative effects of global economic integration on rural areas. For example, economic integration could provide access to new markets and technologies, which could assist in promoting economic development in rural areas. As much as dependency theory strongly emphasises the role of global economic forces in shaping development trajectory, it overlooks the role and importance of local factors in rural areas such as culture, politics, and institutions. The local factors in most cases are more prevalent and may be more important in shaping the development outcomes than global economic forces. Another important theory is the Community-driven development approach to rural development, which emphasises the active involvement of local communities in the development process, i.e., inception, planning, implementation, and monitoring and evaluation of development projects (World Bank, 2004, 2005). Community-driven development approach is further discussed in the following paragraphs.

2.5.1.4 Community-driven Development Approach Theory

While it is challenging to attribute the Community-driven development approach to a single notable contributor the collective efforts of individuals like Robert Chambers, a British development practitioner and researcher, John Friedmann, an American urban planner and scholar, and organisations like the World Bank have played a significant role in shaping and advancing the principle and practices of Community-driven development (Chambers, 1994,

1997; Friedman, 2021; Friedmann, 1992; World Bank, 2004, 2005; World Commission on Environment and Development, 1987).

The Community-driven development approach theory adopts the bottom-up and participatory strategies, which recognise that rural communities have unique needs and challenges and that they are best suited to come up with solutions that work for them (Chambers, 1997; Cooke & Kothani, 2001; Labonne & Chase, 2011; Nguyen & Rieger, 2017). Community-driven development is susceptible to empowering local communities to identify their own needs, set priorities, and implement development projects of their choice and active involvement and collaboration among all the stakeholders (Chambers, 1994, 1997; Cooke & Kothani, 2001). Participatory strategies promote inclusive decision-making processes, capacity building, and knowledge sharing, enhancing social empowerment, local ownership, and sustainable development outcomes (Cornwall & Gaventa, 2001; Pretty, 1995; Pretty et al., 2011). The approach is based on the belief that communities have a better understanding of their needs and priorities than external actors and that involving them in the development process can lead to more sustainable and effective outcomes (Bado, 2012; Daniel, 2014; World Bank, 2004).

Community-driven development is based on a set of principles that prioritise community participation, local ownership, and capacity building. According to Dasgupta and Beard (2007); Daniel (2014), Morton Ninomiya et al. (2020), and the World Bank (2004), the following are some of the key principles of Community-driven development: 1. Community participation: the Community-driven development priorities the participation of communities in all stages of the development process, from identifying needs and priorities to implementing and monitoring projects. 2. Local ownership: Community-driven development emphasises the importance of local ownership of development projects, with communities taking the lead in decision-making and implementation. 3. Capacity building: Community-

driven development recognises the importance of building the capacity of communities to participate in the development process, with a focus on skills such as project management, financial management, and monitoring and evaluation. Finally, sustainability: Community-driven development aims to promote sustainable outcomes by prioritising the use of local resources, building local institutions, and involving communities in the maintenance and management of projects.

There is a growing body of evidence supporting the effectiveness of CDD in promoting sustainable and effective development outcomes. The following are some examples of research that highlights the positive impact of Community-driven development: A study by the World Bank found that Community-driven development projects in Indonesia led to improvements in access to basic services, including water and sanitation, health care, and education (World Bank, 2004, 2005). The study also found that communities involved in Community-driven development projects had higher levels of trust and social cohesion, which contributed to their ability to work together to address development challenges (Bado, 2012; Greene et al., 1989; Grootaert, 1999; Morton Ninomiya et al., 2020; World Bank, 2005). A study by the International Fund for Agricultural Development found that Community-driven development projects in rural areas of Africa, Asia, and Latin America led to improvements in food security, income generation, and women's empowerment. The study also found that Community-driven development projects have a positive impact on the social and political capital of communities, leading to increased participation in local governance (International Fund for Agriculture Development, 2017). A study by the United Nations Development Programme (United Nations Development Programme, 2016) found that Community-driven development projects in Afghanistan led to improvements in infrastructure, including roads, bridges, and irrigation systems. The study further found that the Community-driven development projects had a positive impact on social cohesion and

community empowerment, leading to improved security and stability in the region. As such, policymakers and development practitioners are advised to consider Community-driven development as one of the viable approaches to promoting sustainable and effective rural development outcomes. However, Friedmann (1992) posits that a more recent theory of rural development is the sustainable development approach, which is a concept that has gained increasing attention in the past decades. The sustainable development approach is discussed in the following paragraphs.

2.5.1.5 Sustainable Development Approach Theory

The theory of the sustainable development approach is new, and it emerged in the 1980s as a response to growing recognition of the environmental and social challenges with traditional development approaches (United Nations, n.d., 2014; World Economic Forum, 2020). While there is not a single individual who can be considered the 'father' of the sustainable development approach, there are several key figures who have made significant contributions to its development and popularisation (World Commission on Environment and Development, 1987). According to the World Commission on Environment and Development (1987), one influential figure in the advancement of sustainable development is Gro Harlem Brundtland, a former Prime Minister of Norway. Brundtland chaired the United Nations World Commission on Environment and Development, which produced the landmark report "Our Common Future" in 1987. This report introduced the widely accepted definition of sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987 p245).

Furthermore, the Brundtland Report and the Earth Summit were instrumental in establishing sustainable development as a global priority and influencing subsequent

international agreements such as the United Nations Sustainable Development Goals adopted in 2015. Another notable contributor to the Sustainable Development Approach is Maurice Strong, a Canadian businessman and diplomat. Strong played a crucial role in organising the United Nations Conference on the Human Environment in Stockholm in 1972, which marked a significant milestone in international environmental governance (United Nations Development Programme, 2014). Strong later served as the Secretary-General of the United Nations Conference on Environment and Development, also known as the Earth Summit, held in Rio de Janeiro in 1992. The Earth Summit resulted in the adoption of Agenda 21, a comprehensive blueprint for sustainable development.

Friedmann (1992) insisted that the sustainable development approach emphasises the need for economic growth that is environmentally and socially sustainable, recognises that rural areas are often rich in natural resources and biodiversity and that development should seek to protect and enhance these assets. In rural areas, sustainable development is particularly important as rural communities often face unique challenges, such as limited access to resources and services. The sustainable development approach focuses on various strategies, such as bottom-up, participatory, or integrated strategies that can be employed to promote economic, social, and environmental sustainability. Integrated strategies aim to combine elements of all strategies, top-down, bottom-up, and participatory strategies to leverage their respective strengths and overcome their weaknesses. The integrated strategy identifies the importance of multi-level governance, collaboration, and synergies among various stakeholders and promotes holistic and context-specific interventions that address the diverse needs of rural communities (Thompson & Scoones, 2009; Uphoff, 1992).

Sustainable agriculture is one of the approaches that can be employed to promote sustainable development in rural areas. According to Altieri (2002), sustainable agriculture involves using farming practices that are environmentally friendly and promote soil health.

This includes the use of organic fertilisers, crop rotation, and locally adapted crop varieties. Sustainable agriculture also involves the promotion of agroforestry practices that help to conserve soil and water resources. Several studies have demonstrated the benefits of sustainable agriculture in promoting sustainable development in rural areas. For example, a study by Pretty et al. (2011) found that sustainable agriculture practices can help to increase crop yields, reduce soil erosion, and improve soil fertility. In addition, sustainable agriculture can help to reduce the use of chemicals and promote the health of farmers and rural communities.

Renewable energy is another strategy that could be employed to promote sustainable development in rural areas. Byrne et al. (1998) and Rady (1992) agreed that renewable energy sources such as solar, wind, and hydropower can be used to generate electricity for rural households, reduce the use of fossil fuels and promote sustainable development in rural areas. Several studies have demonstrated the benefits of renewable energy in promoting sustainable development in rural areas. For example, a study by Islam et al. (2022) and Sovacool (2012) found that using solar energy can help provide electricity to rural communities and reduce the use of kerosene lamps, which can have negative health impacts. In addition, renewable energy can help to reduce greenhouse gas emissions and promote environmental sustainability.

Community-based natural resource management is another strategy that can be employed to promote sustainable development in rural areas. This involves the participation of local communities in the management of natural resources such as forests, fisheries, and water resources. Therefore, community-based natural resource management can help promote the sustainable use of natural resources and reduce conflicts over resource use (Berkes, 2004).

Several studies have demonstrated the benefits of community-based natural resource management in promoting sustainable development in rural areas. A study by Ostrom (1990) found that community-based natural resource management can help promote sustainable use of resources and reduce the risk of resource depletion. In addition, community-based natural resource management can help to promote social sustainability by empowering local communities and promoting social cohesion.

Sustainable tourism is another strategy that can be employed to promote sustainable development in rural areas. Sustainable tourism involves the development of tourism activities that promote cultural and environmental sustainability. Sustainable tourism can help generate income for local communities and promote the conservation of natural and cultural resources (Honey, 2008; Weaver, 2006). Several studies have demonstrated the benefits of sustainable tourism in promoting sustainable development in rural areas. In addition, sustainable tourism can help to promote environmental sustainability by promoting the conservation of natural resources and reducing the impact of tourism on the environment.

Finally, sustainable development in rural areas can be achieved through various strategies that promote economic, social, and environmental sustainability. These strategies have been shown to have numerous benefits in promoting sustainable development in rural areas, including increased crop yields, reduced soil erosion, improved soil fertility, reduced greenhouse gas emissions, and increased income for local communities. As such, policymakers need to prioritise these strategies in their efforts to promote sustainable development in rural areas. The other rural development approach is the human development approach which is discussed in the next paragraphs.

2.5.1.6 Human Development Approach Theory

Amartya Sen, an Indian economist, and philosopher has made significant contributions to the field of human development. His work challenges traditional measures of development that solely focus on economic growth, advocating for a broader understanding that incorporates social, political, and cultural factors. Sen, in his book "Development as Freedom" (1999), presents a comprehensive analysis of human development, emphasising the importance of capabilities, freedoms, and agency in promoting well-being and human flourishing. The human development approach is susceptible to participatory strategy and is defined as one that emphasises the importance of improving the well-being of rural communities rather than simply increasing economic growth. He further described human development as the approach that recognises rural development as guided by human needs and aspirations and should focus on improving access to education, healthcare, and other basic services. This approach emphasises the importance of people and their capabilities. He said development is not just about economic growth, but also about improving people's lives and expanding their opportunities. In rural development, the human development approach has gained increasing attention as policymakers seek to address the unique challenges faced by rural communities.

Some studies have demonstrated the benefits of the human development approach in rural development; for example, a study by Alkire and Santos (2010, 2014) found that the human development approach could assist greatly in reducing poverty and promoting social cohesion in rural areas. In addition, the human development approach could help to improve access to education, which is critical for rural development. One of the strengths of the human development approach is to recognise the importance of social cohesion by expanding people's capabilities and opportunities and by reducing barriers to participation in economic, social, and political life. This approach recognises that rural development is not just about

economic growth but also about promoting social cohesion and reducing inequality. Another strength brought forward by Chambers (1997) is that human development recognises the importance of local participation and emphasises that local communities are the best placed to identify their needs and priorities and that any development interventions should be designed in consultation with local communities.

The shortcomings of the human development approach in rural development, as alluded to by Alkire and Santos (2010, 2014), Chambers (1997), Sen (1999), and the United Nations Development Programme (1990), are that the human development concept is difficult to quantitatively measure, unlike economic growth, which can be measured using indicators such as gross domestic product. This is because human development is a qualitative concept; it is about improving people's lives and expanding their opportunities, which can be difficult to quantify. Another shortcoming is that the human development approach could be difficult to implement because it requires a long-term commitment to improving people's lives and expanding their opportunities which can be challenging in the context of limited resources and competing priorities. In addition, the human development approach requires a comprehensive approach to development that addresses the social, economic, and environmental dimensions of development.

However, all that said, the human development approach is a valuable approach to rural development that emphasises the importance of improving people's lives and expanding their opportunities. This approach recognises that rural development is not just about economic growth but also about promoting social cohesion, reducing inequality, and empowering local communities. While the human development approach has several strengths, including its focus on social inclusion and local participation, it also has several shortcomings, including its difficulty in being measured and implemented. As such, policymakers should be cautious in relying solely on the human development approach in

their efforts to promote rural development and should instead adopt a more comprehensive approach, such as Gandhian Philosophy which consists of the social, economic, and environmental dimensions of development. The paragraphs below discuss Gandhian Philosophy.

2.5.1.7 *Gandhian Philosophy on Rural Development*

Mahatma Gandhi was one of the most influential figures in modern history. He emphasised the importance of rural development to achieve sustainable and inclusive progress (Gandhi, 1946). Gandhi's Philosophy, also known as Gandhi's thought, advocates for the empowerment and upliftment of rural communities through self-reliance, decentralisation, equality, limited industrialisation cooperation, and the promotion of traditional and indigenous practices (Patel & Karmakar, 2018; Sinha, 2020; Zeeshan & Kappiarathel, 2023). Gandhi's Philosophy for rural development is to end unemployment, poverty, exploitation, and economic inequalities and bring self-sufficiency in the villages in terms of education, health, food, clothing, and sanitation (Zeeshan & Kappiarathel, 2023). Even though Gandhi's philosophy is highly ambitious, Gandhi was fully aware that the idea of complete economic emancipation is not easy but is a desirable ideal for which it should be our continuous mission to strive (Gandhi, 1946). Gandhi (1946) further emphasised that even though economic emancipation for rural areas or villages is challenging for it to be realised, it needs to be reconciled with ethics. He believed that rural or village development is central to the foundation and development of a country's progress for future generations to be self-sufficient to fulfil their needs, also that centralisation is responsible for increased unemployment and poverty in rural areas (Sinha, 2020; Zeeshan & Kappiarathel, 2023)

Gandhian principles of rural development are self-reliance, decentralisation, sustainable agriculture and traditional practices, education, and skills development (Bharathi,

1994; Patel & Karmakar, 2018; Sinha, 2020; Zeeshan & Kappiarathel, 2023). Gandhi (1946, 1949) posits that rural development should be rooted in self-reliance, with communities taking charge of their own economic and social progress. He advocates for the promotion of locally produced goods and services to foster economic independence and reduce dependency on external sources. By encouraging rural communities to develop and utilise their resources, Gandhi's Philosophy aimed to create sustainable livelihoods and reduce poverty.

Another key aspect of Gandhian Philosophy for rural development is the principle of sustainable agriculture and traditional practices. Gandhi strongly emphasises the importance of sustainable agriculture and the revival of traditional practices in rural development (Gandhi, 1946). Gandhi advocates for the use of organic farming methods, such as composing and crop rotation, to ensure long-term soil fertility and environmental sustainability, which is like a sustainable development approach. He also promoted the revival of indigenous practices to promote economic self-sufficiency and preserve cultural heritage (Patel & Karmakar, 2018; Sinha, 2020). Lastly, the other important rural development principle from Gandhian Philosophy is education and skill development which is like the human development approach.

Gandhi believed that good quality education should be practical, relevant, and accessible to all, particularly to people living in rural areas. Philosophy affirmed the importance of vocational training and skill development to empower rural communities and enable them to create sustainable livelihoods (Bharathi, 1994). Gandhi’s vision of education aimed at mainly fostering self-reliance, nurturing creativity, and promoting holistic development (Zeeshan & Kappiarathel, 2023). The Africans came up with a similar theory of development to Mahatma Gandhi’s Philosophy, which they named the African Renaissance Movement theory. The African Renaissance Movement theory is discussed in the sub-section that follows.

2.5.1.8 African Renaissance Movement Theory

The African Renaissance Movement theory does not have a specific individual who can be considered its 'father' or originator because the concept emerged as a collective effort and has been influenced by various leaders, intellectuals, and activists who have advocated for Africa's empowerment, cultural revival, and development (African Union, 2021; Malima, 2021; Mekoa, 2018). Although the African Renaissance movement theory cannot be attributed to one person or organization, leaders such as Thabo Mbeki, the former President of South Africa, who was the President from 1999 to 2008, played a significant role in promoting the African Renaissance Movement theory concept (Malima, 2021; Mekoa, 2018). Mbeki emphasised the need for Africa to take charge of its development and to reclaim its history and cultural identity, which has similarities to Gandhian Philosophy concerning India.

The other notable figures who contributed immensely to the African Renaissance movement discourse, amongst others, include Kwame Nkrumah of Ghana, who advocated for Pan-Africanism and African unity, and intellectuals like Cheikh Anta Diop of Senegal, who focused on reclaiming Africa's historical contributions and challenging Eurocentric narratives (African Union, n.d.; Austin & Broadberry, 2014; Okudolo, 2022; Tikly, 2003). Nkrumah was a prominent figure in African history and a key leader in the struggle for Ghana's independence from colonial rule. He was the first Prime Minister and later became the first President of Ghana. Diop was a prominent historian, anthropologist, and scholar; one of his notable works is "African Origin of Civilization: Myth or Reality" (1974), in which he presented evidence and arguments supporting the idea that ancient Egypt was an African civilisation. This work challenged prevailing views that downplay Africa's contribution to world history (Diop, 1974).

African Renaissance Movement theory aims to promote sustainable development, improve the quality of life for people living in rural areas of Africa, and work well with

integrated strategies (Austin & Broadberry, 2014; Malima, 2021; Tikly, 2003). The theory is based on the belief that Africa's future lies in its rural areas and that sustainable development in these areas is essential for the continent's overall development because Africa is dominantly rural (Mekoa, 2018; Okudolo, 2022; Viviers, et al. 2021). The African Renaissance Movement theory in rural development focused on addressing the "wicked problems" as put by Rittel and Webber (1973 p163), faced by rural communities, such as poverty, food insecurity, lack of access to healthcare and education, and inadequate infrastructure. The theory aims to promote sustainable agriculture, improve access to clean water and sanitation, and promote renewable energy sources in underdeveloped areas, such as rural areas, specifically in Africa (Ramsden et al., 2022; Sapkota et al., 2013).

Austin and Broadberry (2014), Ramsden et al. (2022), Sapkota et al. (2013), and the United Nations (n.d.) agree that one of the key principles of the African Renaissance movement theory in rural development is the involvement of local communities in the development process which means that development initiatives are designed and implemented in collaboration with the people who will benefit from them. This approach ensures that development initiatives are culturally appropriate and sustainable over the long term. They further emphasised that another important aspect of the African Renaissance movement theory in rural development is using technology to improve the lives of rural communities. That includes the use of mobile phones to provide access to information and services. For example, mobile phones have been used to provide farmers with information on weather patterns, market prices, and best agriculture practices. This has helped to increase agriculture productivity and improve the livelihoods of rural communities. The use of renewable energy technologies such as solar panels and wind turbines to provide electricity and the use of digital platforms to facilitate trade and commerce. For example, e-commerce platforms have enabled rural communities to sell their products online, reaching a wider

market and increasing their income. Digital platforms have also been used to provide access to financial services, such as mobile banking, which has helped to increase financial inclusion in rural areas.

The African Union (2021) has been a major proponent of the African Renaissance Movement theory in rural development. In 2003, the African Union (AU) launched the Comprehensive Africa Agriculture Development Programme, which aims to increase agricultural productivity and reduce poverty in rural areas. The Programme has been instrumental in promoting sustainable agriculture and improving access to markets for smallholder farmers. Overall, the African Renaissance movement theory in rural development is an important movement that has the potential to transform the lives of millions of people living in rural areas of Africa by promoting sustainable development and involving local communities in the development process. The movement is laying the foundation for a brighter future for the continent (African Union, 2021). STI have played a significant role in providing sustainable development in rural areas, and their continued use and development will be essential in achieving the goals of the African Renaissance movement theory (Mekoa, 2018; Okudolo, 2022; Tikly, 2003).

In practice, rural development policies often incorporate elements of multiple theories. For example, the African Renaissance movement theory includes a sustainable development approach by promoting eco-tourism as an alternative to resource extraction while also investing in education and healthcare to improve human well-being. However, it is important to recognise the underlying assumptions and values of different theories to ensure that policies are aligned with the needs and aspirations of rural communities. However, Diop, Mbeki, and Nkrumah denounced the modernisation development approach, dependency development approach, and trickle-down development approach for African development but embraced the Community-driven Development approach, human

development approach, sustainable development approach, and the Gandhian development approach principles for African development in their African Renaissance movement development approach.

As stated at the beginning of this chapter, theories of rural development have evolved, reflecting changes in the global economy and societal values. Key theories include modernisation, dependency, sustainable development, human development, and the African Renaissance movement. Each theory has its advantages, disadvantages, and underlying values and assumptions; hence, development agencies and rural development policymakers should design rural development policies with cognisance of those advantages, disadvantages, underlying assumptions, and values. After reviewing the literature on rural areas, rural development, rural development theories, and strategies, the following section discusses the rural development economic models.

2.5.2 Economic Models

Economic models are used to determine development in rural areas. Economic growth is measured for a certain period in those areas where development is being determined (Martin & Tang, 2007; South African National Parks, 2008; South African National Roads Agency Limited, 2008). The economic indicators used for measuring economic impact are the gross domestic product, business output, value-added and employment rates (South African National Parks, 2008). These economic indicators are used to determine development in rural areas. A view of development in rural areas especially Kareeberg and Karoo Hoogland should encompass economic growth and its benefits. The Hauptfleisch and Singlé (2012) production process model (Figure 3) is developed for the outputs (e.g., gross domestic product, rates of employment, value-added, or/and business output, etc.), which is dependent on processing (activities) of the inputs (e.g., projects, human

resources, capital, raw materials, entrepreneurship, techniques, and adequate management principles. etc.).



Figure 3. Hauptfleisch and Single Production Process Model
Source: (Hauptfleisch & Singlé, 2012)

The Hauptfleisch and Singlé (2012) model is a linear and highly simplified process model because it deals with the relationship between inputs, conversion, and outputs. The conversion may include budgets, services, processes, procedures, methods, policies, and contracts (National Treasury, 2007). The challenge with this input-processing-output model is "if inputs are defective the outputs will be defective as well regardless of the quality of processing or, colloquially, garbage-in/garbage-out" (Levy & Ellis, 2006 p185). Also, if the processing is defective, even if inputs are of good quality, the outputs will be defective. For the outputs to be of good quality, the inputs and the processing should also be of good quality.

On the other hand, Martin and Tang (2007) developed the simple linear or 'science push' model illustrated in Figure 5 below. In the 'science push' model, the outputs from the research are codified knowledge, which should generate new knowledge converted to a knowledge economy. New knowledge is used innovatively to yield technologies that may bring about economic benefits as outputs (Martin & Tang, 2007).

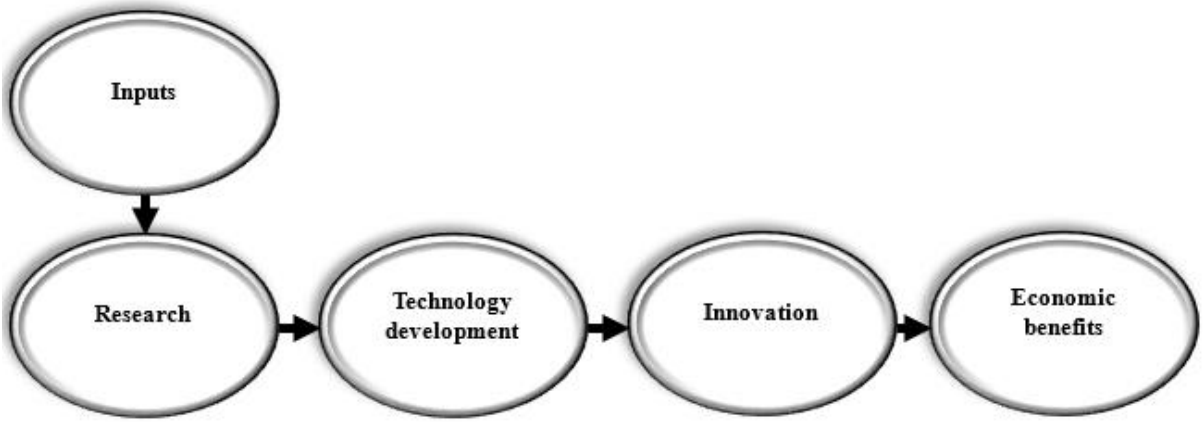

Figure 4. Martin and Tang's Simple Linear Model
Source: (Martin & Tang, 2007)

Martin and Tang's Simple Linear Model or 'science push' model shown in Figure 4 above is significantly simplified and is misleading because it assumes that successful innovation is not dependent on many other things that are not technical, e.g., organisational improvements, stakeholder involvement, marketing, market research, and customer feedback (Martin & Tang, 2007; Simmonds et al., 2013; Tiplay & Hickman, 2008). In addressing this challenge of the simple linear model, Kline and Rosenberg (as cited in Martin & Tang, (2007) came up with the "chain-link model", as shown in Figure 5.

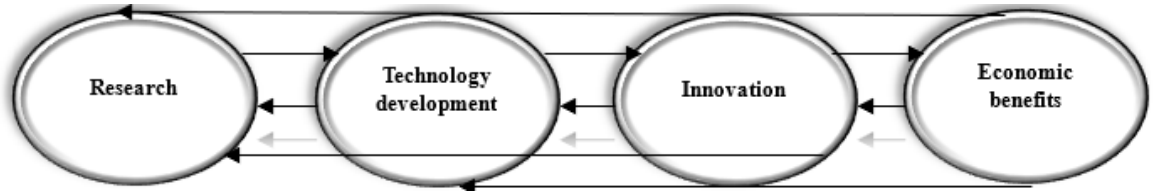

Figure 5. Chain-link Kline and Rosenberg Model
Source (Kline and Rosenberg, as cited in Martin & Tang (2007)

The chain-link Kline and Rosenberg model presents a close to realistic situation because it does not portray economic growth as linear, but it is interactive, and the model still does not account for time. The other model to counteract the issue of time is the Advanced Martin and Tang time-based benefits assessment in Figure 6 (Martin & Tang, 2007; Tiplay & Hickman, 2008). This model shows that development initiatives could show impact even

after the project had been long completed and decommissioned (Martin & Tang, 2007). The development trajectory must be time-dependent, and the assessment of economic benefits of any project's initial implementation, which may be at the time t_1 in Figure 2.5, may address only the early or immediate economic benefits (outputs).

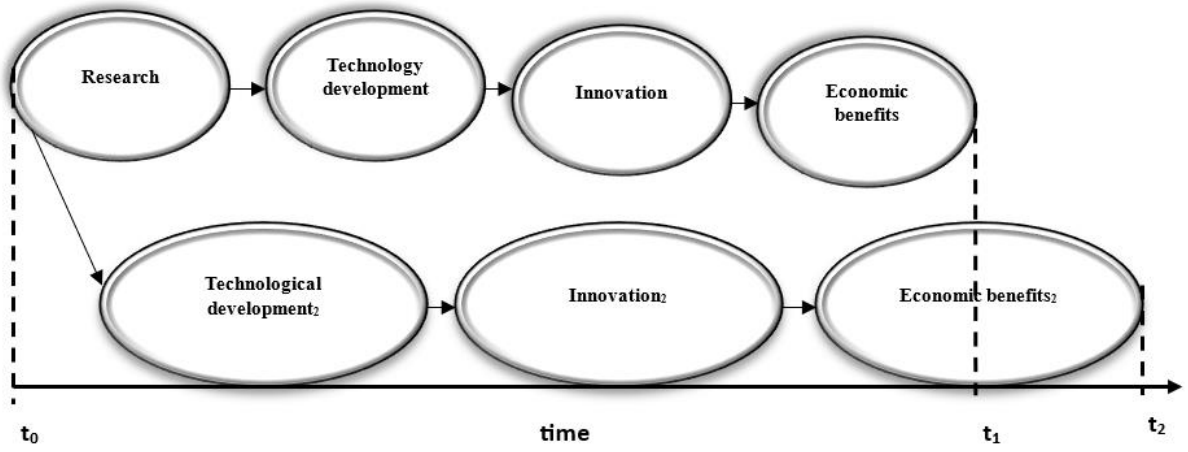

Figure 6. Advanced Martin and Tang Time-based Benefit Assessment
Source (Martin & Tang, 2007).

Despite the availability of the models discussed above, Tsusumi and Seya (2008) found spatial statistical models used with data on land prices to determine the impact of mega projects more valuable.

2.5.3 Spatial Statistical Models

The spatial statistical models could deal with uncertainties brought by the production process, 'science push' and 'chain-link' models. It has been found that Stimson et al.'s (2022) methods in determining area economic growth are shift-share analysis (SSA), economic base theory (EBT), and regional shift. The SSA and EBT methods will be further explained and discussed in the following paragraphs.

Stimson et al. (2022) developed a way of calculating location quotients (LQ) to measure the EBT. One method of determining LQ could assume that the smallest sector area

is considered the initial point. The increase or decrease above or below the initial threshold can contribute to or reduce the area's economy. On the other hand, the other method for calculating the LQ could be determined as a reference area. The economy's partial impact can be defined as more significant than the proportional amount found in the location referenced. It is found that three data sets to help determine LQs for the first analysis consider the determination of size (earnings, regional product, or employment), determination of size change (changes in wages, regional development, or jobs), and resolution of the relative importance of sectors. Refer to Appendix 5 for further mathematical calculations of LQ.

Also, Dinc and Haynes (1999), Haynes and Dinc (1997), and Markusen et al. (1991) described SSA as a quick, descriptive, relatively inexpensive, and straightforward way of analysing local economic benefits and decreases over time. The SSA technique evaluates an area's financial performance relative to other regions. It is the technique used to calculate how the industry structure may impact the area's economies, appraise the area's economic trends, and advise policymakers on industrial targeting. Refer to Appendix E for further mathematical calculations of total and differential shifts.

According to Stimson et al. (2022), the SSA model was adapted by introducing a three-component model of change from the local area, integrating industry mix (IM), regional shift (RS), and national share (NS). After that modification, the model was referred to as the Ashby model, named after the inventor. In the current study, IM is adopted as a local/rural mix rather than an IM (as the originator called it). The calculations may be done per locality rather than per industry. See Appendix E for further mathematical analysis of the SSA model.

The diagrammatic flow chart shown in Figure 7 below provides international best practices in the local economic development framework (Tiplay & Hickman, 2008). The

regional economic impact is based on local economic development defined by the World Bank (Phuravhathu, 2014; Molas-Gallart & Tang, 2011; Tiplay & Hickman, 2008; World Bank, 2020). The regional economy is also described as a procedure in which private, public, and civil organisations work together to form platforms for socio-economic development. It measures a drive and enhancement to generate employment opportunities in local communities through large-scale science and engineering infrastructure projects (Molas-Gallart, 2015; Phuravhathu, 2014; World Bank, 2020). Projects are implemented in rural communities to address local economic development needs in several ways. Firstly, community members are active participants in those projects; second, by attracting investment to their community; third, by lobbying developmental projects to come to the community; and last, by increasing the rate of employment and participation of local labour in the projects (Phuravhathu, 2014; Ruegg & Feller, 2003).

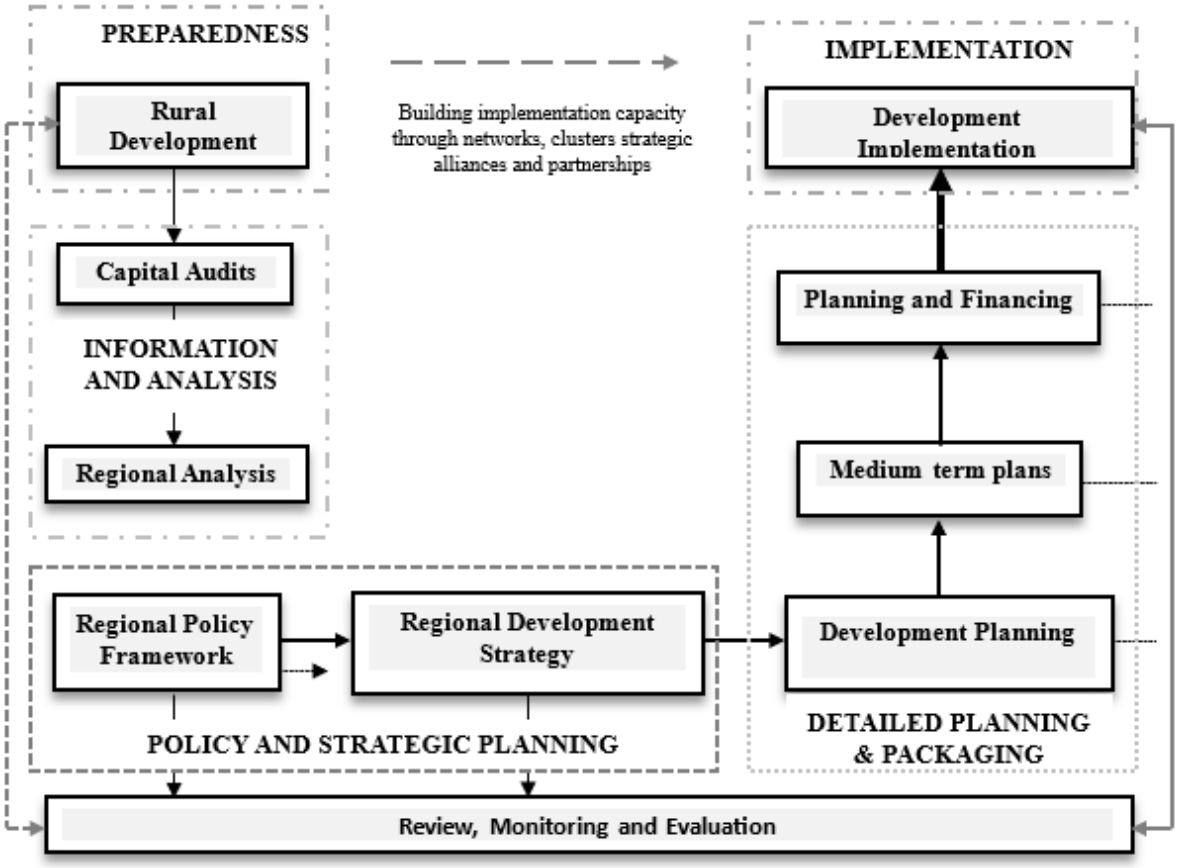

Figure 7. Framework for Local or Regional Economic Development
Source (Stimson et al., 2022)

Through the literature review, it is clear that MAIPs can be the catalysts in bringing change to the developing economies of the host societies. Hence, the current study was undertaken to determine the rural development due to the MeerKAT in Kareeberg and SALT in Karoo Hoogland and how these projects impact economic infrastructure, employment, education, and tourism. The economic impact is due to interventions undertaken in different sectors and to be determined for a specific geographical area, region, or country during a certain period (Martin & Tang, 2007; South African National Parks, 2008; South African National Roads Agency Limited, 2008). The commonly used economic indicators in measuring economic or socio-economic development are average income per household, dependency ratio, average income per capita, business output (either local, regional, or national), rate of employment and job creation (South African National Parks, 2008). These

indicators were helpful in the current study to determine rural development due to MeerKAT in Kareeberg and SALT in Karoo Hoogland. These development indicators mentioned above inform a theory of change regarding the rural development in Kareeberg and Karoo Hoogland due to MAIPs implemented in those areas (South African National Parks, 2008). The following section discusses the Theory of Change.

2.6.3 Theory of Change

The Theory of Change (ToC) is a framework that gained prominence as a valuable tool for planning and evaluating social change initiatives that help organisations and individuals understand how and why their desired change will occur (Weiss, 1972). The ToC outlines the steps, assumptions, and causal relationships that need to happen for the change to take place (Weiss, 1996). It typically includes identifying the problem or need, defining the desired outcomes, mapping out the strategies and activities to achieve those outcomes, and identifying the indicators and evidence that will show progress towards the desired change (Chen & Rossi, 1989; Quinn & Cameron, 1988; Rosenau, 1990). The ToC is often used in program planning, evaluation, and impact assessment to guide decision-making and ensure that efforts are focused and effective (Robinson et al., 2001; Rosenau, 1990).

The ToC is a concept that evolved, and it is difficult to attribute its creation to a single individual. However, one influential figure in the development of the theory of change is Carol Weiss, an American political scientist and evaluation expert (Weiss, 1972, 1996). Weiss is known for her work on ToC and program evaluation, particularly in the field of public policy, she emphasises the importance of understanding the underlying theories and assumptions that guide interventions and how they lead to desired outcomes (Weiss, 1972). While Weiss made significant contributions to the theory of change it is important to note that the concept has been shaped by various individuals and disciplines over the years such as

Peter Rossi (Chen & Rossi, 1989) and The Robert F. Kennedy Children's Action Corps (Armstrong, 2002). The roots of the ToC can be traced back to the 1960s and 1970s when evaluation methods and approaches were being developed (Weiss, 1972). However, it was in the 1990s and early 2000s that the concept gained more prominence and became widely used in the field of program planning evaluation (Armstrong, 2002; Chen & Rossi, 1989; Weiss, 1996). Since then, the ToR has continued to evolve and is still an active area of research and practice today.

Rossi was an American renowned sociologist and statistician, who played a crucial role in advancing the concept of program theory, which forms a fundamental component of the ToC framework (Chen & Rossi, 1989). Rossi was a pioneer in the field of evaluation research and co-authored the influential book "Evaluation: A Systematic Approach" with Howard Freeman and Sonia Wright. His work has had a significant impact on the field of program evaluation and social policy research. Rossi advocated for the explicit articulation of program theories, which provide a logical framework for understanding the causal pathways between interventions and outcomes (Chen & Rossi, 1989; Rossi et al., 2004).

According to Armstrong (2002), the Robert F. Kennedy Children's Action Corps (RFKCAC), a nonprofit organization based in the United States, made significant contributions to the development and application of the ToC framework. The AFKCAC was founded in 1969 by a group of child advocates and professionals in Massachusetts, inspired by the vision and legacy of Rober F. Kennedy. The RFKCAC operates various programs and services aimed at providing support and opportunities for at-risk and justice-involved youth and families. Their initiatives include residential treatment programs, community-based services, education and vocational programs, and support for youth involved in the juvenile justice system. The organization is dedicated to promoting positive youth development, advocating for social justice, and working towards the well-being of children and families.

Their pioneering work in the 1990s focused on articulating the ToC for their programs, emphasizing the importance of explicit assumptions, outcomes, and causal pathways (Connell & Kubisch, 1998).

The ToC is a conceptual framework that offers a structured approach to planning, implementing, and evaluating social change initiatives (Birckmayer & Weiss, 2000; Connell & Kubisch, 1998). It helps stakeholders articulate their assumptions, identify desired outcomes, and map the causal pathways that link inputs, activities, outputs, immediate outcomes, and intermediate outcomes to long-term impact (Patton, 2011). As earlier indicated the ToC begins with the identification and examination of underlying assumptions and beliefs about the social issue being addressed (Connell & Kubisch, 1998). These assumptions shape the intervention's goals, strategies, and expected outcomes. The ToC framework emphasizes the importance of clearly defining inputs (resources), activities (interventions), outputs (direct results), immediate outcomes, intermediate outcomes, and long-term impact (at the wide societal level) (Armstrong, 2002; Connell & Kubisch, 1998; Rossi et al., 2004; Weiss, 1996). Table 2 defines what are inputs, activities, outputs, outcomes, and impact.

Clearly defining inputs, outputs, outcomes, and impact is the step that enables stakeholders to understand the immediate changes resulting from the project's efforts (Connell & Kubisch, 1998). The ToC focuses on identifying short-term, intermediate, and long-term outcomes, as well as the ultimate impact of the intervention (Connell & Kubisch, 1998). This component helps stakeholders establish a logical and evidence-based connection between their activities and the desired social change (Armstrong, 2002). The ToC provides a structured framework for program planning and design by encouraging stakeholders to think critically about the causal relationships between inputs, activities, outcomes, and impact (Connell & Kubisch, 1998). Weiss (1996) posits that this approach ensures that interventions

are strategically aligned with desired social change. He further emphasised that the ToC framework is particularly valuable in monitoring and evaluating social change initiatives. By mapping out the expected outcomes and impact, it enables stakeholders to develop appropriate indicators, collect relevant data, and assess the effectiveness of their interventions (Patton, 2011). The ToC offers a comprehensive and systematic approach to planning and evaluating social change initiatives (Connell & Kubisch, 1998). It enhances clarity and transparency, facilitates collaboration among stakeholders, and promotes evidence-based decision-making (Patton, 2011). It requires stakeholders to make explicit their underlying assumptions, which can be challenging and time-consuming (Connell & Kubisch, 1998). Additionally, the complexity of social issues may make it difficult to establish clear causal pathways and predict long-term impact accurately.

The ToC is a comprehensive and valuable framework for guiding social change initiatives and it is adopted and used with the African Renaissance Movement and Gandhian Philosophy for rural development using mega astronomy infrastructure projects in this research. Its emphasis on assumptions, causal pathways, inputs, activities, outputs, outcomes, and outcomes enhances program planning, implementation, and evaluation processes. Assumptions should be stated up front and throughout the causal pathways. The complexity increases as we move from inputs through to impacts and control of the results diminishes as we move from inputs to impact. This is demonstrated in Figure 8 below. Assumptions, stakeholder, and performance management are done through all levels and are iterative processes. As time and complexity increase, control diminishes as the is a move from inputs to impact, the question we need to ask ourselves is whether it is fair for the success of the program to be judged at the impact level or not. However, ongoing research and refinement are necessary to address the limitations and improve the efficiency and effectiveness of this framework in addressing complex social issues.

The framework is the Theory of Change impact framework which is the improvement from all other frameworks that are discussed above. The Change of Theory impact framework has five levels. Those five levels are inputs, activities, outputs, outcomes, and impact. The relationship between inputs, outputs, outcomes, and impact is further outlined in the Framework for Managing Performance Information (National Treasury, 2007) and the Policy, Programme, Project Evaluation Guidelines and Standards for Evaluations (Department of Science and Technology, 2014).

The Theory of Change Framework model gained popularity in the OECD countries in the field of impact studies, monitoring, and evaluation refer to Figure 9. According to this model from the National Treasury document, Framework for Managing Performance Information (2007) and Organisation for Economic Co-operation and Development (2022), the output results are experienced in the short-term during the project implementation (i.e., during project construction) or a short while after project implementation. Whereas the outcomes results are experienced in the medium to long term after project implementation. The impact results get experienced in the long term. After reviewing the literature on rural areas, rural development, rural development theories, strategies, and frameworks, the following section that follows discusses the research knowledge gap that this research fills.

Table 2. Defines what are Inputs, Activities, Outputs, Outcomes, and impact (Armstrong, 2002; Chen & Rossi, 1989; Funnell & Rogers, 2011; Patton, 2011; Weiss, 1996)

<table>
<tr><th>Inputs</th><th>Activities</th><th>outputs</th><th>Immediate (short-term) outcomes</th><th>Intermediate (medium-term) outcomes</th><th>Impact (Long-term outcomes)</th></tr>
<tr>
<td>Human Resources:
- people,
- skills,
- expertise, and
- qualifications

Financial Resources:
- Availability of funding and
- Budget allocation

Material Resources:
- Physical materials i.e., training material,
- Equipment i.e., computers, telephones, chairs, tables, cupboards, etc. and
- Infrastructure i.e., facilities, transportation etc.

Organisational and institutional support:
- Legislative framework,
- Strategies
- Standard Operating Procedures,
- Policies,
- Governance framework,
- Though leadership,
- Administrative support, and
- Partnerships

NB: Inputs are crucial for the successful implementation of a program as they provide the necessary resources and support to carry out the activities and achieve desired outcomes. It is important to carefully plan and allocate these inputs to ensure they are sufficient and appropriate for the program’s goals and target population</td>
<td>- Activities refer to the specific actions or interventions that are undertaken as part of a program.

- Activities can vary widely depending on the nature of the program and the target population.

Categories of Activities:

1.Direct service provision: These activities involve directly delivering service or support to the target population. For example, if the program aims to improve access to education, the activities may include providing tutoring, distributing educational materials, or organising workshops.

2.Capacity building: These activities focus on enhancing the skills, knowledge or capabilities of individuals or organisations involved in the program. This may involve training sessions, workshops, mentoring, or technical assistance to improve their ability to deliver services effectively.

3.Advocacy and awareness-raising: These activities aim to raise awareness about an issue or advocate for policy changes. This can include public campaigns, community mobilization, lobbying, or media engagement to promote understanding, support, and actions.

4.Research and evaluation: These activities involve conducting research or evaluation studies to gather data, assess program effectiveness, and inform decision-making. This can include surveys, interviews, data analysis, or impact assessments.

5.Collaboration and networking: These activities focus on building and maintaining partnerships and collaborations with other organisations or joint initiatives to leverage resources, share knowledge, and enhance collective impact.

NB: Activities in the ToC are designed to be strategic and purposeful, aiming to address the underlying causes or factors that contribute to the desired outcomes. It is important to ensure that the chosen activities are evidence-based, feasible, and aligned with the overall ToC to maximise the program’s impact.</td>
<td>Outputs refer to the immediate and tangible results or products that are produced because of the activities and interventions implemented within a program. Outputs are typically measured in terms of quantity, quality, or timeliness and serve as indicators of progress towards achieving the desired outcomes.

Outputs can be categorized into different types, including:

1. Products or services: These are the tangible goods or services that are delivered because of the program activities. For example, if the program aims to improve healthcare access, the outputs may include the number of medical consultations provided, the distribution of medication, or the number of health education sessions conducted.

2. Training and capacity-building: These outputs are related to the development of skills, knowledge, or capabilities of individuals or organizations. This can include the number of training sessions conducted, the number of participants trained, or the completion of capacity-building programs.

3. Awareness and knowledge dissemination: These outputs are related to the dissemination of information or knowledge to the target population. This can include the number of awareness campaigns conducted, the reach of informational materials distributed, or the number of people reached through media campaigns.

4. Policy or system changes: These outputs are related to influencing or contributing to changes in policies, procedures, or systems. This can include the number of policy briefs developed, the number of advocacy meetings held, or the adoption of new policies or practices by relevant stakeholders.

NB: Outputs serve as important indicators of program implementation and can be used to assess the efficiency and effectiveness of the program, refer to Figure 8. However, it is important to remember that outputs alone do not capture the ultimate impact or outcomes of a program, which are typically measured at a higher level in the theory of change framework.

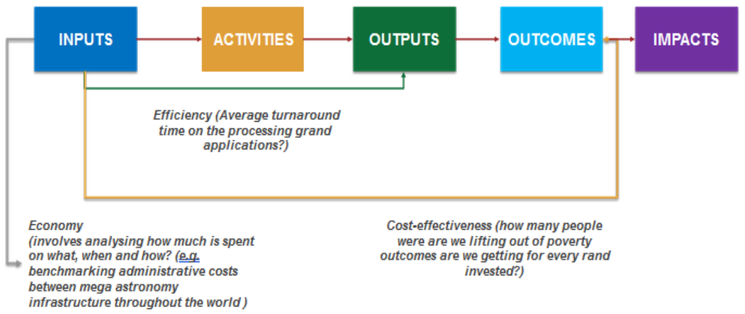

Figure 8. Shows how efficiency and effectiveness can be assessed
Adapted from Theory of Change Framework</td>
<td>These are the immediate changes that occur as a direct result of the program. They are usually related to the knowledge, skills, attitudes, or behaviours of the target population. For example, if the program aims to improve literacy rates, the short-term outcome may be an increase in the number of students who can read at their grade level.

NB: It is important to note that outcomes should be specific, measurable, achievable, relevant, and time-bound (SMART) to effectively measure the impact of a program and assess its success.</td>
<td>These are the changes that occur over a longer period, usually within a few months or years. They are often related to the environment or systems in which the program operates. For example, if the program aims to reduce poverty, a medium-term outcome may include increased access to education and skills training, improved employment opportunities, enhanced financial literacy, or increased access to microfinance services. These intermediate outcomes contribute to the broader goal of poverty reduction and serve as indicators of progress towards achieving the impact.</td>
<td>The impact refers to the ultimate and long-term outcomes or changes that are expected to occur because of implementing a particular intervention or initiative. It represents the desired and intended effects or benefits that the intervention aims to achieve.

The impact is usually the highest-level outcome and is typically related to broader social, economic, or environmental changes. It goes beyond the immediate or intermediate outcomes and focuses on the larger-scale transformation or improvement that the intervention seeks to bring about. For example, if the program aims to reduce poverty, a long-term outcome may be a decrease in the overall poverty rate in the target population.

The impact is important as it helps define the overall purpose and vision of the intervention. It provides a clear understanding of the desired long-term results and guides the planning and implementation of activities and strategies to achieve those outcomes.

Additionally, the impact serves as a basis for monitoring and evaluation efforts to assess the effectiveness and success of the intervention in creating the intended change.</td>
</tr>
</table>

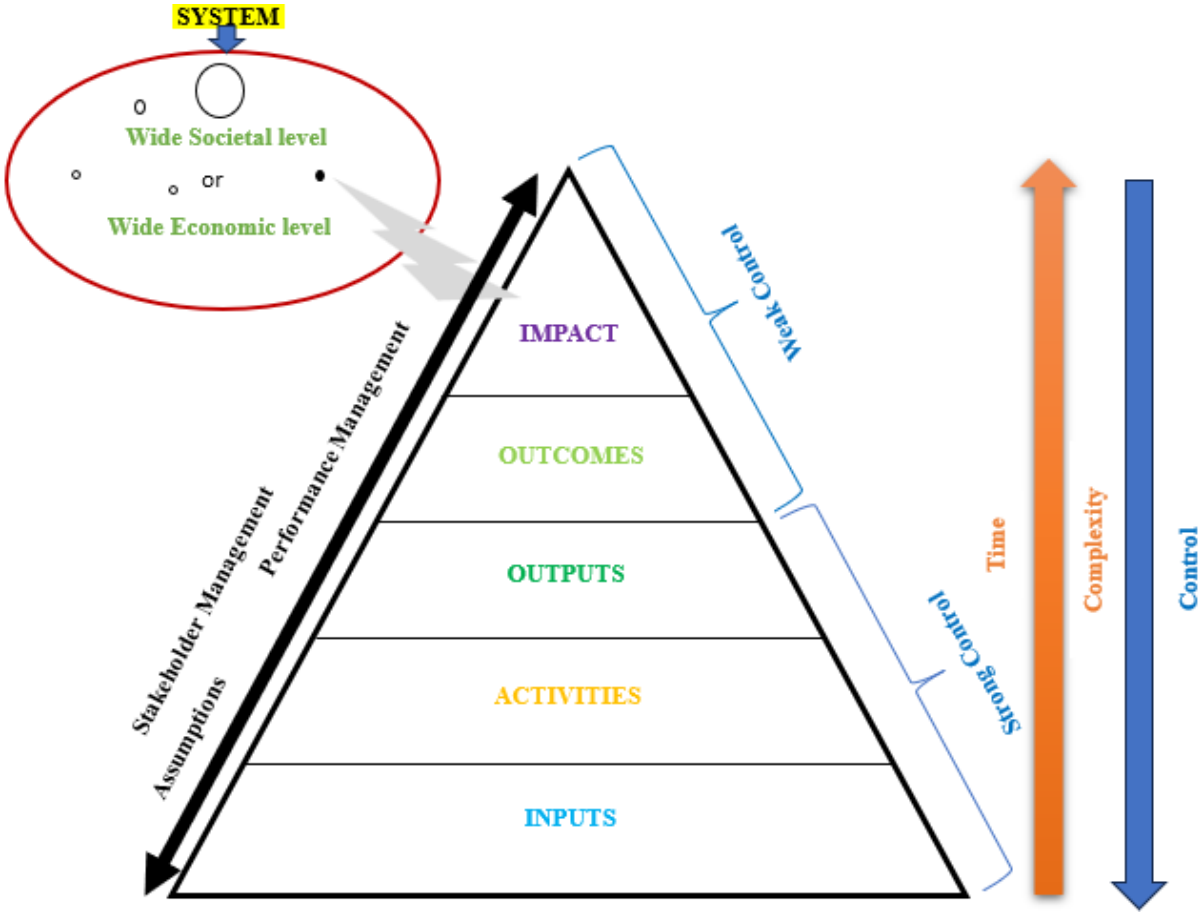

Figure 9. Shows the control and complexity of the ToC through the causal pathway

2.6 Research Knowledge Gap

The impact of MAIPs on development in rural areas is a growing area of research that explores the potential benefits and opportunities that MAIP-related initiatives can bring to rural communities. While existing literature, such as Bhogal (2018), Hurley-Walker (n.d.), International Astronomical Union (n.d.), Kigotho (2021), Lazio (2008), Peng (2010), Simmonds et al.(2013), Tiplay and Hickman (2008), and Walker et al. (2019), have highlighted various positive outcomes there are others, i.e., Atkinson (2019), ChinigÒ, (2019), Gastrow (2017), Gastrow & Oppelt (2019), Parkington et al. (2019), and Twidle (2019), who highlighted negative outcomes. However, there are still knowledge gaps that need to be addressed to provide a more comprehensive understanding of MAIPs on development in the rural Northern Cape, of South Africa.

The current body of literature on the impact of astronomy on rural development primarily focuses on specific aspects such as STEM education (African Academy of Science, 2018; Bhogal, 2018; International Astronomical Union, n.d.; South African Astronomical Observatory, n.d.-a, n.d.-b; Square Kilometre Array, 2021), tourism (Department of Science and Innovation, 2021; DFA, 2020; Leiden Science - Universiteit Leiden, n.d.; Tiplay & Hickman, 2008; Twidle, 2019; C. Walker, 2019), and cultural preservation (Absher, 2022; Aveni, 2009; Dalgleisch, 2020; O'Shea et al., 2021; Sidorenko, 2009). While these studies have provided more valuable insights, there is a need for more research that examines the long-term and holistic impact of MAIP initiatives on rural communities. Specifically, the following research knowledge gap exists as a long-term socio-economic impact, community empowerment and capacity building, and sustainable development indicators, and are further discussed in the paragraphs below.

Limited research has explored the long-term socio-economic effects of astronomy-related initiatives such as MAIPs on rural communities. Absher (2022) and Aveni (2009) allude that while some studies have examined the immediate economic benefits of astrotourism, there is a lack of comprehensive research that investigates the sustained economic growth, job creation, and economic infrastructure development resulting from astronomy programmes such as MAIPs. Secondary research question one: '*How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs*?' will be used to probe the long-term socio-economic impact of MAIPs in Kareeberg and Karoo Hoogland. Secondary research question two: '*How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs*?*'* was used to further assess the concept of long-term socio-economic impact.

Dalgleisch (2020) and Sidorenko (2009) agree that more research is needed to understand how astronomy initiatives empower rural communities in the areas in which such

initiatives are taking place. Also, such astronomy initiatives enhance rural community capacity for self-governance and decision-making, including studying the impact of astronomy programmes on community cohesion, leadership development, and the ability to drive local development initiatives. Secondary research question four: '*How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' was used to investigate this concept of understanding how astronomy initiatives empower rural communities.

Another concept from the literature that is identified as less studied concerning astronomy is sustainable development indicators (Friedmann, 1992; Thompson, 2008; Uphoff, 1992). There is literature on sustainable rural development-related tourism (Honey, 2008; Weaver, 2006), related to agriculture (Altieri, 2002; Pretty et al., 2011), related to renewable energy (Byrne et al., 1998; Islam et al., 2022; Rady, 1992; Sovacool, 2012), and lastly, there is literature related to community-based natural resources management (Berkes, 2004). The research gap is in identifying and measuring specific indicators of sustainable rural development resulting from astronomy initiatives such as MAIPs through astrotourism. According to Friedmann (1992), sustainable development indicators include assessing the environmental, social, and economic dimensions of sustainability and understanding how MAIPs through astrotourism contribute to these three dimensions.

The other issue investigated in this research is the impact of MAIPs on education in rural development. Literature (Alkire & Santos, 2010, 2014; Chambers, 1994; Sen, 1999; World Bank, 2018) has shown that good education can play an important role in rural development. Good education is a fundamental driver of rural development, empowering individuals, fostering economic growth, and promoting social progress (Organisation for Economic Co-operation and Development, 2018, 2019; United Nations Educational, Scientific and Cultural Organisation, 2003, 2018). Investing adequately in the education of

rural communities can unlock their full potential and contribute to sustainable development. Access to quality education, teacher training, and relevant curriculum are crucial elements in ensuring the transformative power of education in rural areas. Also, to achieve inclusive and sustainable rural development, it is essential to prioritise education as a fundamental pillar of rural development strategies; hence, it is paramount to investigate how MAIPs impact education in rural development. The secondary research question three: '*How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' was used to assess the impact of education from the implantation of the MAIPs in Kareeberg and Karoo Hoogland.

As this is a mixed-method research study, I found it to be useful that after to not only assess the impact of the MAIPs on economic infrastructure, employment, education, and tourism but to assess that equally the perceptions of the research respondents as well. Through this exercise, valuable insights were derived as explained in Chapters 5 and 6. In the quest to fill the research knowledge gap by adequately responding to secondary research questions, the summary of the literature review is undertaken, and the research conceptual framework is developed and discussed in the following Chapter.

Chapter 3

Conceptualising and Theorising Rural Development

3.1 Introduction to the Conceptual and Theoretical Framework

This Chapter, the conceptual and theoretical framework chapter serves as the cornerstone of this thesis, providing a theoretical foundation for the research. This Chapter explores the key processes, concepts, theories and models (discussed in Chapter 2, on pages 48 to 88) that guide the investigation into the impact of mega astronomy infrastructure projects on development in rural Northern Cape in South Africa. By establishing a framework for understanding the research problem, this Chapter helped to shape the development and refining of the main research questions, four secondary research questions and the overall methodology of the study.

At the heart of this Chapter lies a discussion of the key terms and concepts that are central to the research. By defining these terms and concepts, I aim to establish a common understanding of the theoretical framework and provide a solid foundation for the analysis that follows in Chapter 6. Additionally, this Chapter explores the theoretical perspectives that informed the research, drawing on both established theories and models from previous research as well as new and innovative approaches that were applied in this study.

The objective of the conceptual and theoretical framework chapter are twofold. Firstly, it provides a roadmap for how the research was conducted, guiding the collection and analysis of data, and informing the interpretation of findings. Secondly, it contributes to the broader aims and objectives of the thesis by offering a theoretical lens through which to understand and make sense of the research outcomes.

In the following sections, we delved into summary of literature review from Chapter 2, the key concepts, theories, and models that shaped the investigation into the impact of

MAIPs on development in the rural Northern Cape in South Africa. By doing so, we hope to have laid a solid theoretical foundation for the study and set the stage for the detailed analysis in the subsequent chapters.

3.2 Summary of Literature for Conceptual and Theoretical Framework

The areas classified as underdeveloped are defined as being backward or primitive while developing areas are those that are trying to move from primitive to developed, and the developed are the modernised areas. Therefore, development models' linearity, according to Rostow (1960), Shuurman (1993), and Singh and Shishoda (2016) speaks of areas that are ahead and those that are lagging as far as development is concerned. Those linear models imply that the burden is on those lagging in development to catch up with those who are ahead and already developed. Therefore, within the linear development model discourse, rural space is characterised as backwards in terms of development and is presented with the burden of catching up with its urban space counterpart. This analogy of linearity of rural development has a narrow, singular, homogenous objective to equate rural development to the urbanisation of rural spaces (Ndlovu, 2017).

Frankema et al. (2013), Martinussen (2004), and Ndlovu (2017) agree that the development of rural areas in terms of urban development principles is a microcosm of what is taking place at the national and international level, in which the developers pursue the so-called developing space to become like the developed space. The Eurocentric view in which developers reduce African development to the Europeanisation of Africa is problematic. Indeed, it is disconcerting that the global South developers are emulating the development trajectory of the global North. They also posit that this current dominant analogy of linearity in development originated in Western civilisation, which the Western developers attained through the invention of Eurocentric modernisation. Eurocentric modernisation presented

Europe and North America as modern and developed while other societies, such as Africa, Latin America, and some parts of Asia as pre-modern, thereby demanding them to leapfrog into becoming like Europe. This narrative and rhetoric formed the basis for the colonisation and apartheid processes that destroyed other civilisations by substituting them with European ones. Ndlovu (2017) posits that Western civilisation's modernisation mission was to disguise colonialism (anywhere in the world) and colonialism and apartheid in South Africa as Western civilisation. When it was apparent that colonial and apartheid (in recent times) masters disguised colonialism and apartheid as the civilisation of the West, the colonialists substituted that ideology as 'development' – linear development. The narrative that others are developing (evolving to be like those developed) while others are developed never changed.

Detractors of linear development perceive the developed-developing paradigmatic posture of the development discourse as influencing the imaginations of modern rural development (Ndlovu, 2017). They purported that the model that rural spaces are not developed or underdeveloped and need to be developed, emulating developed urban areas as a fallacy. Rural is a social construct that plays a vital role in the social sphere, and it should not be eliminated but developed so that it does not lose its being. The goal of achieving rural development should be to avail the life conveniences brought about by the urban spaces without compromising them to become urban. In this research, it is paramount that rural development is not simply conceived of by the stereotypical rural spaces requiring fast-tracking into quasi-urban areas. As stated earlier, in the Cartesian philosophy of meaning-making, it is not easy to imagine rurality without imagining urbanity, but still, it is a fallacy to think that rural development is the urbanisation of rural hinterlands (Heinämaa, 2003). There is a need to decolonise the rural development concept such that there would be a radical break with the linear development discourse. In doing so, this study might claim a decolonised

version of rural development that charts other possibilities for a conversation about the progress of rural and agricultural societies.

Undoubtedly, rural development is one of the most popular concepts in the study and practice of development. Despite its popularity, the meaning of the concept of rural development remains elusive as suggested earlier. Ndlovu (2017) agrees that while rural development has been part of the development discourse, development scholars have not yet given the controversies surrounding the meaning of the phenomenon adequate attention. In this part of the current study, I sought to understand the controversies surrounding rural development.

There are several reasons developers, scholars, teachers, and students of development studies must be concerned about not taking the meaning of a popular development concept seriously, such as that of rural development. One of the reasons is that a misconstrued rural development initiative could cause no good but damage to the rural communities (Ndlovu, 2017). The hypothetical Ndlovu (2017) example is when the government's initiative to promote rural development is through the electrification of a rural area where a rural community depended on cattle rearing. This rural electrification became a developmental setback as it killed the cattle that were the basis of this community's livelihood. This example vividly indicated that rural development practitioners, scholars, students, and policymakers need to be critical about what they mean by the development of rural spaces in the discourse and practice of rural development.

The questions on this anecdotal example of rural electrification are: 1. What might have motivated thinking of rural electrification as an appropriate form of development required in that area? 2. What kind of thinking about development might have been behind the logic that electrification would constitute rural development? These are critical questions explaining how rural development activities are happening today. Dominant paradigms may

inform rural development about the activities we think constitute rural development. Rural development practitioners, researchers, students, and policymakers need to question the correctness of these paradigms before we even entertain whether this or that form of rural development intervention is relevant. Thus, for instance, the electrification of a rural area can easily be associated with the modernisation of rural communities. The researcher could guess the epistemic and spatial location of the actors behind that rural electrification intervention when conceptualising this intervention. Epistemically, one could imagine the actors were thinking about development from a modernist viewpoint. As already alluded to, spatially, one could imagine them sitting somewhere in government offices in an urban area.

The current study sought to respond to the pertinent issues. The concerns of the development that former Africa's SKA Project Director, Dr Fanaroff, meant when he said the SKA project should be taken not as an end-in-itself but as the means to development in South Africa (Square Kilometre Array, n.d.). There is a paradox in using MAIPs to develop rural areas. On the other hand, there is the Act (The Astronomy Geographic Advantage Act of 2007) to preserve space from modernisation. Those rural sites became candidates for astronomy projects because of their remoteness from the cities – modern sites, underdeveloped, and with little or no light and radio pollution (Bhogal, 2018; Slotegraaf & Glass, 2018; Smorenburg, 2016). The MAIPs proponents proclaim that the tasks bring scientific and economic benefits (Department of Science and Technology, 2002; Smorenburg, 2016), but those who are opposed to these projects regard them as unaffordable luxurious ventures for only the few science and engineering elites – 'big toys for big boys' (Bhogal, 2018; Gastrow, 2017; Smorenburg, 2016).

Developers should be aware of the intentions of those who conceived the intervention of mega astronomy infrastructure as an initiative to assist rural development. It cannot be assumed *a priori* that astronomy will have a positive impact on rural development.

Will a person living in KLM or KHLM have thought of rural development the same way the developers thought of rural development? In referring to the earlier anecdotal example of the dying cattle the researcher made, he does not think the people living in that area ever thought the development would lead to the killing of their cattle. He felt that if residents were involved, they would have come up with different interventions that would have led to the growth of their livelihood. When the developers begin to ask such questions and practice participatory governance, they are already on the path of reaching a consensus on rural development, which cannot mean the same thing to different people from different epistemic, social, and spatial backgrounds.

Acquiring the same level of thinking about the contentedness of rural development indicates the time to deepen critical engagement with the idea by asking the question of the origin of the concept, not just in terms of who coined the word but what condition of possibility led to its emergence. Thus, will the idea of rurality have emerged without urbanisation? Would people who lived predominantly in rural areas in the pre-colonial era today think of themselves as rural communities? These questions are necessary to avoid combining the urbanisation process with rural development. When the developers imagine rural development, it is from an urban point of view. Is this how to develop rural spaces that would resemble some elements of urbanisation? Other communities might not prefer the urbanisation of rural areas as a form of development because their livelihoods depend on that rural state. In other words, we must constantly question whether it is appropriate for development interventions to conceive of rural development in such a way that changes the rurality of rural areas.

As mentioned earlier, it is a fallacy to think that rural development is the urbanisation of rural hinterlands (Heinämaa, 2003). Still, according to the Cartesian philosophy of meaning-making, it is not simple to imagine rurality without imagining urbanity. Even

though this study is not about urban development, pragmatically, it is not easy to isolate rural development from urban development (Frankema et al., 2013; Ndlovu, 2017). Rural development phenomenon relates to urban development phenomenon. More than half of the world's population stays in urban places and has high rural-urban migration, but people still prefer to live in rural areas (Dwivedi et al., 2021). Ndlovu (2017) confirms that some people migrate from urban to rural; however, it is negligible compared to people migrating from rural to urban places, which brings us to the issue that not all people live in rural areas because they are stuck and do not have an option. Other people built their livelihoods based on rural status; hence, they prefer to live in rural areas rather than cities. In South Africa, many people in rural areas temporarily migrate to the cities to get employment and send money home because they have left their families home in the villages.

Temporary migration is the legacy of apartheid because Black African people were not allowed to reside in the cities and travelled some distances to work or remained in temporary shelters – hostels, backyard rooms and, in recent times, informal settlements (shacks) while at work (Mlambo, 2018; Mulcahy & Kollamparambil, 2016). Developers, scholars, and policymakers acknowledged that in the apartheid era, pre-1994, rural South Africa, especially the former Bantustans, was deliberately starved of resources. Rural South Africa became entrapped in massive poverty and underdevelopment, and in post-apartheid, people from rural areas migrated to urban areas in significant numbers (Meyiwa et al., 2014). This vast migration influx from rural to urban poses a considerable risk to the urban infrastructure, ageing and not developing on par with the influx rate within South Africa's urban and peri-urban areas. Hence, there is a dire need for rural development and urban development to reduce migration to the urban and retain most rural dwellers. Above all, the integrated nature of rural and urban development is a result of recognising that developmental challenges that affect urban areas also affect rural areas. One cannot tackle them by

concentrating only on one side of the situation. In this way, development planning cannot be one-sided but needs to be holistic in approaching the present bifurcated phenomenon called urban-rural development (Frankema et al., 2013; Mertaugh, 1976; Mlambo, 2018; Mulcahy & Kollamparambil, 2016; Ndlovu, 2017). Following this summary of the literature review, the next sub-section identifies, develops, and discusses the research conceptual framework based on the literature reviewed.

3.3 Research Theoretical and Conceptual Framework

As stated at the beginning, the purpose of this chapter is to review the literature to derive a conceptual framework for this research. The conceptual framework is defined by Creswell (2014), Mills (2017), Čížek (2009), Wotela (2016) and many others as the roadmap for the research based on literature to frame the empirical research. They also agree that a conceptual framework brings a theoretical lens through which research questions are formulated and understood. The key variables, attributes, data collection, and data analysis are identified through a conceptual framework (Miles et al., 2014).

Therefore, the other two objectives of Chapters 2 and 3, which were to understand the research problem and identify the knowledge gap, were done, and the third one, which is to develop a framework for interpreting the research findings, follows. Refer to Table 3 summaries of the rural development theories, strategies, and models. However, the last two highlighted theories in Table 3, Gandhian Philosophy and the African Renaissance movement theory were the best to be used in this study to build a conceptual and theoretical framework. The theories are used with integrated strategy and chain model i.e., advanced Matin and Tang time-based benefits assessment model. These two theories complement each other because they apply both endogenous and exogenous processes and are compatible with the Theory of Change.

Table 3. Rural Development, Strategies, Models, Frameworks and Their Applicability to the Study

No.	Theory	Notable contributor/s	Susceptible strategy/ies	Model (Linear/Chain)	Process	Specific area applicability (Yes/No)	Applicability to the research (Yes/No)
1	Modernisation theory	- **Max Weber -** a German sociologist, philosopher, and political economist - **Karl Marx** – a German philosopher, economist, sociologist, journalist, and political theorist - **Emile Durkheim** – a French sociologist who is widely regarded as one of the founding figures of modern society - **Georg Simmel** – a German sociologist, philosopher, and critic who is also considered one of the founding figures of modern sociology	Top-down strategy	Linear, i.e., Houptfleisch and Singlé production process or Martin and Tang's simple linear model	Exogeneous	No	No
2	Trickle-down theory	- **Adam Smith** – an 18th-century Scottish economist, is best known for his influential work "The Wealth of Nations" (1776) - **David Ricardo** – an economist of the early 19th - century, is best known for his contribution to classical economics, particularly his theory of comparative advantage - **Jean-Baptiste Say** - an 18th and 19th -and 19th-century French economist, is known for the formulation of Say's Law, which states that "supply creates its demand" - **Ronal Reagan** - served as the 40th President of the United States of America from 1981 to 1989	Top-down strategy	Linear, i.e., Houptfleisch and Singlé production process or Martin and Tang's simple linear model	Exogeneous	No	No
3	Dependency theory	- **Raůl Prebisch** - an Argentine economist and diplomat, served as the Executive Secretary of the United Nations Economic Commission for Latin America and the Caribbean	Top-down strategy	Linear, i.e., Houptfleisch and Singlé production process or Martin and	Exogeneous	No	No

No.	Theory	Notable contributor/s	Susceptible strategy/ies	Model (Linear/Chain)	Process	Specific area applicability (Yes/No)	Applicability to the research (Yes/No)
		- **Andre Gunder Frank -** a German-American economic historian and sociologist. Frank's work, particularly his book "Capitalism and Underdevelopment in Latin America" (1969) expanded on Prebisch's idea and emphasised the role of historical colonialism and imperialism in perpetuating underdevelopment in the global South - **Fernando Henrique Cardoso** and **Enzo Faletto -** co-authored "Dependency and Development in Latin America" (1979). Their work focused on the political and social dimensions of dependency, exploring how power structures and social relations within and between countries contribute to underdevelopment (Cardoso & Faletto, 1979)		Tang's simple linear model			
4	Community-driven development approach	- **Robert Chambers** – a British development practitioner and researcher. He is known for his work on participatory rural appraisals and participatory learning and action (PLA) methodologies - **John Friedmann** – an American urban planner and scholar. He also authored several books, including "Planning in the Public Domain: From Knowledge to Action" (1987) and "The Routledge Handbook of Planning Theory" (2017) - **World Bank**	Bottom-up or participatory strategies	Chain, i.e., chain-link Kline and Rosenberg model or advanced Matin and Tang time-based benefits assessment model or Theory of Change Framework	Endogenous	No	Yes

No.	Theory	Notable contributor/s	Susceptible strategy/ies	Model (Linear/Chain)	Process	Specific area applicability (Yes/No)	Applicability to the research (Yes/No)
5	Sustainable development approach	- **Gro Harlem Brundtland** – a former Prime Minister of Norway and chaired the United Nations World Commission on Environment and Development, which produced the landmark report "Our Common Future" in 1987 - **Maurice Strong** – a Canadian businessman and diplomat. He served as the Secretary-General of the United Nations Conference on Environment and Development also known as the Earth Summit, held in Rio de Janeiro in 1992	Integrated strategies	Chain, i.e., chain-link Kline and Rosenberg model or advanced Matin and Tang time-based benefits assessment model or Theory of Change Framework.	Endogenous	No	Yes
6	Human development approach	- **Amartya Sen** – an Indian economist and philosopher, who authored the book "Development as Freedom" (1999), presents a comprehensive analysis of human development, emphasising the importance of capabilities, freedoms, and agency in promoting well-being and human flourishing	Participatory strategy	Chain, i.e., chain-link Kline and Rosenberg model or advanced Matin and Tang time-based benefits assessment model or Theory of Change Framework	Endogenous	No	Yes
7	Gandhian Philosophy	- **Mahatma Gandhi –** was born in 1869, he was an influential leader and activist in the Indian independence movement against British colonial rule	Integrated strategies	Chain, i.e., chain-link Kline and Rosenberg model or advanced Matin and Tang time-based benefits assessment model or Theory of Change Framework.	Both	Yes	Yes
8	African Renaissance Movement	- **Thabo Mbeki** – the former President of South Africa – from 1999 to 2008 - **Kwame Nkrumah** – a prominent figure in African history and a key leader in the struggle for Ghana's independence from colonial rule. He was the first Prime Minister and later became the first President of Ghana	Integrated strategies	Chain, i.e., chain-link Kline and Rosenberg model or Advanced Matin and Tang time-based benefits assessment model or Theory of Change Framework	Both	Yes	Yes

No.	Theory	Notable contributor/s	Susceptible strategy/ies	Model (Linear/Chain)	Process	Specific area applicability (Yes/No)	Applicability to the research (Yes/No)
		- **Cheikh Anta Diop** - a prominent historian, anthropologist, and scholar. One of his notable works is “African Origin of Civilization: Myth or Reality” (1974), in which he presented evidence and arguments supporting the idea that ancient Egypt was an African civilisation - **African Union**					

African Union, Diop, Mbeki, and Nkrumah denounced the modernisation development approach, dependency development approach, and trickle-down development approach for African development but embraced the Community-driven development approach, human development approach, sustainable development approach, and the Gandhian development approach principles for African development using the African Renaissance Movement theory. The African Renaissance Movement theory, Integration strategies, Advanced Martin & Tang time-based, and ToC Framework for rural development were used in the current study as theoretical and conceptual frameworks (Figure 10) below. The Gandhian Philosophy, the African Renaissance Movement and ToC Framework provide a valuable rural development framework. While Gandhi's Philosophy emphasises self-reliance, decentralisation, sustainable agriculture, and education, the ARM theory focuses on cultural revitalisation, economic development, and political empowerment. Gandhian Philosophy and the African Renaissance Movement both reject classical Modernisation theory, trickle-down theory, and dependency theory. Modernisation Theory is rejected because of its Westernisation way of approaching rural development, while trickle-down theory is perceived as a big failure because development has been proven not to trickle down from the more developed areas, such as urban areas, to the less developed areas, such as villages or rural areas. The dependency theory was rejected because it centralised resources with a notion that less developed areas are dependent on the more developed areas, i.e., rural areas' development being dependent on urban areas' development. The community development approach, sustainable development approach, and human development approach are accepted approaches that are used together in both Gandhian Philosophy and African Renaissance Movement, Gandhian Philosophy being more specific to the Indian conditions of need for development and African Renaissance Movement focusing on the African conditions for development. However, Indian, and African specifically South African conditions have a

lot of similarities; hence, both theories were used in this research. These principles, as outlined by Mahatma Gandhi and the African Renaissance Movement theory, remain relevant in contemporary times, offering insights into addressing the challenges faced by rural communities. By embracing Gandhian Philosophy, the African Renaissance Movement theory and the ToC Framework for MAIPs, policymakers, development practitioners, and rural communities can work together to create sustainable and inclusive progress, ensuring the well-being and empowerment of rural populations.

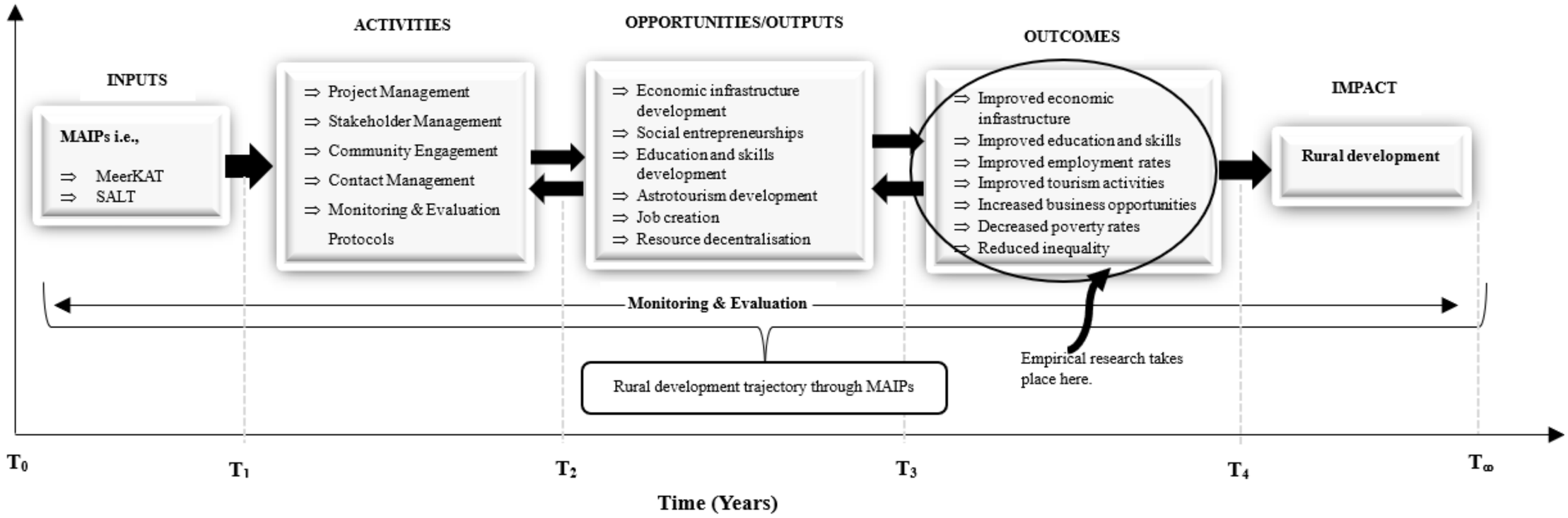

Figure 10. Theory of Change for MAIPs' Impact on Rural Development

Chapter 4

Methodological Approach to the Study

4.1 Introduction to Methodological Approach

The methodological approach adopted in this study serves as the foundation that underpins the entire research process, guiding the collection, analysis and interpretation of data. This chapter engages with the intricate details of the research methodology, outlining the systematic and rigorous approach employed to address the research questions and objectives. By elucidating the methods and techniques utilised in this study, I aim to provide transparency and clarity regarding the research process, ensuring the reliability and validity of the findings. From the selection of research design and data collection methods to the procedures for data analysis and interpretation, this chapter offers a comprehensive overview of the methodological framework that shapes the investigation. Through a meticulous and well-structured methodology, this study endeavours to generate meaningful insights and contributions to the existing body of knowledge in the field of development.

Therefore, the main research question supported by four secondary research questions that this thesis intends to answer was provided in Section 1.3.3 (Table 1 in Chapter 1). The main question was *How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs*? In Chapter 2, I reviewed the literature and developed an interpretative and conceptual framework that guides the research techniques. This chapter identifies and describes the research strategy, design, procedure, and methods employed to collect, collate, process, and analyse the empirical evidence. Broadly, this chapter has five objectives: to identify and describe the research strategy (Section 4.2), the research design (Section 4.3), as well as the procedure and methods (Section 4.4). The chapter also discusses the study's reliability and validity measures

(Section 4.5) to make the research credible. In Section 4.6, I outline the inherent technical and administrative limitations of my research choices. Lastly, Section 4.7 summarises the research strategies and designs.

4.2 Research Strategy for the Study

Phrases, research approaches, and research strategy are interchangeable in most research methodology literature, but research strategy was preferred for the current study. Research strategy is defined as how the researchers conduct their research. It is a plan and procedure that researchers follow in detailed steps to conduct their study (Cohen et al., 2011; Creswell, 2014; Gunasekare, 2013; Welman et al., 2005; Wotela, 2017). Generally, research has three strategies: quantitative, qualitative, and mixed-method (Creswell, 2014; Morgan, 2014; Wotela, 2017). The mixed-method strategy was used for the current study, and its accompanying philosophical worldview and design are discussed below.

Mixed-method research has advantages compared to other research strategies, such as individual qualitative and quantitative research strategies. I used the mixed-methods research approach to respond to the complex research questions and access complex societal issues within the South African rural areas where MAIPs are situated (Cohen et al., 2011; Molina-Azorin, 2016). The mixed-method research strategy combines quantitative and qualitative strategies and is a progressive way of drawing and utilising merits from both qualitative and quantitative research attributes, allowing researchers to combine approaches in a single study (Creswell, 2014; Harrison III, 2013). For the current study, I deemed one research approach inadequate to unravel the complexities found in rural development using MAIPs.

Triangulating different data sets i.e., qualitative, and quantitative data sets, was of interest in the current study. Even though mixed-method was preferred for the current study, according to Bryman (2012), J. Creswell and Plano Clark (2007) and Molin-Azorin (2016), it

is not a straightforward research strategy due to many challenging factors that are inherent to it. Mixed-method was chosen for the current study over qualitative or quantitative research strategies because it allowed expanded comprehension of the research problem (Creswell, 2014; Goles & Hirschheim, 2000; Harrison III, 2013). According to research methodology literature, the mixed-method research approach requires more time and work than other single strategies, such as qualitative or quantitative, because the researcher requires double effort compared with qualitative or quantitative research strategy (Bryman, 2012; J. Creswell & Creswell, 2017; J. Creswell & Plano Clark, 2007, 2011). The mixed-method research strategy demands that researchers fully develop a broader set of skills and integrate them (Caulley, 2007; Čížek, 2009; Cohen et al., 2011; Creswell & Plano Clark, 2011). However, for the current study, I did not consider these mixed-method challenges as barriers but rather opportunities for my personal development in multi-discipline research (Creswell, 2003; Molina-Azorin, 2016).

The inquiry strategies or philosophical worldview utilised in this study is a pragmatic philosophical worldview that allows hybrid design. Pragmatic procedures were used as an overarching qualitative and quantitative data design perspective. The pragmatic paradigm provides a framework for collecting data, topics of interest, and outcomes anticipated by the study (Caulley, 2007; Creswell, 2009; Creswell & Plano Clark, 2011; Goles & Hirschheim, 2000). The pragmatic research paradigm, explained by Creswell (2014), Lather (1992), Merriam and Simpson (2000), Mills (2017), Morgan (2014), Neuman (2006), and Stringer and Dwyer (2005), is associated with situations, actions, and consequences. All available approaches can be utilised to vividly understand the problem at hand. In this worldview, the researchers focus on applications, such as, what is working, what is happening and what the possible solutions to problems being dealt with are, focusing on available research methods or what happened before (Čížek, 2009; Creswell, 2009; Morgan, 2014).

The pragmatism research paradigm's knowledge claims come from actions, situations, and consequences, and the type of inquiry uses the discovery of patterns – induction (Creswell, 2014). In addition, Harrison III (2013) emphasised that researchers based their discoveries on the best explanations for comprehending research outputs abduction and theories and hypothesis testing deduction. Furthermore, researchers use the pragmatic maxim in the mixed-method research strategy to select the combination of procedures and methods that best respond to the research questions outlined (outlined in Chapter 1 for the current study). Creswell and Creswell (2017) and Morgan (2014) also agreed with other mixed-method proponents that a pragmatic paradigm can commit to different systems of realities and philosophies as it applies to a mixed-method research approach. The current study draws from the strengths of qualitative and quantitative research approaches. In this way, I could choose whatever methods, procedures, and techniques we deemed fit for this research.

The pragmatism ontology assumes that many social realities are continuously changing due to several factors, i.e., culture, social status, power base, and political factors (Creswell & Creswell, 2017; Neuman, 2006). Creswell and Creswell (2017) posit that pragmatic paradigm researchers believe that many realities are there to discover, and they are constantly changing; in contrast, positivists and postpositivists believe the opposite. The pragmatic paradigm states that facts have various layers where the surfaces are visible, and other deep layers cannot be observed because they are not visible. Therefore, theories are used to assist in unbundling those deep layers (Čížek, 2009; Cohen et al., 2011; Creswell & Creswell, 2017). The researcher can achieve the pragmatic paradigm axiology's objectivity by examining and reflecting on the value propositions, ensuring they are appropriate for the research study (Antwi & Hamza, 2015; Morgan, 2014). There cannot be an issue with the interpretative research paradigms as the researcher considers the interpretative research paradigms and every viewpoint correct and accurate or incorrect.

There is a notion that qualitative and quantitative research methods do not complement each other but rather dichotomy. Therefore, the pragmatic paradigm researcher should redefine that notion instead of showing that quantitative and qualitative research approaches are a continuum (Čížek, 2009; Cohen et al., 2011; Creswell et al., 2003; Creswell & Plano Clark, 2011; Harrison III, 2013; van Griensven et al., 2014). Pragmatism is a paradigm in which research participants are not entirely involved in defining and identifying the problem, gathering and analysing data, and disseminating the research findings (Chilisa & Kawulich, 2012; Čížek, 2009; Cohen et al., 2011; Creswell, 2014). The current study used the mixed-method research strategy, accompanying data-collecting techniques and sampling procedures in the pragmatic research process.

Data collection involving a sequential or a concurrent approach could be used within the pragmatic paradigm (Creswell et al., 2003; Creswell & Creswell, 2017; Creswell & Plano Clark, 2011; Harrison III, 2013). The sequential approach is when qualitative and quantitative data are collected sequentially. In contrast, qualitative and quantitative data are collected simultaneously for concurrent data collection. I used simultaneous data collection because the two MAIPs were studied separately, compared, and triangulated. The current study examined the two Local Municipalities (KLM and KHLM) with MAIPs and compared them with Joe Morolong Local Municipality, which is geographically distant from KLM and KHLM and does not have MAIPs (see Figure 1.1, Chapter 1). Generally, a mixed-method research strategy tends to base knowledge claims on pragmatism and uses the inquiry technique that involves collecting data concurrently to comprehend research problems (Creswell, 2009; Creswell & Creswell, 2017; Creswell & Plano Clark, 2011).

4.3 Research Designs for the Study

Bryman (2012), Neuman (2014), Symon and Cassell (2012), and Wagner et al. (2012) broadly describe research design as the research framework and architectural blueprint developed during the research exercise and, after that, be able to analyse the collected data. The research design guides a researcher in how to undertake the research. The researcher needs to consider the study's objective while conceptualising the study, such as whether the study needs generalisation or causality, how to sample the targeted population, how to take measurements, and which research techniques to employ. The research design for this study for the current study was convergent (or concurrent) parallel mixed-method, as outlined below.

4.3.1 Convergent Parallel Mixed-Method Research Design

Creswell & Creswell (2018) define the convergent (or concurrent) parallel mixed-method design as one in which the researcher collects qualitative and quantitative data sets to integrate, merge, compare, contrast, and converge them. Both qualitative and quantitative data sets should be given equal value. Merging and combining qualitative and quantitative data sets assists in providing a comprehensive analysis and adequate response to research questions. This research design was used for triangulating different data types to find the definitive answer; however, I probed further to identify incongruencies and contradictions in the research findings. Convergent mixed-method was also used to gain an in-depth knowledge of the topic studied because the study's qualitative and quantitative components could be reviewed independently, and the results interpreted together (Demir & Pismek, 2018).

The current study looked at the impact of MAIPs, specifically MeerKAT in KLM and SALT in KHLM, on development in the rural Northern Cape, South Africa. The study

responded to one main research question supported by four secondary research questions. The secondary research questions are related to economic infrastructure, employment rates, education levels, tourism, and people's perceptions of KLM and KHLM.

Within the convergent parallel mixed-methods design, Cohen et al. (2011) and Fink (2017) inform that surveys are data-gathering methods to describe the nature of prevailing conditions at a particular time. The convergent mixed-method design was appropriate because the study investigated the existing state between 2001 and 2021. Further, I chose a survey research design to scope a considerable population to measure, determine, or describe any features that could be generalised (Fink, 2017). Furthermore, it was efficient and economical for the current study because I could collect data concurrently and generate quantitative data (Cohen et al., 2011). Besides quantitative data, it also gathered qualitative data on beliefs and predictions, preferences and attitudes, opinions, behaviours, and experiences. Appendix A6.1 provides the predetermined sample to adequately sample the vast target population.

The data collected, cleaned and processed generated appropriate information through piloting and revising. Data was captured from observation schedules, test scores, closed questions, and multiple-choice. It provided descriptive, inferential, and explanatory information for researchers to respond to research questions. The survey research design fulfilled the quantitative aspect of the mixed-method strategy research. The teleological survey research design is exploratory; the researcher deeply explores the research variables' patterns and relationships, and the researchers do it through factor analysis, correlation, and regression (Cohen et al., 2011).

I used the case study research design, as a multiple case study design which incorporated the survey method with quant & qual instruments, as well as quantitative

secondary data. It also incorporated a comparison group in a quasi-experimental design. I desired to understand a real-life phenomenon bound by contextual conditions in great detail – the researcher is assessing the impact of MAIPs on development in the rural Northern Cape. The contextual needs of the study are highly pertinent to the researcher's phenomenon of study. The case study research design copes with technically specific situations with many variables and attributes of interest. The case study research designs rely on multiple sources of empirical evidence that converge through triangulation. The case study research designs immensely benefit from prior theories to guide collections of data and analyses. The case study research design can consist of single- and multiple-case studies and utilise qualitative and quantitative data in the same research study. Yin (2009, p. 19) developed four case study research design applications: "1. To explain the supposed causal relationships in real-life intervention, 2. To characterise an intervention and the real-life setting it happened, and 3. To demonstrate specific issues within an assessment, in descriptive mode, the researcher may utilise a case study research design to illuminate those instances in which the intervention they are assessing does not have a clear, single set of results."

The other important reason that needs to be noted is that using case-study research I could not arrive at broad generalisations based on the empirically gathered evidence. I also use the quasi-experimental research design because it deliberately separates a phenomenon from its context. It does that by controlling the context in the environment and focusing on only a few variables—the survey research is designed to deal with phenomena and limited contextual conditions with non-contemporary events. Researchers must limit the number of variables (economic infrastructure, education, employment, and tourism) to be analysed in the survey research design so that they are not outside the recommended minimum number of research respondents (Cameron, 2009; Caulley, 2007; Creswell, 2014).

4.4 Research Procedure and Methods

This section documents the procedure and the methods employed in the current study to collect, collate, process, and analyse the empirical evidence. The data and information collection instruments (Section 4.4.1), the target population and sampling of respondents (Section 4.4.2), the ethical considerations related to the research process (Section 4.4.3), data and information collection process and storage (Section 4.3.4), data and information processing and analysis (Section 4.5.5), and the background description of the respondents who provided empirical evidence for this research study (Section 4.3.6) are detailed.

4.4.1 Research data and information collection instrument(s)

The research data and information collection instruments are the tools the researcher selects and uses to collect research data. For the current study, I chose observation, a combination of structured, and semi-structured questionnaires, interview schedules, secondary data from censuses and organisational reports. According to Cohen et al. (2011), Fink (2017), and Welman et al. (2005), structured questionnaires and interview schedules collect specific, quantitative data. They also initiate a formal inquiry, supplement data, check previously accumulated data and help validate any prior hypothesis. While unstructured questionnaires collect qualitative data, they have a basic structure and some branching questions, but nothing limits the respondents' response, and the questions are open-ended. A sample of a structured and semi-structured questionnaire and interview schedule are provided in Appendix A.1 and A.2.

4.4.2 Research Target Population and Sample

4.4.2.1 Research target population

The target population was the community members in Kareeberg and Karoo Hoogland Local Municipalities. According to the 2011 census and IDPs, Kareeberg had a population of 11385, and Karoo Hoogland has a population of 11601 (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020; Stats SA, 2013). Tables 6 and 14 show that 304 participants filled out the questionnaire from Kareeberg and 302 from Karoo Hoogland. This was random sampling in which the area was mapped, and the numbers of households were identified. The numbers were written on a small paper which was put in the back and randomly picked. The tables used to determine the appropriate sample for Kareeberg and Karoo Hoogland are shown in Appendix F, Table 54. This research used 90% confidence and 5% confidence intervals. The characteristics of the population were ordinary community members consisting of the youth aged between 18 and 35 years old; adults, defined as people over the age of 35; any disabled persons over the age of 18; community leaders such as chiefs and political leaders; farming community members in around Kareeberg and Karoo Hoogland; managers of the MeerKAT and SALT projects; workers for the MeerKAT and SALT projects; and business people or entrepreneurs (e.g. guest houses; hotels; shops; construction companies) in Kareeberg and Karoo Hoogland.

4.4.2.2 Selecting Research Respondents

The convergent parallel mixed-method research approach was used for the current study, and basic strategies for mixed-method research sampling in this study were deployed. In the parallel mixed-method research approach sampling in this instance, non-probability sampling was done. According to Cohen et al. (2011), collected data from probability

sampling should not influence collected data from non-probability sampling and vice versa. In probability sampling, the probability that the researcher includes any population of research respondents in the sample is determined, whereas, in non-probability sampling, the researcher does not specify the probability (Welman et al., 2005). Probability sampling enables the researcher to estimate sampling error while using non-probability sampling for convenience (Welman et al., 2005). In this study, I used non-probability sampling and purposive samples.

Structural and non-structural questionnaires were used to collect the quantitative data. I used semi-structured interviews and walkabouts or 'house-to-house visits' for illiterate ordinary participants, community, social entrepreneurs, and farming community members. For 'house-to-house visits', after defining and identifying the sample, then I visited the identified households and interviewed the family' representative or group of family members. The household was given the liberty of choosing how I conduct the interview.

A questionnaire was developed to be utilised in the semi-structured interviews based on the main research question and four secondary research questions. Structured questions were also included in the questionnaire to concurrently collect qualitative and quantitative data as the chosen design is the convergent parallel mixed-methods.

4.4.3 Ethical Considerations for the Study

On 03 November 2020, the Human Research Ethics (HRE) – Non-medical granted ethics clearance (Appendix C.3) to conduct the current study. The ethics clearance is valid until 03 November 2023. I fully understood the conditions under which the certificate authorised me to conduct this research and complied with all those conditions. There was no departure contemplated from the research procedure as approved.

The convenient method, according to several scholars such as Burger (2005), Caulley (2007), Cohen et al. (2011), Creswell (2014), Čížek (2009), Harrison III (2013), van Griensven et al. (2014), Molina-Azorin, (2016), Riazi, (2017), and Welman, et al. (2005), is less desirable because the likelihood of the sample being representative and controlling the sample is very low. These scholars recommended this sampling technique where slight variation in population exists, which is not the case with this research and the researcher needs to know about areas to study and cultures that prevail in those regions. In the early stage of my study, I underwent this process of visiting Kareeberg and Karoo Hoogland for convenience sampling and learned a great deal through that process. I have been involved in these projects for a long time, and my judgement, left unchecked, could be highly biased. I did not deceive the research respondents as I had promised the research community, and I did not in any way harm or stress the respondents (physically or developmentally) or drive them to the point of 'losing self-esteem'. I obtained informed consent to interview the research respondents and, when applicable, recorded them and protected the respondents, including securing the data I obtained from them and not revealing their identity.

The English and Afrikaans written letter explaining who I am and outlining the firm promises of participants' anonymity and confidentiality. The Consent Form and Participants' Information sheet are included in Appendix C.1 and C.2, respectively. I used these documents to manage issues of anonymity and confidentiality in my research project through the Participant Information Sheet, a short letter I wrote to a potential participant. I did not record the participants' names, addresses, and identity numbers on the research instruments. In this study, there was no need to identify potential participants or their specific organisation except for general groupings that the research was researching as represented in this research.

4.4.4 Research Data and Information Storage

Data and information were stored in hard copies and electronic formats. The hard copies are sealed and stored in the locked cupboard at the DSI Offices. The security personnel and I are the only ones who have the key to the cupboard. For the electronic format of the data and information, I linked Google Drive to my Google account, which has a password needed to access it. I also stored data in the University of the Witwatersrand and DSI repositories.

4.4.5 Research Data and Information Collection Process

The primary research data collection was done through face-to-face participant interviews, questionnaires, and observations. Interviews were conducted using unstructured questions, whereas the questionnaire contained structured and semi-structured questions. During the interviews, notes were made on observed mannerisms. Secondary data was collected from the MAIPs reports, websites of entities responsible for MAIPs in the country i.e., NRF, South African Optical Observatory and SARAO and census data (Stats SA, 1998, 2003, 2013). Please refer to Table 4 below, which summarises the data and information collection process.

Table 4. The Research Question and Research Methods

Research Questions		Data Collection	Data Analysis
Main Question		**Quantitative data and qualitative information** (Primary data - structured questions and questionnaire) and triangulate with the response from interview questions, unstructured questions.	SSPS program
How have the district municipalities of Kareeberg and Karoo Hoogland Local Municipalities developed from 2001 to 2021 since the introduction of MAIPs?			
Secondary research questions			
1	How have the economic infrastructures of Kareeberg and Karoo Hoogland Local Municipalities changed since the introduction of MAIPs?		Text analysis by using ATLAS.ti
2	How have employment rates in Kareeberg and Karoo Hoogland Local Municipalities changed since the introduction of MAIPs?		
3	How have education prospects in Kareeberg and Karoo Hoogland Local Municipalities changed since the introduction of MAIPs?		
4	How has astrotourism developed in Kareeberg and Karoo Hoogland Local Municipalities changed since the introduction of MAIPs?		

4.4.6 Research Data and Information Processing and Analysis

4.4.6.1 Research Data and Information Processing

I pursued a convergent parallel mixed-methods research strategy. The data processing for the quantitative aspect was through data coding, data entry onto a computer i.e., SPSS, and data cleaning. For the qualitative aspect of the study, I transcribed, determined themes theoretically or data-driven (thematic analysis), and analysed data using ATLAS. ti 22. In a convergent parallel mixed method research strategy, the challenge is merging or converging the research data (Caulley, 2007; Čížek, 2009; Creswell, 2009; Creswell, 2014). The quantitative and qualitative data sets were gathered concurrently but analysed separately and, in the end, merged for comparison to check divergence or convergence (Creswell &

Creswell, 2017). I merged the two databases by changing qualitative codes or themes into quantitative variables, which Creswell (2014) referred to as data transformation. Data transformation is when the researcher counts the qualitative principles or themes to form quantitative measures (Creswell, 2014). I used a side-by-side comparison approach to merge these two data sets. I statistically analysed the quantitative data and then analysed the qualitative data to identify themes and trends. I discussed the outcome of the qualitative data analyses in conjunction with quantitative statistical analyses to confirm or disconfirm the quantitative results.

4.4.6.2 Research Data and Information Analysis

In a convergent parallel-mixed method research strategy, qualitative data analyses are reported separately from the results from quantitative and then checked if the results from qualitative and quantitative data analyses converge or diverge. If they converge, the study ends, and the researcher reports them. However, Creswell (2014) posits that comparing qualitative and quantitative data sets does not yield a clean convergence situation in most cases. In the current study, Census data was inconclusive, primary data did not converge to secondary data from institutional reports which brought some differences to some concepts, themes, and scales in which I regarded the situation as divergent in that regard. However, there was convergence in the sense of primary data from Kareeberg and Karoo Hoogland.

In the case of divergence, according to Creswell (2014), the simple and weak solution reported divergence and limitation in the research study without further follow-up. The alternative is for the researcher to explore the data sets further and, in some instances go back to the field to collect additional data to resolve the differences. If the differences persist after this intervention, the researcher reports limited results from one of the datasets (Caulley,

2007; Creswell, 2009; Creswell & Creswell, 2017; van Griensven et al., 2014). In the case of this research limited results were reported due to time and funding constraints.

4.4.7 Description of the Research Respondents

Here I expand on the essential characteristics used to describe the research respondents to authenticate them as the most appropriate providers of information. Youth are aged between 18 and 35 years old and adults are defined as people over the age of 35. There were four distinct categories of the research respondents: gender, standing in the community, race, and duration one has been in the community. Gender was divided into three subcategories which are, female, male, and others. Others did not identify with the stereotypical gender classification of male and female. It was important in designing the questionnaire that gender classification was not limited but rather broadened so that participants who did not align with the limited category of gender did not feel left out and left the question unanswered. Anyone who describes themselves as non-female and non-male should feel accommodated. Standing in the community was divided into four sub-categories: community member – any ordinary community member; farming community – those who are from the farming community or farmers in the area; community leader – anyone who holds a leadership position within the community, i.e., the chief, religious leader, leaders of community cooperatives, or political leader; business representative – anyone owning or running a business within the community. Race was divided into Coloured, Black, White, and Other. Another was anyone who cannot classify themself as either Coloured, Black, or White. Duration in the community was divided into four sub-categories: 0 to 20 years, 21 to 40 years, 41 to 60 years, and over 60 years. This category was to understand how long the respondents have been living in the community to ascertain if such respondents understood the issues about the researched community.

4.5 Research Reliability and Validity Measures

The current study utilised a mixed-method research approach for both validity and reliability as essential aspects. Reliability is regarded in the quantitative part of the research, while researchers use validity in the qualitative part of the research (Creswell et al., 2003; Creswell & Creswell, 2017; Creswell & Plano Clark, 2007; Creswell, 2014; Neuman, 2006). Reliability in quantitative research is characterised into three categories: representative reliability, stability reliability, and measurement reliability (Creswell, 2014). Measurement reliability considers the consistency and dependability of the measure of a variable/s. Representative reliability is a measurement across social groups, which helps yield consistent results across different social groups (Creswell, 2014). Lastly, measurement reliability across time or stability reliability is a measure that yields consistent results at various points with the assumption that what the researcher is measuring is constant (Creswell, 2009; Creswell et al., 2003; Creswell, 2014; Neuman, 2014).

Validity is considered a strength for qualitative research because it is utilised to determine the accuracy of the research results from the position of the one conducting the study, the ones who are research participants and the ones that the researchers disseminate the results to (Creswell, 2009). For the current study, I increased the validity of the results by conducting triangulation, peer debriefing, and presenting negative or discrepant information. Triangulation is an essential aspect of both qualitative and quantitative social research. The researchers derived triangulation from the idea that observing an object from a different point of view improves the accuracy of what the researchers observed (Chilisa & Kawulich, 2012; Creswell & Plano Clark, 2007; Mertens et al., 2016).

Peer debriefing is where someone is familiar with the social setting and knowledgeable about the challenges in that social setting (Burger, 2005; Johnson & Onwuegbuzie, 2004; van Griensven et al., 2014). The researcher would identify anyone with

similar characteristics as explained above to review what they have found and investigate to clear biases to ensure that the findings resonate well with the research participants rather than the researcher only. However, in the current study, it is expected that even divergent views still need to be recorded and reported.

The convergent parallel mixed-methods approach validity establishes qualitative and quantitative validity for each database (Čížek, 2009; Creswell & Creswell, 2017). Creswell (2014) affirms that the results may be difficult and incomparable when merged due to the qualitative and quantitative data set's different variables or concepts from qualitative and quantitative data sets. He further stated that if there is no follow-up on diverging results, that also represents invalidity.

4.6 Research Weaknesses

Research weaknesses are technical and administrative limitations of this research. First, I discuss the technical limitations of the selected research strategy, design, procedure, and methods that might affect the current study. The convergent parallel mixed-methods approach combines qualitative and quantitative data collection and analysis in parallel, to merge or compare the findings. While this approach has significant advantages, it also has some limitations to consider. Managing and integrating qualitative and quantitative data was challenging because I needed to have expertise in both qualitative and quantitative methods to analyse and interpret the data from each effectively. As additional training was required, I attended the training that was regularly offered by the Faculty of Commerce and Law and collaborated with experts from the Wits School of Governance (both based at the University of the Witwatersrand) in each method. The other programme which I was regular was Stats Antie, run by Dr Merle Werbeloff. It is in this platform where various lessons on research are presented. I benefitted greatly from regularly attending those lessons. Due to the parallel

nature of this design, there were limitations in the depth of exploration for both qualitative and quantitative data. I did not have sufficient time and resources to fully explore these complex phenomena and capture a nuanced understanding that could be achieved through a more focused single-method approach. In some instances, combining qualitative and quantitative data led to inconsistencies or contradictions in the findings. The two data sets did not always align or provide the same conclusions, which I found challenging to reconcile and interpret.

Second, I examine the administrative issues encountered during the study, such as timeframe, accessing respondents, and interacting with respondents. Choosing appropriate sampling strategies for both qualitative and quantitative components was complex. I needed to carefully consider how to select participants or cases to ensure they were representative and provided meaningful insights for both data types. Communicating the results of convergent parallel mixed-methods research was demanding because I needed to effectively present and integrate findings from both qualitative and quantitative analyses, ensuring clarity and coherence in reporting. Conducting convergent parallel mixed-methods research was time-consuming and resource-intensive because it required conducting two data collection and analysis processes simultaneously, increasing the workload and cost of the study.

The other limitation is that the dominant language spoken in Kareeberg and Karoo Hoogland is Afrikaans, I do not adequately comprehend the Afrikaans language. Thus, I acquired the services of interpreters to translate from Afrikaans to English, cognisance of the risk that the participants' intended meaning might be lost in the processing of interpretation.

4.7 Summary of Research Strategies and Designs

Figure 11 summarises the research methods, research design, data collection and data analysis technique used in the current study. This is a rural development study using has

social relevance. The teleologic type is a combination of descriptive, explanatory, and interpretive studies. A descriptive study design aims to describe and characterise a particular population (Cohen et al., 2020; Cohen et al., 2011; Vaismoradi et al., 2013; van Engelsdorp et al., 2009). In the current study, a partly descriptive method was used to describe how the MAIPs have affected the lives of the Kareeberg and Karoo Hoogland populations. The explanatory method seeks to explain the relationships between variables and establish causal connections between variables (Lacy et al., 2022; Leung et al., 2023; Uher et al., 2023). This study is an impact study in which we are assessing the relationship between rural development in the Northern Cape and the MAIPs was assessed. The interpretive study is the research approach that focuses on understanding and interpreting the subjective meaning and experiences of the individual group (Harikkala-Laihinen, 2022; Sarker et al., 2021; Turgut et al., 2022). In the current study, the subjective meaning, and experiences of the Kareeberg and Karoo Hoogland people in terms of the MAIPs were interpreted.

The research category is policy research and partly programme evaluation. The current study applied, tested, and built a theory. The data was acquired using a convergent parallel mixed-methods research method, and data analysis follows the mixed-methods techniques. I extracted employment rates, household incomes, income per capita, and dependency ratios, from census data. The data was analysed using Economic Base Theory (EBT) and Shift Analysis Models. These economic models helped in assessing if there was an improvement in the economy in the Kareeberg and Karoo Hoogland during the implementation of the MAIPs. The Joe Morolong was used as a comparison group in this regard. This research has a social relevance and its teleologic type is exploratory thus no hypotheses are framed. Its research category was the combination of policy research and programme evaluation. Regarding the analysis methods, the multi-case research design was carried out as a convergent design because qualitative and quantitative data were

simultaneously collected and analysed separately, and then merged or compared to gain a more comprehensive understanding of the research topic. This approach allowed for the integration of qualitative, quantitative, primary, and secondary data to provide a more holistic view of the research problem. It was carried out with multiple levels of analysis for each of the four secondary research questions, and census 2001, 2011, and institutional reports were analysed in parallel with triangulation of the findings per research question. The next chapter presents the empirical research results.

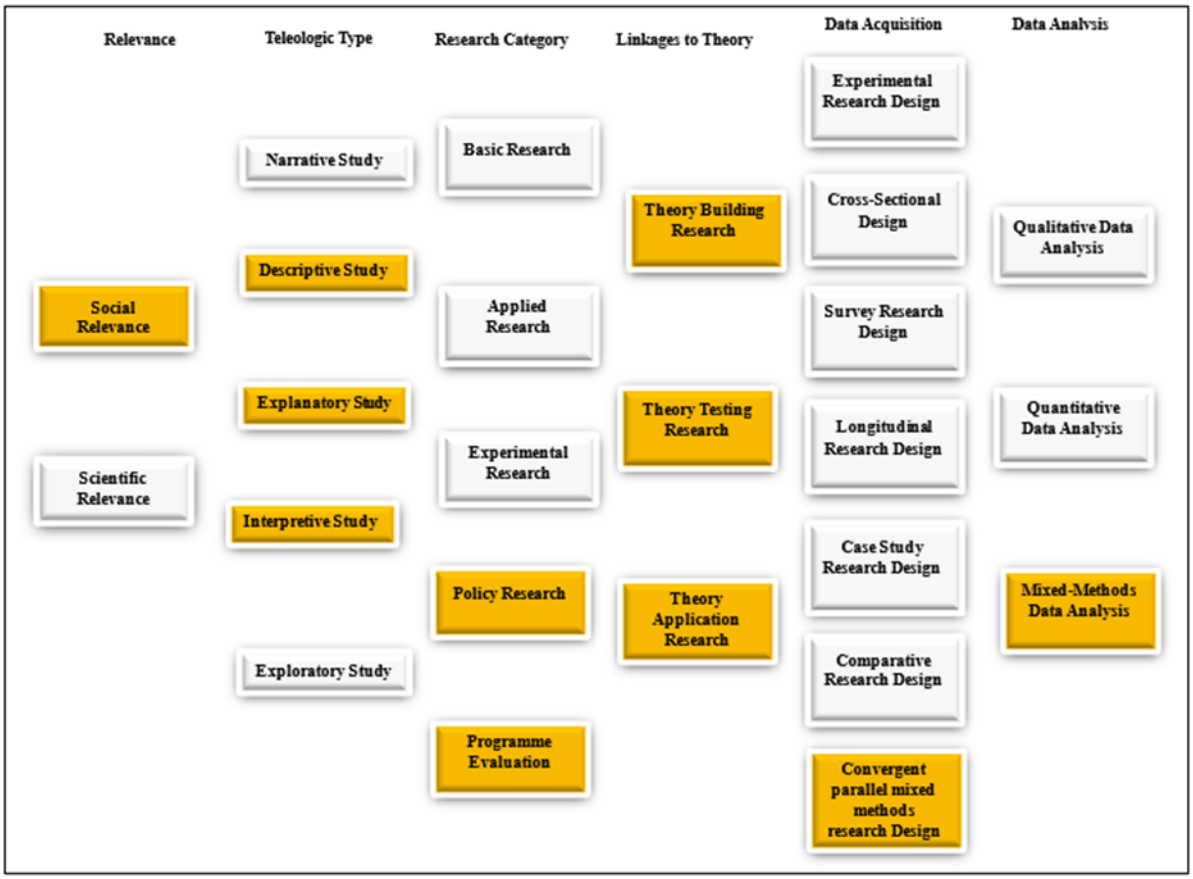

Figure 11. Summary of the Research Methodology

Chapter 5

Empirical Research Results Presentation

This chapter delves into the presentation of the empirical impact of MAIPs on the development of rural Northern Cape province in South Africa. Through an in-depth analysis of the data collected during the research process, this chapter aims to uncover the key findings and insights that emerged from the study. It examines the relationships, patterns, and trends identified in the data and sheds light on how mega astronomy infrastructure projects have influenced the development of rural communities in the Northern Cape region.

The research results presented in this chapter provided a comprehensive overview of the outcomes of the study, offering valuable insights into the implications of these projects on the socio-economic landscape of the Northern Cape region. Empirical data is arranged in two categories primary and secondary data in which within both primary and secondary data there is qualitative and quantitative data as this is a mixed-method study. Through this detailed examination of the research findings, I gained a deeper understanding of the MAIPs on the rural development of the Northern Cape province especially in Kareeberg and Karoo Hoogland Local Municipalities.

5.1 Presentation of Primary Data

In survey research, Barlett et al. (2001) developed a table (Table 6) for determining the appropriate sample size. The complete table is shown in Appendix F, Table 54. A confidence level of 90% and 5% confidence intervals were used in the current research. According to the 2011 census and IDPs both Kareeberg and Karoo Hoogland, Kareeberg had a population of 11385, and Karoo Hoogland had a population of 11601 at the time of the study (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020; Stats SA, 2013). The highlighted rows in Table 4.1 show the sample size confidence intervals for the

10000 to 20000 population size range. Tables 4.2 and 4.12 show that 304 participants filled out the questionnaire from Kareeberg and 302 from Karoo Hoogland; both are more than the minimum of 265 to 269 range (Table 4.1).

Table 5. The Sample Size for Kareeberg and Karoo Hoogland Local Municipalities Random Samples Source (Barlett et al., 2001, p. 48)

Population size	**Confidence level 90%**		
	Confidence Interval 5%	**Confidence Interval 4%**	**Confidence Interval 3%**
2 500	246	364	581
5 000	258	392	657
7 500	263	403	687
10 000	265	408	703
20 000	269	417	729
30 000	270	419	738
40 000	270	421	742

5.1.1 Description of the Samples from Kareeberg and Karoo Hoogland.

5.1.1.1 Kareeberg Local Municipality Results

Table 6. Kareeberg Demographics Statistics
Participant Demographics (N=304)

Measure	Number	Per cent (%)
Sex		
Female	152	50.0
Male	146	48.0
Others	6	2.0
Race		
Coloured	274	90.1
Black	20	6.6
White	7	2.3
Others	3	1.0
Age		
18-35 years (Youth)	93	30.6
36-60 years (Middle age)	152	50.0
Over 60 years (Old age)	59	19.4
Status in community		
Community member	239	78.6
Farming community	28	9.2
Community leader	23	7.6
Business representative	14	4.6
Duration in community		
0 to 20 years	63	20.7
21 to 40 years	126	41.4
41 to 60 years	74	24.4
Over 60 years	41	13.5
Knowledge of MeerKAT		
Yes	263	86.5
No	41	13.5

Table 6 presents the demographic statistics of the Kareeberg research sample (produced using SPSS). The sample of 304 participants was represented by 152 females (50.0%), and 146 males (48.0%). The sample constituted 90.1% of Coloured and 8.9% of other ethnicity groups. In terms of age, the sample was predominantly people between the ages of 36-60 years, referred to as adult middle age. Most of the sample were ordinary

community members (78.6%); the rest, such as the farming community members, community leaders, and business representatives, make up 21.4%. Regarding duration in the community, most participants had resided there between 21 to 40 years, constituting 41.4%. Lastly, 86.5% of the participants were aware of the MeerKAT project in their community.

5.1.1.1.1 Research questions response for Kareeberg

The main research question from Table 1.1 in Chapter 1, to be responded to is '*How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs?'* Four secondary research questions (Table 1 in Chapter 1) were answered in response to the main research question. Qualitative and quantitative data were concurrently collected through a questionnaire, interviews and observation and used to respond to these four secondary research questions. The questionnaire had 11 questions: questions: one to five were structured questions relating to the participant's demographic; six to eight were structured questions to collect quantitative data. Questions nine to 11 were semi-structured questions to collect both qualitative and quantitative data. Interview questions were also 11 unstructured questions which were collecting qualitative data. In the following paragraph, the researcher endeavours to respond to secondary research question 1: *How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*

In responding to the first secondary research question, questions 6.8 on the survey and question

Table 7. Descriptive and Frequency Statistics for Respondents Responses to Question 6.8

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The MeerKAT project brought development to the community	02 (0.7)	27 (8.9)	17 (5.6)	74 (24.5)	42 (13.9)	140 (46.4)

The result indicated that a large number (46.4%) of the respondents indicated that the question – '*The MeerKAT project brought development in the community'* did not apply to them. A high percentage of respondents (38.4%) disagreed with the statement that the MeerKAT project brought development to the community.

For qualitative data collection, out of 33 purposively sampled research respondents who were interviewed, only 29 participants responded to interview question 2. '*Was the community informed of the developments of the MeerKAT?'* It was found that 55.2% of participants agreed that they were regularly notified of the developments relating to MeerKAT. C/S003, one participant who agreed that the information was regularly provided, said, "*Yes, the community was timeously informed of the development within the MeerKAT through regular community meetings, and flyers were regularly handed out.*" To respond to the secondary research question 2: '*Did employment rates and levels of economic participation in KLM improve since the implementation of MeerKAT*?' questions 6.3, 6.10, 9, and 11 on the survey instrument and questions 3, 3.1, 3.2, 9, and 11 on the interview instrument were used (Appendix A). Quantitative results are presented in Table 8 for questions 6.3 and 6.10 on the survey instrument.

Table 8. Descriptive and Frequency of Respondents' Responses to Questions 6.3 and 6.10

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The MeerKAT project created jobs for the people in your community	02 (0.7)	46 (15.2)	24 (7.9)	50 (16.6)	39 (12.9)	141 (46.7)
The MeerKAT project contributed to the economy of the area	04 (1.3)	33 (10.9)	22 (7.3)	60 (19.9)	43 (14.2)	140 (46.4)

The result showed that 46.7% of the respondents indicated that the statement '*The MeerKAT project created jobs for the community members*' did not apply to them, and 29.5% disagreed that the MeerKAT project created jobs for community members. Similarly, the result showed 46.4% of the respondents indicated that the question – '*The MeerKAT project contributed to the economy of the area*' did not apply to them, and 34.1% of the respondents respectively disagreed with the statement that the MeerKAT project contributed to the economy in Kareeberg. The secondary research question was negatively responded to.

For the open-ended question 9, '*Please identify, if any, the most valuable contribution of the MeerKAT project in the community*'. 8.9% of the respondents identified 'employment creation' as the most valuable contribution MeerKAT had made thus far. Given that statements 6.3 and 6.10 were not being positively responded to, it corroborated that the MeerKAT project did not contribute to job creation. The themes 'employment creation' and 'SMMEs' development did not feature prominently. Even worse, the 'SMMEs' development' theme did not even feature more than five times.

For qualitative data collection, out of 33 purposively sampled participants responded to an interview research question 3: '*Do you or had you ever worked for MeerKAT*?', with

67.7% responding negatively. Interview research question 3.1. '*If yes, did you acquire worthwhile experience or knowledge that you think may benefit you in the future*?' and 3.2: '*If not, do you know anyone who worked or is currently working for the MeerKAT*?' were used to get a detailed response from interview question 3.

Only seven participants responded to interview question 3.1 because they answered question 3 positively. Participant A1 said he had acquired five years of experience and thinks that would be useful in future. Participant C/S001, an SMME providing catering services to the project, said, "*I had a catering project at the SKA site for some time. However, I do not think the experience will help me in future because I am a pensioner now*." The participants who were not employed by the project (67.7%) responded to the interview question 3.2.: 70.8% of the respondents at least knew someone who was employed at the MeerKAT project.

Survey questions 6.6, 6.7, 9 and 11 on the survey instrument and question 11 on the interview instrument (Appendix A) to respond to secondary research question 3. '*How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' The results for questions 6.6 and 6.7 from the survey instrument are presented in Table 9.

Table 9. Descriptive and Frequency Statistics for Questions 6.6 and 6.8 Responses

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The MeerKAT project assisted in improving education in the community	01 (0.3)	52 (17.2)	15 (5.0)	52 (17.2)	41 (13.6)	141 (46.7)
The MeerKAT project offered scholarships/bursaries to students in the community	02 (0.7)	51 (16.9)	14 (4.6)	54 (17.9)	41 (13.6)	140 (46.4)

Many (46.7%) of the respondents indicated that the statement '*The MeerKAT project assisted in improving education in the community'* did not apply to them, and 30.8% of the respondents rejected this statement. Similarly, 46.4% of the respondents indicated that the statement '*The MeerKAT project offered scholarships/bursaries to students in the community*' did not apply to them, and 33.5% of the respondents rejected this statement. Given that many respondents reported that the MeerKAT project did not offer scholarships/bursaries to students in Kareeberg. Secondary research question 3, which stated how education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs was not positively responded to.

The qualitative data collection from semi-structured, open-ended question 9: '*Please identify, if any, the most valuable contribution of the MeerKAT/SKA project in the community'*, and question 11: '*Do you have comments or suggestions to make on how the MeerKAT/SKA project can improve your community?*' from survey instrument, revealed the themes 'providing bursaries' or 'providing scholarships' many times. For question 9, the combined themes of 'providing bursaries' or 'providing scholarships' were identified 33

times as the most valuable contribution made by the MeerKAT project. This was followed by the theme 'employment', which was identified 27 times.

For open-ended question 11 from the survey instrument, participants were requested to comment and suggest how the MeerKAT project could improve their community. A dominant theme was about 'providing more bursaries' even though it was not as prevalent as other themes such as 'providing employment'.

Questions 6.9 on the survey instrument and questions 7, 8, 9, and 10 on the interview instrument (Appendix 1) were used to respond to secondary research question 4. '*How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' The results for question 6.79 are presented in Table 10.

Table 10. Descriptive and Frequency Statistics to Respondents' Responses to Question 6.9

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The MeerKAT project improved tourism in the community	07 (2.3)	40 (13.2)	15 (5.0)	63 (20.9)	38 (12.6)	139 (46.0)

The result indicated that 46.0% of the respondents indicated that the statement '*The MeerKAT project improved tourism in the community*' did not apply to them. and 33.5% rejected this statement. These results suggest that many respondents believe the MeerKAT project did not improve tourism in Kareeberg.

Question 7 on the interview instrument: '*Do you think tourism in Kareeberg has improved due to the MeerKAT astronomy mega infrastructure project?*' was responded by 32 out of 33 participants, 28.1% of participants believed that tourism in Kareeberg improved due

to the MeerKAT. C/S017 said, "*Yes, Kareeberg tourism improved because of what MeerKAT is offering to be seen by the tourist[s]*", and C/S030 agreed, "*Yes, because of many people having interest and visiting our area*". Those (22, 68.8%) who did not agree that the MeerKAT project had improved tourism had this to say for example, C/S009 said, "*No, because there is no tourist route here. The tourist route is between Carnarvon and Williston*." C/S016 responded, "*No, there are no tourist attractions in Kareeberg*." One respondent, A1, said, "*No response to this question,*" while another, C/S005, responded, "*I do not know*." Therefore, interview instrument question 7 corroborated the results from question 6.9 on the survey instrument that tourism in Kareeberg had not improved, even with MeerKAT.

Of the 33 respondents interviewed 11 (33.3%) agreed interview instrument, question 8: 'Are there tourist attraction marketing platforms in Kareeberg?' While 20 (60.6%) respondents believed that there are no tourist attraction platforms in Kareeberg. Respondent A1 responded that he does not know if tourist attraction marketing platforms are available in Kareeberg. C/S001, said, "*The marketing attraction platforms available are [the] Museum and Korbeel House.*" C1 responded, "*The South African National Parks is one of the marketing platforms available in the area.*" C/S003 disagreed, *"No, there are no tourist marketing attractions in our area, and nothing can be done to attract tourism into this area*." C/S030 agreed with C/S003: "*No, absolutely nothing*." These results concurred with question 7 on the interview instruments and that from question 6.9 on the questionnaire, substantiating the community's opinion that there was no tourism improvement in Kareeberg because of the MAIPs.

Questions 6.4, 6.5, 10, and 11 on the survey instrument and questions 1 and 2 on the interview instrument (Appendix A) were used to gather people's perceptions in Kareeberg about the MeerKAT. Survey instrument questions 6.4 and 6.5 results are presented in Table

11, and the results for questions 10 and 11, also from the survey instrument, are shown in Table 11.

Table 11. Descriptive and Frequency Statistics of Respondents' Responses for Questions 6.4 and 6.5

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Not Applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
You are satisfied with the way the SALT project is being implemented	02 (0.7)	35 (11.6)	18 (6.0)	65 (21.5)	42 (13.9)	140 (46.4)
Community members are involved in the implementation of the SALT project	02 (0.7)	32 (10.6)	15 (5.0)	58 (19.2)	55 (18.2)	140 (46.4)

Most (46.4%) respondents indicated that the statement '*You are satisfied with the way the MeerKAT project is being implemented*' did not apply to them, and 35.4 % of the respondents respectively disagreed with the statement. Similarly, 46.4% of the respondents indicated that the statement '*Community members are involved in the implementation of the MeerKAT project*' did not apply to them, and 37.4% of the respondents disagreed with the statement. Thus, many respondents believed community members were not involved in implementing the MeerKAT project in Kareeberg.

Table 12 below analyses Kareeberg participants' perceptions concerning the MeerKAT project.

Table 12. Descriptive and Frequency Statistics of Participants' Responses to Questions 10 and 11

Questions	Yes	No	Not applicable	No comment	No response	Do not know	Discontinued
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Are you happy with implementing the MeerKAT project in your community?	58 (19.1)	152 (50.0)	35 (11.5)	21 (6.9)	27 (8.9)	9 (3.0)	2 (0.7)
Do you have comments or suggestions to make on how the MeerKAT project can improve your community?	207 (68.1)	5 (1.6)	39 (12.8)	25 (8.2)	25 (8.2)	1 (0.3)	2 (0.7)

In response to question 10: '*Are you happy with implementing the MeerKAT project in your community*?', most (50.0%) respondents, said they were not pleased with the project's performance. The follow-up interview question was: '*If the respondent is not pleased, they should state why they are not satisfied*'. The respondents raised many issues ranging from 'access' and 'social' to 'the economy'. Respondent C/S04 complained about access to the site and said, '*I am not happy because there is no access [to] the MeerKAT/SKA site for the community members*.'

Respondent C/S19 and many other respondents expressed concern over the number of issues that prevailed because of the project in their community. One of them said, '*I am not happy with the implementation of MeerKAT because they only offer bursaries to students who are good in science and mathematics and exclude others who are not good in those subjects but talented at others*.' They further protested that since MeerKAT was implemented in the Kareeberg, the cost of living has increased, and housing and domestic product prices have significantly increased. There is a belief that since MeerKAT/SKA bought several farms, the cost of food, especially meat, has increased drastically. The people working on those farms that MeerKAT/SKA expropriated are now unemployed. In addition, a respondent reported nepotism because only selected people from Kietfontein, the small area outside Carnarvon,

were employed for the MeerKAT project. Respondent C/S19 informed me that job advertisements and applications were not transparent because only a few community members were notified. Respondent C/S28 concurred by saying the Kareeberg community members did not secure permanent employment, but those in permanent positions are from outside the Kareeberg community. C/S91 support this perception by stating, "*No because MeerKAT brings people from outside the Kareeberg to work and does not do much for the Kareeberg community.*" Expressing unhappiness, C/S80 alarmingly responded, "*I'm not happy because the project only benefits a few people and businesses within the community. The community is poorer than before the MeerKAT arrived.*" MeerKAT did not uplift the community, and other community members felt they were better off before the arrival of MeerKAT.

Issues that were raised related to residential areas and race. The people from Van Wyksvlei and Vosburg have a strong perception that the people who were employed were those from Carnarvon. They thought Carnarvon was favoured over the other two areas. C/S225 complained, "…*No community projects were established in Van Wyksvlei, no jobs were created in Van Wyksvlei, the youth is unemployed and are struggling*." C/S202 concurred, "*No, they only work for Carnarvon*." Another respondent, C/S257 from Vosburg, said, "… *MeerKAT is not benefiting the Vosburg community*." Regarding race, C/S135 stated, "… *They only employ from the Coloured areas and do not think that we, Whites, also go hungry and need jobs*. …"

Several respondents raised honesty and trust. In affirming this, C/S224 murmured, "…. *MeerKAT people are not honest about bursaries. .... They create expectations that they did not fulfil and [they] make empty promises*." This is corroborated by what C/S230 said "*MeerKAT say one thing but does another. They do not adequately inform the community about scholarships. They do not monitor the students to whom they have given bursaries.*

Everyone thinks we are okay because of the SKA or MeerKAT project within our community, but that is not the case." Responding to the question 1fom the interview instrument: 'Do you think MeerKAT benefitted the community in the area?', respondents believe that MeerKAT was not for the people of Kareeberg but just like a show that did nothing for the people in the area. It was affirmed by C/S013, who said, "*No, it is more like a show-off for the government because it is not for the Kareeberg people.*" Most respondents said 'No' in response to question 2: '*Was the community informed of the development of the MeerKAT project*?' For example, C/S013 responded, "*Not at all. We heard from the gossip, but we did not see anyone coming to the township to inform us of the MeerKAT development*." C/S029 confirmed, "*No, the meetings were held secretly because most of us did not get invited to such meetings.*"

Twelve dominant themes were raised in the respondents' answers to question 11 – as a follow-up to question 10: '*Do you have comments or suggestions to make on how the MeerKAT project can improve your community?*' The most dominant theme was 'creation of employment' followed by 'providing more bursaries', 'access to free, reliable Wi-Fi and computers', 'provide business opportunities', 'offer vocational training to the adult population', 'transfer skills to the community', 'be transparent and provide regular information to the community', 'provide support to their first-year bursary holders', 'involve the community more into the project', 'provide an educational program to the school going children' and lastly 'empower youth and women'. In addition to these twelve themes considered relevant to the current study, a further 12 themes were raised but not within the project's ambit. 'provide housing', 'fix roads', 'provide better health, sports facilities and recreational centres', 'provide more ambulances', 'provide bursaries for other streams other than science and mathematics', 'build a technical school within the community', 'help community with funding to start businesses', 'provide food parcels, free water and electricity to the poor in the community', 'build a shopping mall', 'help with drug abuse and making

Kareeberg safe', and 'provide every household with uncapped Wi-Fi, school transport, and sponsorship for community events'. Raising issues that were falling outside the project mandate shows that the project's purpose was not understood. Therefore, perceptions of Kareeberg people about MeerKAT were negative.

When asked if the MeerKAT project has led to the development in the area, 62 (20.5%) of the participants stated that the MeerKAT project led to the development in their community. However, 96 (31.8%) of the participants noted that the MeerKAT project had not led to the development in their area. Unsurprisingly, most 144 (47.7%) participants stated that the question did not apply to them. The examples of the development projects as a result of MeerKAT, as indicated by the participants, are presented in Table 13.

Table 13. Frequency Statistics of the Type of Development

Types of Development Projects	Yes	No	Not applicable
	N (%)	N (%)	N (%)
Paved roads	14 (4.6)	47 (15.6)	241 (79.8)
Reliable energy supply	-	59 (19.5)	243 (80.5)
Reliable internet connectivity	07 (2.3)	55 (18.2)	240 (79.5)
Reliable phone connectivity	01 (0.3)	61 (20.2)	240 (79.5)
Women development	02 (0.7)	59 (19.8)	241 (79.8)
Tourism development	17 (5.6)	45 (14.9)	240 (79.5)
More shopping outlets	03 (1.0)	59 (19.5)	240 (79.5)
More lodging places	11 (3.7)	54 (17.9)	237 (78.5)
Access to computing facilities	52 (17.7)	12 (4.0)	238 (78.8)

Regarding MeerKAT's value to the community, 98 (32.5%) participants indicated that the MeerKAT project made a valuable contribution to the community, while 57 (18.9%) said

the MeerKAT project did not contribute to the community and 145 (48.0%) participants stated that the question did not apply to them. When asked if the participants were happy with implementing the MeerKAT project in their area, 38 (12.6%) participants indicated yes. In comparison, 112 (37.1%) answered no, and 142 (47.0%) participants stated that the question did not apply to them.

The participants were also asked to comment or suggest how the MeerKAT project can improve their community. While most (47.7%) participants felt the question did not apply to them, 41.7% of the participants made comments and suggestions. Therefore, the response to the main research question: '*How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs?*' was not positively responded to.

5.1.1.2 Karoo Hoogland Local Municipality Results

Table 14. Karoo Hoogland Demographics Statistics
Participant Demographics (N=302)

Measure	N	%
Sex		
Female	164	54.3
Male	135	44.7
Others	3	1.0
Race		
Coloured	259	85.8
Black	14	4.6
White	20	6.6
Others	9	3.0
Age		
18-35 years	119	39.4
36-60 years	139	46.0
Over 60 years	44	14.6
Status in community		
Community member	271	89.7
Farming community	11	3.6
Community leader	10	3.3
Business representative	10	3.3
Duration in community		
0 to 20 years	62	20.5
21 to 40 years	148	49.7
41 to 60 years	55	18.2
Over 60 years	37	12.3
Knowledge of SALT		
Yes	162	53.6
No	140	46.4

Table 14 presents the demographic statistics of the sample used for the study, which comprised 54.3% females and 44.7% of males. The Coloured race was about 85.8%, whereas Black, White and Others made up the remainder of the study population. In terms of age, the sample was predominantly adult participants between the ages of 36 and 60 years (46.0%). Most of the sample is 89.7% community members. Regarding their residency in the community, those who had stayed in the community between 21 and 40 years were in the majority, constituting 49.7%. Lastly, 53.6% of the participants were aware of the SALT

project, and the remaining 46.4% of participants did not know anything about the SALT project.

5.1.1.2.1 Research questions response for Karoo Hoogland

Questions on the survey instrument and question 2 on the interview instrument were used to respond to secondary research question 1. '*How have the economic infrastructures of Karoo and Karoo Hoogland changed since the introduction of MAIPs?*' The results are presented in Table 15 for the survey question for question 6.8.

Table 15. Description and Frequency Statistics for Participants' Responses to Question 6.8

Questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Not applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The SALT project brought development to the community	06 (2.0)	27 (8.9)	16 (5.3)	72 (23.8)	42 (13.9)	139 (46.0)

According to 46.0% of the participants who responded, the statement '*The SALT project brought development in the community*' did not apply to them, and 37.7% disagreed with the statement. For qualitative data, out of 33 purposively sampled research respondents who were interviewed, all 33 participants responded to interview question 2: '*Was the Karoo Hoogland community informed of the developments of the SALT*?' In response to this interview question, 36.4% of participants agreed that they were informed of the developments. Whereas most (55.5%) participants disagreed that the project administrators gave them information timeously concerning developments of the SALT project. In affirmation of the above statement, respondent S005 said, "*No, we were not informed as the community. However, few community members always had insight into the project*."

Respondent S029 agreed with respondent S005 and complained, "*Not at all, and we were just informed at the beginning of the project implementation when the government Ministers visited our area. Even then, we were just informed about the construction of the telescope. That's all."* Noteworthy is that Karoo Hoogland research participants' responses differed compared to Kareeberg research participants. The Karoo Hoogland participants indicated that they were not informed on development happening in the project, whereas Kareeberg participants felt they were told.

Questions 6.3, 6.10, 9, and 11 on the survey instrument and questions 3, 3.1, 3.2, and 9 on the interview instrument were used to respond to secondary research question 2. '*How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' to answer the second research question. The result is presented in Table 15 for questions 6.3 and 16 from the survey instrument.

Table 16. Descriptive and Frequency Statistics of Participants' Responses to Questions 6.3 and 6.10

Questions	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Not applicable**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
The SALT project created jobs for the people in your community	07 (2.3)	46 (15.9)	24 (7.9)	48 (15.9)	38 (12.6)	139 (46.0)
The SALT project contributed to the economy of the area	07 (2.3)	32 (10.6)	22 (7.3)	59 (19.5)	43 (14.2)	139 (46.0)

The result showed that 46.0% of the respondents indicated that the statement '*The SALT project created jobs for the people in the community*' did not apply to them, and 28.5% of the respondents disagreed with the statement. Most respondents indicated that the SALT project did not create jobs for the people in Karoo Hoogland. In addition, 46.0% of the

respondents indicated that the statement, '*The SALT project contributed to the economy of the area*' did not apply to them and 33.7% disagreed with this statement. Because many respondents reported that the SALT project did not contribute to the economy of Karoo Hoogland.

The themes 'employment creation' and 'SMME development" did not feature prominently for open-ended question 9: '*Please identify, if any, the most valuable contribution of the SALT project in the community.*' The themes '*employment creation*' and *'SMMEs' development*' did not feature prominently. The theme '*employment creation*' only appeared twice for SALT, whereas participants identified '*employment creation*' as the most valuable contribution MeerKAT had made thus far. It is even worse with the theme *'SMMEs development*' because it does not even feature. The responses to questions 6.3 and 6.10 were not corroborated by open-ended question 9, indicating that the SALT project did not contribute to employment creation.

For qualitative data collection, all 33 purposively sampled research respondents who were interviewed responded to an interview research question 3. '*Do you or had you ever worked for SALT*?' Only 6.1% responded that they were or had ever worked for SALT. A staggering 93.9% had never been employed by the SALT project. Like in Kareeberg, there was a follow-up question. The few participants who responded that they have worked for the SALT project were further probed by being asked question 3.1. '*If yes, did you acquire worthwhile experience or knowledge that you think may benefit you in future.*?' Respondent S002 said, "*I had done the site testing in the veld to establish the correct site to build the SALT."* S002 acquired the site testing experience. S022 added, "*I was a cleaner at SALT for a while."* S022 obtained cleaning experience.

The respondents who said they had never worked at SALT were further probed using interview question 3.2: '*If not, do you know anyone who worked or is currently working for*

SALT?'. The positive response improved, in which 51.5% of respondents indicated they at least knew someone working at the SALT. Participant E1, responded, "*Yes, my friend's mother works there*." Respondent S004 said, "*Yes, my family member."* Whereas S009 added, "*My niece is working at the SALT."* Lastly, S023 contributed, "*Yes, my brother worked at the SALT."* These two interview questions were asked to investigate why the project had not created employment. The responses to the probing interview question showed that even though there is a strong feeling that the SALT project did not assist in employment in the Karoo Hoogland, a few people from the community did get some jobs. Despite evidence of employment, many respondents believed that the SALT project did not contribute to the economy of Karoo Hoogland. Therefore, secondary research question 2, was negatively responded to.

Questions 6.6, 6.7, 9, and 11 on the survey instrument and 11 on the interview instrument were used to respond to secondary research question 3. '*How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' The results for questions 6.6 and 6.7 on the survey instrument are presented in Table 17

Table 17. Descriptive and Frequency Statistics of Participants' Responses to Questions 6.6 and 6.7

Questions	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**	**Not applicable**
	N (%)	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
The SALT project assisted in improving education in the community	6 (2.0)	52 (17.2)	14 (4.6)	51 (16.9)	41 (13.6)	138 (45.7)
The SALT project offered scholarships/bursaries to students in the community	5 (1.7)	51 (16.9)	13 (4.3)	53 (17.5)	41 (13.6)	139 (46.0)

The result revealed that 45.7% of the participants indicated that the statement '*The SALT project assisted in improving education in the community*' did not apply to them and 30.5% of the participants disagreed with this statement. These results suggest that many respondents believed that the SALT project did not assist in improving education in Karoo Hoogland. Similarly, the result showed that many (46.0%) of the respondents indicated that the statement '*The SALT project offered scholarships/bursaries to students in the community*' did not apply to them, and 31.1% of the participants disagreed with the statement. These results suggest that many participants believed that the SALT project did not offer scholarships/bursaries to students in Karoo Hoogland. Therefore, secondary research question three was not negatively responded to.

The qualitative data collection from semi-structured, open-ended question 9. '*Please identify, if any, the most valuable contribution of the SALT project in the community*', quantitatively analysed (Table 18).

Table 18. Descriptive Frequency Statistics of Participants' Responses to Question 9

Questions	Valuable Contribution	No valuable Contribution	Not Applicable	No Comment	Do Not Know
	N (%)	N (%)	N (%)	N (%)	N (%)
Please identify, if any, the most valuable contribution of the SALT project in the community.	93 (32.2)	55 (19.0)	139 (48.1)	1 (0.3)	1 (0.3)

Of 302 respondents, only 289 responded to interview question 9, in which only 32.2% of the participants identified the valuable contribution of the SALT project to the Karoo Hoogland community. Most participants did not think the SALT project brought a valuable

contribution to the community. In probing this question further, it was found that 79.6% identified the SALT's valuable contribution as a 'Community Computer Centre' in the vicinity. Respondent S282 interestingly noted, "*The Local Community Computer [Centre] is the most valuable contribution. We used to go there and use computers for our school activities. Everything was free, but the computers are not working lately, and we must pay R5 for a copy."* S205 also contributed to the discussion, saying, "*The most valuable contribution at the Karoo Hoogland is the Computer Centre, but now it is often closed when we need it to be opened*." S57 alluded, "*Only Computer Centre, but currently is not functional.*" Even though the Community Computer Centre was a valuable contribution of the SALT project to the community, many participants reported it as not working, and I made a similar observation. At the time when data was collected, most of the time, the Community Computer Centre was closed. I frequently visited the Centre. There was one day that it was opened; however, there were no working computers.

The other contribution was the high school mathematics teacher, recruited and renumerated by the SALT project. This was confirmed by S62, who said, "*The valuable contribution is the Computer Centre, the free Wi-Fi, and the high school mathematics teacher paid by the SALT."* The other valuable educational contribution was gathering young people from the community and giving them a talk and tour of the SALT project. Participant S61 reported, "*SALT took the children on [a] tour to learn more about the SALT."* The other issue that was raised was the bursaries that were offered for the students who are pursuing STEM studies at South African tertiary institutions. SALT has also donated computers to schools in and around the region. This was confirmed by S40: "*...other computers were donated to the schools in the Karoo Hoogland.*"

The responses to question 11 from the quantitative survey instrument: '*Do you have comments or suggestions on how the SALT project can improve your community?*' are analysed in Table 19.

Table 19. Descriptive and Frequency Statistics of Participants' Responses for Question 11

Questions	Yes	No	Not Applicable	No Comment	Do Not Know
	N (%)	N (%)	N (%)	N (%)	N (%)
Do you have comments or suggestions on how the SALT project can improve your community?	125 (42.7)	15 (5.1)	138 (47.1)	14 (4.8)	1 (0.3)

The secondary research question 3 may not have been quantitatively responded to positively; however, some participants still considered SALT-provided bursaries as one of the most valuable contributions within the community. The financial assistance could greatly help improve the education prospects within Karoo Hoogland.

Open-ended question 11 from the survey instrument prompted participants to comment and suggest how the SALT project could improve their community. A dominant theme was 'providing more bursaries or scholarships' to the Karoo Hoogland community, even though it was not as prevalent as other themes such as *'providing employment*'. The wishes of the people within Karoo Hoogland were the same as Kareeberg: to improve education; hence they wished for more financial assistance to be provided because most people residing in Karoo Hoogland are poor, making it difficult for them to afford tertiary education for their children (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020; Stats SA, 2013).

In response to question 1 from the interview instrument: *'What do you think can be done to improve the implementation of the SALT project?*' all 33 interviewed participants

gave their view regarding education in Karoo Hoogland. They acknowledged that something is happening concerning education in the area, but more still needs to be done. They advised that more students should be helped with financial assistance by making the requirements for bursary applications less stringent. Participant S006 said, "*... Let me use an example, thank you SALT, for the Computer Centre in town. It's a white elephant. You won't find any of our children in that Centre because there is a person, a staff member from SALT, sitting there every day. Still, there are no computer programs for children. There are no activities for our children. If at least, from Monday to Friday, we know they have the little ones from primary school coming in from 2:00. They are watching Sesame problems on the computers and teaching them about Word or anything on the computers. There are no programmes for little ones from primary school. There is also no programme for high school, and there is no programme for adults in this town, but we've got a Computer Centre donated by SALT. It is so bad that your staff member sits there, but when community members go there to make a photocopy, they don't get assisted. It is almost like we are bothering them when we go there. That is the structure that doesn't benefit the community because it is like SALT, said there is a Computer Centre, you guys go and do what you want. No, you cannot put an asset in the community, and you do not give us the tools to use them.*"

Questions 6.9 on the survey instrument and 7, 8, 9, and 10 on the interview instrument were used to respond to secondary research question 4. '*How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?* The results for question 6.9 are presented in Table 20.

Table 20. Descriptive and Frequency Statistics of Respondents' Responses for Question 6.9

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Not Applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The SALT project improved tourism in the community	01 (0.3)	40 (13.2)	15 (5.0)	61 (20.2)	37 (12.3)	138 (45.7)

The result indicated that 45.7% of the participants indicated that the statement '*The SALT project improved tourism in the community*' did not apply to them and 32.5% of the participants disagreed with this statement. These results suggest that many respondents indicated that the SALT project did not improve tourism in Karoo Hoogland.

All 33 participants who were interviewed responded to question 7 from the interview instrument: '*Do you think tourism in Karoo Hoogland has improved due to the SALT astronomy mega infrastructure project?*' Many (45.5%) of participants responded that they think tourism in Karoo Hoogland improved due to the SALT project, compared to 28.1% who believe that tourism in Karoo Hoogland improved due to the MeerKAT project. Respondent E1 confirmed, "*Yes, because more guest houses were built, and more people came into our town. More people from the community work in those guest houses.*" S023 concurred, "*Yes, more guest houses were opened, and the shops did more business. Tourism has improved our area….*"

An interesting aspect raised during the interview that is further interrogated in Chapter 6 is the aspect of White areas that experience the impact of astrotourism, whereas the Coloured regions do not experience an effect or are left unchanged. Participant S028 said*, "Yes, tourism improved our community, but only in White areas, not the location where the majority of Coloured people are residing."* Participant S006 corroborated these accessions in response to question 11 from the interview instrument: "*We are so poor here that White*

people still manage 99% of businesses in this area. Coloured people own nothing. You will not find Coloured people's shops, no 'spaza shops', not a little fruit garden, nothing. There is nothing Coloured people own because there has never been any help in terms of development for Coloured people." In South Africa, as defined by Bisseker (2006); MobileMoneyAfrica (2011); Spazanews (n.d.), and The Economist (2016), spaza shops are informal businesses found in townships and villages. They are like convenience stores, like tuck shops, primarily operated from the owners' homes; however, recently, some have become large stores that look like mini supermarkets. Spaza shops are more dominant in Black and Coloured townships, but of late, the migrants, Somalis and Pakistanis, have taken over and are running them.

Some respondents (37.7%) did not agree that tourism had improved. For example, S013 complained, "No, because tourism is still only happening in Sutherland." C/S016 murmured, "No because no one is coming to Fraserberg, and nothing is happening here." Interview question 7's responses did not corroborate survey question 6.9's results that tourism in Karoo Hoogland did not improve during the implementation of SALT. Here, there was some conflict between quantitative and qualitative results.

Responding to the interview instrument, question 8: '*Are there tourist attraction marketing platforms in Kareeberg?*', 51.5% of participants agreed that there were tourist attraction marketing platforms in Karoo Hoogland, which improved from Kareeberg with 33.3%. While 39.4% of respondents disagreed that there are no tourist attraction platforms in Karoo Hoogland, a decrease from Karoo Hoogland's 60.6%. Respondent S025 did not know whether tourist attractions marketing platforms are available in Karoo Hoogland. Another respondent, C/S030, did not respond to this interview question. Those who responded positively, like S027, said, for example, "*Yes, the planetarium and SALT.*" S029 replied, "*Yes, we have the Sutherland Planetariums SAAO* [South African Astronomical Observatory] *and*

SALT." C/S003 disagreed, *"No, there is no tourist marketing attraction in our area, and nothing can be done to attract tourism into this area*." C/S030 agreed with C/S003, saying, "*No, absolutely nothing*." These results concurred with question 7 on the interview instruments but not with question 6.9 on the questionnaire.

Thirty-three participants responded to question 9 on the interview instrument: '*Are there tour guides from Karoo Hoogland*?' An overwhelming 63.6% of participants agreed that there were tour guides in Karoo Hoogland. Even S001 responded, "*Yes, but still busy training.*" However, few disagreed, with 30.3% saying no. Amongst those who disagreed, S003 said, "*No, only the permanent workers at the SALT.*" The statement means no tourist guides exist, but the SALT officials are doing this function. It is like what is happening at Kareeberg. The only difference was that instead of this function being performed by the MeerKAT employees, it was being done by the Municipality employees. The issue needs to be further investigated to establish its authenticity. These responses correspond with earlier responses concerning the issue of tourism growth in Karoo Hoogland. Those who disagreed did not substantiate why they disagreed. This demonstrates the significant impact of SALT on tourism and the considerable progress being made in astrotourism development.

Questions 6.4, 6.5, 10, and 11 on the survey instrument and questions 1, 2, 4, 5, and 11 on the interview instrument were used to determine people's perceptions of Karoo Hoogland concerning SALT. The results of questions 6.4 and 6.5 are presented in Table 21.

Table 21. Descriptive and Frequency Statistics of Participants for Questions 6.4 and 6.5

Questions	Agree	Neutral	Disagree	Strongly Disagree	Not Applicable
	N (%)	N (%)	N (%)	N (%)	N (%)
You are satisfied with the way the SALT project is being implemented	34 (11.3)	18 (6.0)	63 (20.9)	42 (13.9)	139 (46.0)
Community members are involved in the implementation of the SALT project	32 (10.6)	15 (5.0)	56 (18.5)	55 (18.2)	139 (46.0)

The result revealed that 46.0% of the participants indicated that the statement '*You are satisfied with how the SALT project is being implemented*' did not apply to them, and 34.8% of the participants disagreed with the statement. These results suggest that many respondents were not satisfied with how the SALT project is being implemented in Karoo Hoogland. Also, 46.0% of the respondents indicated that the statement '*Community members are involved in the implementation of the SALT project*' does not apply to them, and 36.7% of the participants disagreed with the statement. However, only 12.3% of participants respectively agreed. These results indicate that many respondents reported community members were not involved in implementing the SALT project in Karoo Hoogland. Therefore, the respondents from Karoo Hoogland perceived SALT negatively.

Table 22 analyses Karoo Hoogland participants' perceptions concerning the SALT project.

Table 22. Descriptive and Frequency Statistics of Participants' Responses to Questions 10 and 11

Questions	Yes	No	Not Applicable	No Comment	Do Not Know
	N (%)	N (%)	N (%)	N (%)	N (%)
Are you happy with implementing the SALT project in your community?	38 (12.6)	112 (37.1)	142 (47.0)	10 (3.3)	0 (0.0)
Do you have comments or suggestions to make on how the SALT project can improve your community?	125 (42.7)	15 (5.1)	138 (45.7)	14 (4.6)	1 (0.3)

A few (12.6%) participants responded positively to question 10: '*Are you happy with implementing the MeerKAT project in your community?*' indicating they were delighted with the implementation of the project. Many respondents (37.1%) said they were not pleased with the project's performance. When further probing dissatisfaction with a follow-up

interview question, it was found that most people in Karoo Hoogland were not happy with the implementation of the project. The respondents raised many themes, such as 'access', 'employment', 'street lights', 'awarding of bursaries', 'Community Computer Centre that is a white elephant', 'SALT people not being visible enough in the community', 'lack of communication', 'not being transparent', 'not the community being involved in all aspects of the project and vice-versa', 'for lack of development in the area', 'nepotism', and 'state of the economy in the Karoo Hoogland'.

Regarding 'access', participant S014 complained about access to the site and said, "*I am not happy because there is no access at the SALT site for the community members*." Respondent D raised three issues, 'community involvement', 'employment', and 'streetlights'. "*No, I am not happy with the implementation of the SALT project in the Karoo Hoogland because the Karoo Hoogland community is not involved in what is going on with the SALT project. The employment is not reserved for Sutherland people. SALT people do not want bright lighting because they say it affects - optical telescope negatively…."* Respondent E also complained about the same issues that Respondent D murmured about but added the case of 'bursaries'. *"No, because the community does not benefit much from this project. We cannot even get bright streetlights in our town and location because they negatively impact their telescope. There are not enough jobs in the community. To secure a bursary, one must have science and mathematics."* There is a prevailing perception that the deemed streetlights have increased criminal activities. On 'nepotism', S14 responded, "*No, employment at SALT is not for everyone but for people that are known to the SALT people."* S181 affirmed*, "No when it comes to employment, only people known to the SALT people get jobs…."* Some of the issues raised in Karoo Hoogland are similar to those raised in Kareeberg; only a few are areas-specific, such as 'bright streetlight' and the 'white elephant Community Computer Centre'.

As in Kareeberg, interview participants were asked in question 11 to elaborate following their answer to question 10: *'Do you have comments or suggestions to make on how the SALT project can improve your community?*' Respondent S006 summarise all the issues or perceptions:

> *"…. so, my heart is in this community. We are here to talk about why SALT is here in this community. I am a small business owner in this community. I do not see any benefits why SALT is here. Our people are still the poorest of the poor in Sutherland. We sometimes feel like we are not Black people and not White people because now it is like things a dedicated to Black people while some time ago, they were dedicated to White people. It is almost like Coloured people do not exist. We are not a Nation; we are nothing, and Sutherland is even worse. We are so poor here that White people still manage 99% of businesses in this area. Coloured people own nothing. You will not find Coloured people's shops, no spaza shops, not a little fruit garden, nothing. There is nothing Coloured people own because there has never been any help in terms of development for Coloured people.*
>
> *Let me also be frank and say we are not here for a handout because everyone always thinks that it is like this; we are a small community, there is so much poverty and fallen into alcohol that we just come, and we want. We do not wish to. There must be a low-hanging fruit because we are looking for opportunities for our people. Let me use an example: thank you, SALT, for the Computer Centre in town. It's a white elephant. You won't find any of our children in that Centre because there is a person, a staff member from SALT, sitting there every day. Still, there are no computer programs for children. There are no activities for our children. Suppose at least we knew that from Monday to Friday, the little ones from primary school come in from 2:00. They are watching Sesame problems on the computers and teaching them about*

Word or anything on the computers. In that case, there are no programs for little ones from primary school. There is no programme for high school, and there is no programme for adults in this town, but we've got a fully functional Centre donated by SALT. You know, so bad that your staff member sits there, and when people go there to make a photocopy, they don't even feel like coming to help because they come from the community. It is almost like we will bother them when we go there. That is the structure that doesn't benefit the community because it is like SALT said, there is a Computer Centre, [and] you guys go and do what you want. No, you cannot put an asset in the community, and you do not give us the tools to use them.

Another thing that is very, very heart[sore], people come here, and they say, 'you do not have businesses. We do not know if we can give you money. We do not know what you will do with that money. I have got a small business. We are ten small businesses in Sutherland that nobody has ever come and asked who these SMMEs are in Sutherland. I am a qualified small business owner in Sutherland, where I am asking SALT to give me funding so that I can employ other young people in my town so we can learn how to bake and cook. There are a lot of wind farms where we can provide meals to those farms. Why can you guys give us a contract to provide meals to SALT, where you guys are? Give that opportunity to small businesses.

We know how to operate. We do not have funding. So, we use a little bit of our money to sustain ourselves, but we can't help anybody else around us. It is just me, and all I can employ is one other mama, but we do not take the salary we make; we sell and put it back to [the] business, and the little we have, we cook for the community because there are many hungry children around us. We start sitting here and say we want cash injection into our business, and you guys come and tell us what you want to see happening with that money. Suppose there are incubation

programmes, yes, but we want programmes like university modules, such as financial modules and entrepreneur modules. In that case, you can say this month, we will teach you about finance for your businesses, and in that finance module, we should bring two young people that we can prepare as well. We can say here is the opportunity for you to go and do something. Incubator, you ask for feedback, engage with us, and hold our hand in that process because all we want to do is help ourselves, and there must be low-hanging fruit that can come out of SALT; it is business access, and we do not want handouts. You, too, say here is the opportunity.

For transport, many wind farms are coming, but people are coming here with business from outside Sutherland with what is happening in Sutherland, but they say there are no taxis in Sutherland. There are entrepreneurs with taxis here. You hire another driver because our drivers take people to the wind farm from 5:00 a.m. After all, you can't employ another driver. We had to beg these people to give us a little business, and then when they do come on board, give us a little business, they want to exploit us so much that we don't even make enough money. After all, they are under margin with the money they want to give us, but they get millions from the wind farms, giving us this little bit. For example, we thought the Department of Public Works gave two companies from the Free State a contract to fix the roads in the mountains out of the south just 15 kilometres from here from the Free State. They took out local people to do menial labour, giving them a stipend of R2500. When people wake up early in the morning to work in the mountains in the cold in the rain, pay them R2500 pittance.

The other thing was to say, you guys coming from outside, and you [are] going to collect people here, please give some business to our taxi operators, the guys with taxes in Sutherland. They do not want to do that because they do not want to pay that

small business taxi operator. They want to take all the money for themselves and leave Sutherland, but the work and the job are in Sutherland. How is it fair that you don't want to give a taxi operator R25,000 to R35,000 to take our people into the mountains to work and back at night? They bring their taxes from the Free State to come and work here. So now a small business tax operator is standing. The taxis are standing at home but work here goes to people who don't even live in Sutherland.

So, what happens? Not giving work to businesses within Sutherland perpetuates a situation in which the people of Sutherland stay in poverty, and again, I'm saying we don't want handouts. There's an opportunity for small businesses. For all ten of us small businesses, we've got a Small Business Chamber here. We have a WhatsApp group and e-mail addresses every time there are opportunities, and I would say call all those people so we can sit with them. We don't necessarily want you to give us money. We want you to say I've got an opportunity, we answer, I got a new contract where I fit in here. Can you guys help me employ the people, recruit them from the community, out of that recruitment? We will give you something for your business.

Those 45 people now need to be transported to the wind farms. Do you know taxi drivers, small businesses, taxi drivers, and taxi owners in your community who cannot take that part of the business? Yes, we do, because we have three taxi drivers in our Small Business Chamber. So, [S006], there is a little bit of business again. No handout is an opportunity to market.

That's what we want—only asking us. We say you do not look for things outside before you talk to us inside in small business because small businesses will grow the economy.

The White people own all the guest houses in Sutherland. 99.9% of guest houses belong to White people. We have only one guest house belonging to a Black person. You know, what is happening is we got new wind farms opening, there is going to be an influx of people, Department of Tourism and Social Economics were here, you know what they said to us, 'you guys must start accumulating some chicken start small. Why don't you guys have some vegetable gardens?'

What we are saying is we want you people to understand why you people can sponsor us for money a guest house because we cannot afford the land for the price of land is high because these White people have raised the price of land so high that Black people cannot afford it.

I've been here two years now, almost two years. I'm still struggling today to get a house in town because they [White people] don't want us in town. So, they are raising the prices of properties high out of the market, so we can't afford houses. So, there are no Black businesses in town. There are Pakistani businesses; the rest are White people's businesses, but there is no Black business in the city.

How will we ever change what this looks like after 27 years? SALT is here. The wind farms are here. We have got billions of rands of business around us. Look where we live. Look how we live. The dropout of our school-going children is so high. There are no programs that are all the same in our Computer Centre. These programmes are literally for your high school dropouts, Grade 9s.

High school dropout is 72% in this area. Our high school used to have just over 1000 students; now, it is 250 students. After Covid [the COVID-19 pandemic], kids did not want to go back to school. How do we empower those children? Now, the problem is that the drug problem is enormous. The housebreaking is high, and

how do they survive? Once again, why can they come to the community and ask us about the social ills in society? Ask how they can help. A small drug rehabilitation centre with one psychiatrist or one social worker to support five children. Five children will bring the other five children because they know the problems in our community, so there is a lot wrong here. Still, there is a lot that can be done now. There is low-hanging fruit that we can work with. The low-hanging fruit can fix five families around—low-hanging fruit cures five children that can go back to school. Low-hanging fruit improves five businesses that can employ 15 other people [who] were [to] put bread on the table that feed[s] 15 families can support five different families.

Sutherland is a forgotten town, but there are billions of businesses around this town. How is that even possible? [It] [i]sn't even right that you drive town through town? See the White people's properties. It is what our yards look like on the White people's properties. You can put five houses. You are giving us perpetually the structure of what the township should look like. Why can we not all benefit from what's happening around us? It is not right and immoral. It is sinful and wrong because we will never change the system. Poverty is the structure, the evils that our people are sitting with. It is incorrect; you know the answers because of this money in Sutherland here. We have got small businesses here."

The tools of analysis that used for analysing the above quote from analysing Respondent S006 response were thematic, content, speech and conversation analysis. Then Twelve themes were raised dominantly in the S006's response and that of many others. S006's response was unique in offering solutions to the issues raised. The theme '*creation of employment'* dominated as in Kareeberg, followed by 'bright street lights', 'functional

Community Computer Centre with free, reliable Wi-Fi and computers', 'provide business opportunities', 'providing more bursaries and support to the students within the community', 'transfer skills to the community', 'be transparent and provide regular information to the community', 'provide support to their first-year bursary holders', 'involve the community more into the project', 'provide an educational program to the school going children' and lastly 'empower youth and women'. In addition to the 12 themes considered relevant to the project, other themes were raised but not within the project's ambit. Those themes similar to the ones that were raised in Kareeberg are to 'provide housing', 'fix roads', 'provide better health, sports facilities and recreational centres', 'provide more ambulances', 'provide bursaries for other streams other than science and mathematics', 'build a technical school within the community', 'help community with funding to start businesses', 'provide food parcels, free water and electricity for the poor in the community', 'build a shopping mall', 'help with drug abuse and making Karoo Hoogland safe', and 'provide every household with uncapped Wi-Fi, school transport, and sponsorship for community events'. Therefore, people's perception of Karoo Hoogland concerning SALT was negative.

When participants were asked if the SALT project had led to the development of Karoo Hoogland, 20.9% of the participants stated that it had led to the development of their community. In comparison, 31.8% of the participants reported that the SALT project had not developed their area. Examples of SALT-related development projects indicated by the participants are presented in Table 23.

Table 23. Frequency Statistics of the Types of Development

Types of Development Projects	Yes	No	Not Applicable
	N (%)	N (%)	N (%)
Paved roads	16 (5.3)	47 (15.6)	239 (79.1)
Reliable energy supply	2 (0.7)	59 (19.5)	241 (79.8)
Reliable internet connectivity	9 (3.0)	54 (17.9)	239 (79.1)
Reliable phone connectivity	2 (0.2)	61 (20.2)	239 (79.1)
Women and youth empowerment	4 (1.3)	59 (19.8)	239 (79.1)
Tourism development	9 (3.0)	54 (17.9)	239 (79.1)
More shopping outlets	19 (6.3)	45 (14.9)	238 (78.8)
More lodging places	7 (2.3)	58 (19.2)	237 (78.5)
Access to computing facilities	15 (5.0)	52 (17.2)	235 (77.8)

Regarding the most valuable contribution of the SALT project to the community, 35.1% of the participants indicated that the SALT project made a valuable contribution to the community. 18.2% of participants responded that the SALT project made no valuable contribution to the community, and 46.0% stated that the question did not apply to them.

When asked if the participants were happy with the SALT project in their area, 38 (12.6%) participants indicated yes. In comparison, 112 (37.1%) said no, 142 (47.0%) participants stated that the question did not apply to them, and the remaining 10 (3.3%) participants indicated no comment. The participants were also asked to comment or suggest how the SALT project could improve their community. 44.4% of the participants made comments or suggestions, and 45.7% of participants stated that the question did not apply to them.

Four secondary research questions in (Table 1.1 in Chapter 1) were negatively answered hence, it follows that the main research question '*How have the district municipalities of Karebeerg and Karoo Hoogland developed from 2001 to 2021 since the*

introduction of MAIPs? was negatively responded to. Questions 6.1, and 6.2 from Table 23 on the survey instrument and question 1 from the interview instrument were used to confirm the results; the analysis is presented in Table 24.

Table 24. Descriptive and Frequency Statistics of Participants' Responses for Questions 6.1 and 6.2

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Not Applicable
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
The SALT project benefited your community	3 (1.0)	30 (9.9)	21 (7.0)	60 (19.9)	48 (15.9)	140 (46.4)
The SALT project benefited your household	6 (2.0)	18 (6.0)	05 (1.7)	79 (26.2)	55 (18.2)	139 (46.0)

The majority (46.4%) of the respondents indicated that the statement '*The SALT project benefited your community'* did not apply to them and 35.8% disagreed with the statement. Similarly, the majority (46.0%) of the respondents indicated that the statement '*The SALT project benefited your household*' did not apply to them and an overwhelming 44.4% disagreed with the statement. Therefore, the main research, which stated that the How have the district municipalities of Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs, did not respond positively.

For qualitative data collection, 33 purposively sampled research respondents were interviewed. A few (18.2%) of participants responded yes to question 1: '*Do you think SALT benefitted the community in the area?*' F1 said, "*Yes, the SALT project gave us good things.*" S015 supported this, "*Yes, because some time back, they used to take our children to tour their premises, but they do not do it anymore*." These respondents felt that the SALT project had benefited their community because they had benefitted, while others felt that the project had not benefitted their community, because they did not directly experience it. The overwhelming majority (75.8%) of participants responded negatively, meaning that the

responses for question 1 from the interview instrument concurred with the answers to questions 1 and 2 from the questionnaire.

MeerKAT PROJECT- KAREEBERG LOCAL MUNICIPALITY

Table 25. Descriptive Statistics and Item-Total Statistics of Survey Questions

Questions	Mean	SD	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
1. The MeerKAT project benefited your community	5.26	1.810	46.91	257.60	.948	.906	.988
2. The MeerKAT project benefited your household	5.43	1.634	46.75	264.30	.922	.864	.989
3. The MeerKAT created jobs for the people in your community	5.13	1.956	47.05	252.55	.959	.932	.988
4. You are satisfied with the way the MeerKAT project is being implemented	5.22	1.849	46.96	255.56	.964	.938	.988
5. Community members are involved in the implementation of the MeerKAT project	5.29	1.797	46.88	258.33	.942	.921	.988
6. The MeerKAT project assisted in improving education in the community	5.13	1.959	47.04	252.47	.959	.940	.988
7. The MeerKAT project offered scholarships/bursaries to students in the community	5.12	1.960	47.05	253.25	.944	.918	.988
8. The MeerKAT project brought development to the community	5.27	1.780	46.90	257.82	.961	.936	.988
9. The MeerKAT project improved tourism in the community	5.12	1.952	47.05	254.24	.931	.894	.989
10. The MeerKAT project contributed to the economy of the area	5.20	1.871	46.98	256.19	.939	.904	.989

Item-total statistics were conducted to determine the usefulness of each question/statement used for data collection in Kareeberg. The descriptive statistics (i.e., mean and standard deviation) and item-total correlation were conducted to know the usefulness of each item included in the scale. The results are presented in Table 35. None of the statements are below the recommended 0.3 reliability coefficient, meaning that no identified statement load reduces the Cronbach alpha's value of the entire instrument below the acceptable value. The corrected item-total correlation values ranged from .922 to .964, suggesting that all the items are reliable and valuable. The reliability statistics revealed an alpha coefficient of .990. The overall mean was 52.18, with an SD of 17.78.

SALT PROJECT- KAROO HOOGLAND LOCAL MUNICIPALITY

Table 26. Descriptive Statistics and Item-Total Statistics of Survey Questions

Questions	Mean	SD	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
1. The SALT project benefited your community	5.25	1.825	46.46	272.38	.925	.863	.989
2. The SALT project benefited your household	5.37	1.702	46.34	276.15	.926	.867	.989
3. The SALT created jobs for the people in your community	5.05	2.017	46.66	263.78	.971	.953	.987
4. You are satisfied with the way the SALT project is being implemented	5.18	1.897	46.53	268.07	.962	.936	.988
5. Community members are involved in the implementation of the SALT project	5.25	1.842	46.46	270.69	.947	.923	.988
6. The SALT project assisted in improving education in the community	5.06	2.015	46.65	264.97	.952	.923	.988
7. The SALT project offered scholarships/bursaries to students in the community	5.09	1.995	46.62	266.00	.945	.917	.988
8. The SALT project brought development to the community	5.23	1.837	46.48	269.97	.963	.935	.988
9. The SALT project improved tourism in the community	5.07	2.003	46.64	267.21	.920	.874	.989
10. The SALT project contributed to the economy of the area	5.17	1.907	46.54	268.85	.943	.908	.988

Item-total statistics were conducted to determine the usefulness of each question/statement used for data collection in Karoo Hoogland. The descriptive statistics (i.e., mean and standard deviation) and item-total correlation were conducted to know the usefulness of each item included in the scale. The results are presented in Table 26. None of the statements are below the recommended 0.3 reliability coefficient, meaning that no identified statement load reduces the Cronbach alpha value of the entire instrument below the acceptable value. The corrected item-total correlation values ranged from .920 to .971, suggesting that all the items are reliable and useful. The reliability statistics revealed an alpha coefficient of .989. The overall mean was 51.71, with an SD of 18.21.

5.1.2 Kareeberg and Karoo Hoogland Results Comparison

Tables 6 and 14 and Appendix 4 (Tables 42 to 47) found that more female participants in Kareeberg and Karoo Hoogland's towns took part in the research than their male counterparts, except in Fraserberg and Vosburg. In these towns, more males than females participated in the study. In Vosburg, 15 females and 43 males out of 58 respondents participated in the research. In Fraserberg, there were 27 females and 33 males out of 60 participants. There was no significant difference in gender between the participants, even when more males than females were present. The difference ranged between 2.0 and 15.2%. However, in Vosburg, there was a 48.9% difference between males and females and no 'other' (Figure 12).

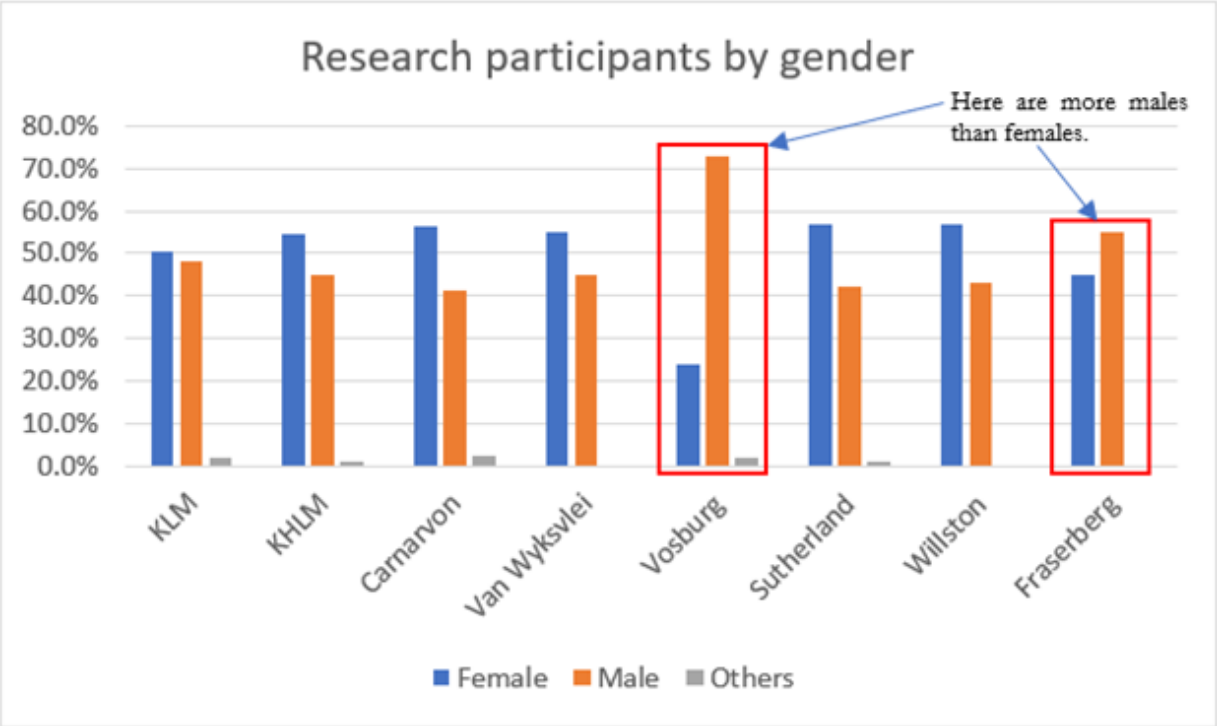

Figure 12. Comparison of Research Participants by Gender
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

Classifying participants according to their age was essential because it was necessary to determine what people thought and whether it was motivated by age. However, participants were not asked to give their ages but were requested to reveal their age range. Therefore, the participants' ages were classified into three categories: youth from 18 to 35 years of age, middle age from 36 to 60 years, and old age over 60 years. From Kareeberg, 30.8% of the participants were youth, 50.3% were middle-aged group and 18.9% were old age participants. From Karoo Hoogland, there were 39.7% youth participants, 46.7% middle-aged participants, and 14.0% were old age participants. In these Kareeberg and Karoo Hoogland Local Municipalities, most participants were middle-aged, followed by the youth group, and the smallest group is old-aged participants (Tables 6 and 14 and Appendix D (Tables 42 to 52)). However, Sutherland had more youth participants than any other group (Figure 13).

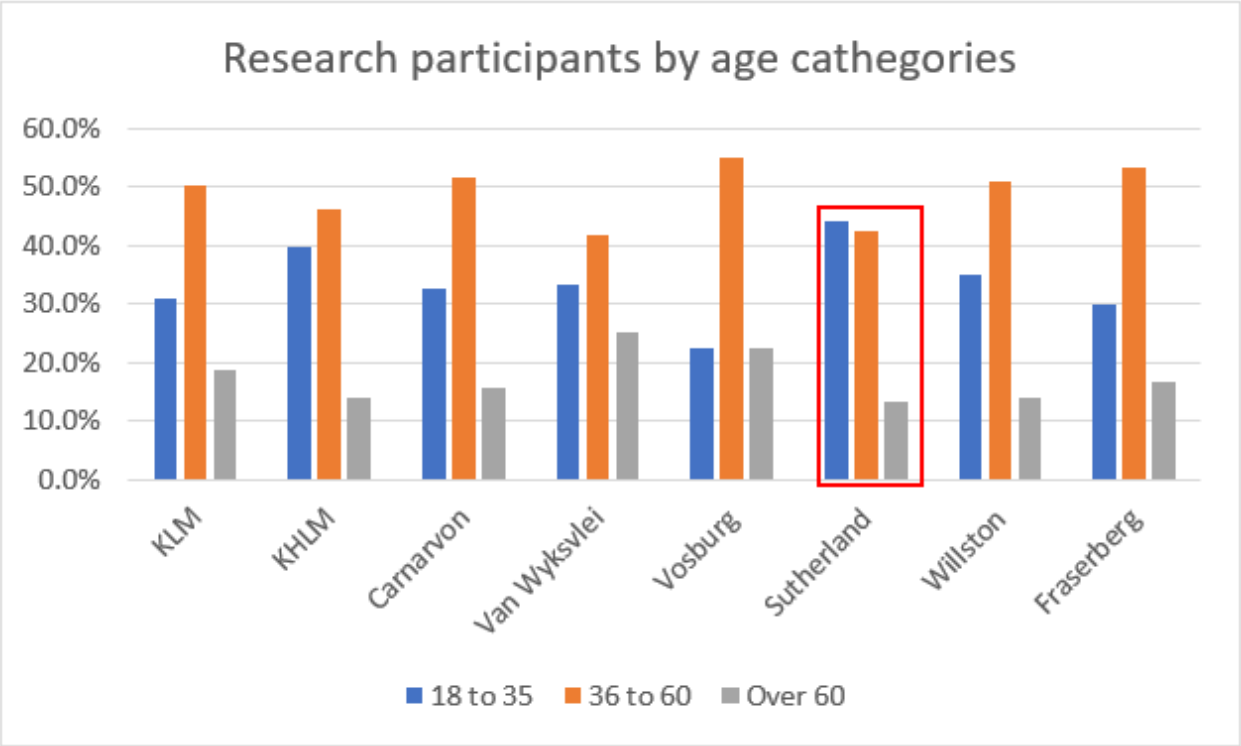

Figure 13. Comparison of Research Participants by Age
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

In the current study, the participants were classified by ethnicity, and four groups were allocated: Coloured, Black, White, and Others (Tables 6 and 14 and Appendix D Tables 42 to 52). Others could not be classified or did not wish to be categorised as any of the assigned categories, i.e., Coloured, Black, and White and formed a negligible number, for example, people of Asian descent, such as Indians, Pakistanis, Japanese, and Chinese. These people are sparsely found in the Northern Cape, especially in Kareeberg and Karoo Hoogland. Due to the dominance of Coloured people in the Northern Cape, it was expected that they would form the majority of the participants. In all towns in Kareeberg and Karoo Hoogland, Coloured participants ranged between 84.5 to 96.6%. The participants who indicated as Blacks, the second largest cohort, ranged from 1.7 to 7.7%. White participants ranged from 0.0 to 8.9%, and the Others were from 0.0 to 1.7%. However, there is a distinct feature in these results because, in Van Wykvlei and Vosburg, there were no White and Other participants. No participants identified as Other in Wilston and Fraserberg (Figure 14).

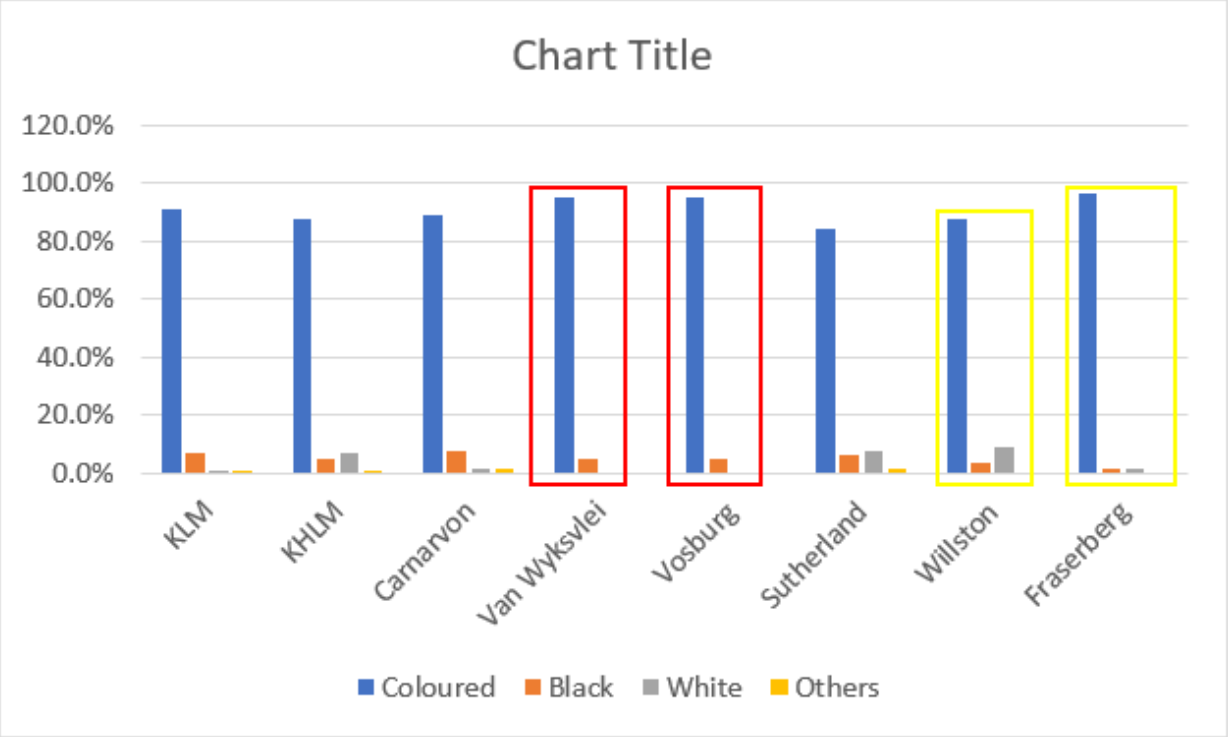

Figure 14. Comparison of Research Participants by Ethnicity
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

The researcher was also keen to determine who the participants represented in the community and classified community representation into four categories: ordinary community members, farming community members, community leaders, and business representatives. The ordinary community members who participated in the research ranged between 80.0 to 96.4%. The farming community members represented a range of 0.0 to 10.9% of all the participants. The community leaders accounted for 0.0 to 9.1%, and business represented 0.0 to 7.1% of participants (Tables 5, 13 and Appendix 6 Tables 41 to 47). There was no business representative from Van Wykvlei, no farming community members from Wilston and no community leader or business representatives from Fraserberg (Figure 15)

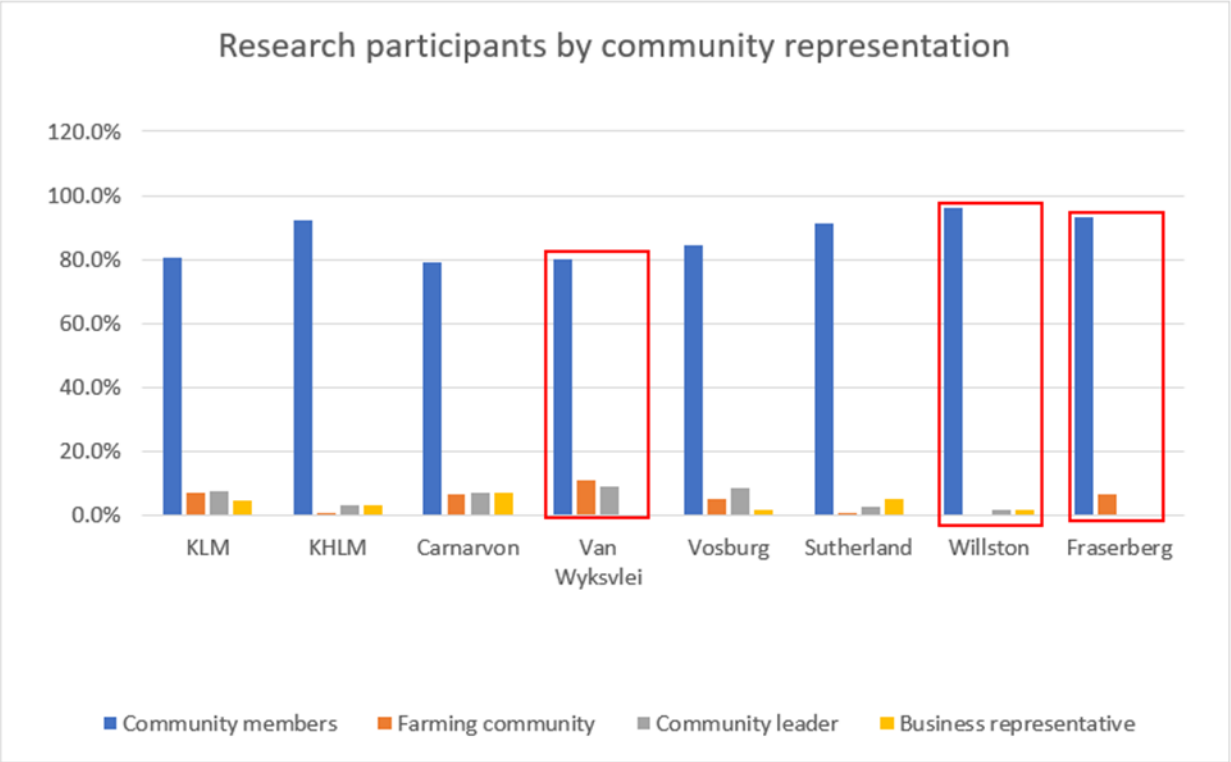

Figure 15. Comparison of Research Participants by Status in the Community
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

I also found out how long people had lived in Kareeberg and Karoo Hoogland because the assumption was that the longer a person lived in the area the better such a person would understand history and issues within those areas. Residence duration was also used to determine if those who participated were indeed from the Municipalities. The period of residence was classified into four categories: 0 to 20 years, 21 to 40 years, 41 to 60 years, and Over 60 years (Tables 6 and 8 and Appendix 4, Tables 41 to 47). Participants who resided in the Municipalities under study between 0 to 20 years ranged from 15.8 to 27.5%. Participants living in the Municipalities under the study between 21 to 40 years accounted for 29.8 to 59.6%; from 41 to 60, 14.0 to 31.6%; and over 60 years, 8.6 to 15.8%. A distinct variable feature is there were more participants in the cohort of 41 to 60 compared to those of 21 to 40 in Van Wyksylei (Figure 16).

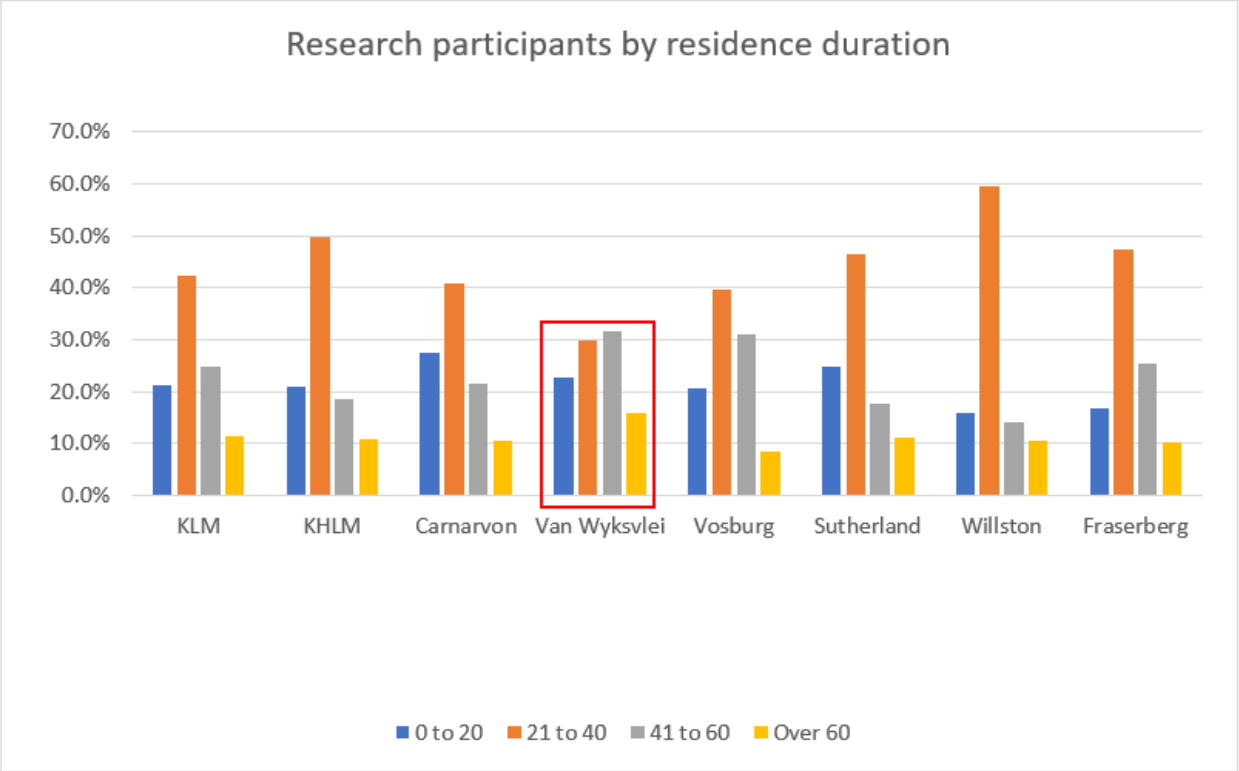

Figure 16. Comparison of Research Participants by Time Spent Within the Community
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

Knowledge of the MeerKAT and SALT projects was determined to confirm that the participants were the sample representing Kareeberg and Karoo Hoogland populations (Tables 5 and 13 and Appendix 6 Tables 41 to 46). A total of 608 (304 each) respondents from Kareeberg and Karoo Hoogland participated in the research. In Kareeberg, 263 (87.1%) participants knew about the MeerKAT project, and only 39 (12.9%) did not know about the project. When filtering on towns, it was found that 162 (88.5%) participants in Carnarvon knew what MeerKAT was all about, 81,7% of participants from Van Wyksvlei knew about the project, and 88.7% of participants in Vosburg were aware of the MeerKAT project. In Karoo Hoogland, 161 (53.5%) participants were aware of the SALT project, while 140 (46.5%) participants did not know the SALT. A higher percentage of participants from Sutherland (60.7%) knew about the SALT project compared to Karoo Hoogland overall. Participants from Williston had approximately the same average as the whole of Karoo

Hoogland (53.4%). In Fraserberg, more participants (68.3%) did not know about the SALT project (Figure 17). Based on this data, the data collection proceeded, and only those who knew about the projects were interviewed.

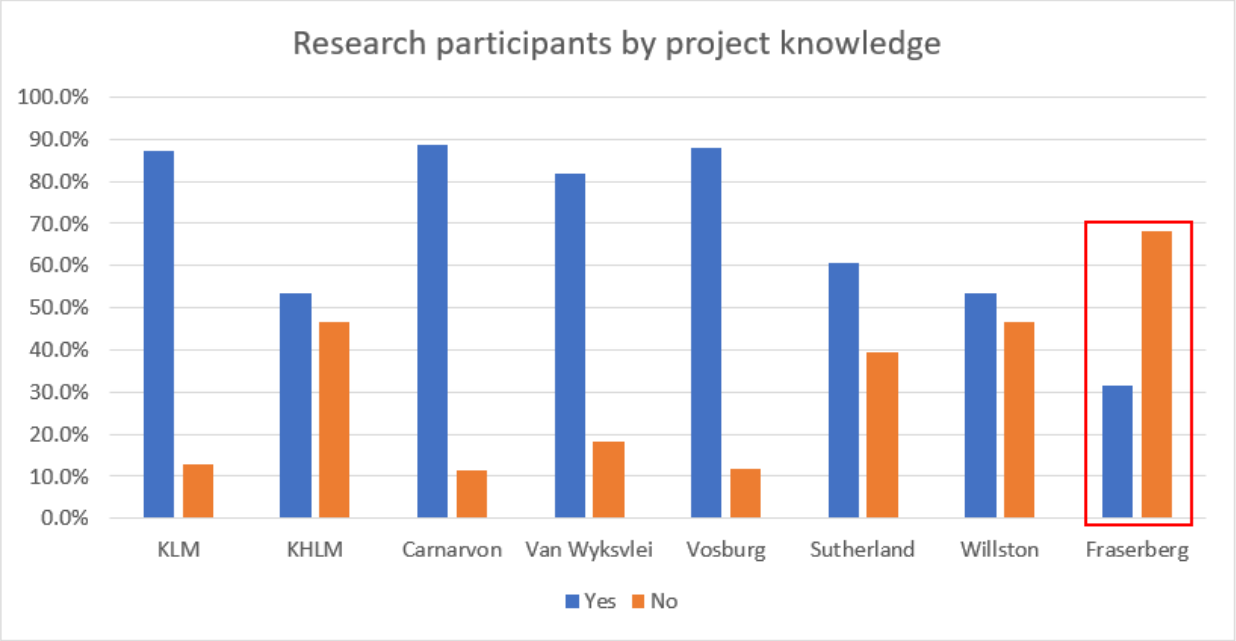

Figure 17. Participants by Project Knowledge
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality

5.2 Presentation of Secondary Data

5.2.1 Census Data

Secondary data was acquired from the 1996 to 2011 censuses for South Africa, Northern Cape, Pixley Ka Seme District Municipality, Kareeberg, Namakwa District Municipality, Karoo Hoogland, John Taolo Gaetsewe District Municipality, and Joe Morolong. John Taole Gaetsewe District Municipality and Joe Morolong were used as a comparative group in this research. Figure 18 below and Table 47 – 58 in Appendix D.4 provide an overview of the average household income and the average per capita income in the Kareeberg, Karoo Hoogland, and Joe Morolong areas. Data for 2001 and 2011 is based on the respective censuses, and data for 2007 is based on a survey undertaken by the

University of the Free State for the baseline study on behalf of the MeerKAT South Africa project team (Stats SA, 1998, 2003, 2013; University of Free State, 2007). A comparison of data from the 2007 survey with that from the 2001 and 2011 census data indicated a significant decline in both average household income and average income per capita.

The demographics of the Kareeberg and Karoo Hoogland areas were reported that most people living in the Kareeberg area were Coloured (85,1%), 9,1% were White, and 4.8% were Black, with other population groups making up the remaining 2% (Stats SA, 2013). The average household size in the Kareeberg area, as reported in the census 2011, was 3.4 (Stats SA, 2013), which is on a par with the average household size in South Africa, indicating that the household size in the Kareeberg area is representative of that of the country. Most people living in the Karoo Hoogland area were Coloured (81.1%), 6,7% were White, and 5.9% were Black, with other population groups making up the remaining 1% (Stats SA, 2013). The average household size in the Kareeberg area, as reported in the census 2011, was 3.1 (Stats SA, 2013), which is on a par with the average household size in South Africa, indicating that the household size in the Karoo Hoogland area is also representative of that of the country.

Furthermore, census data, according to Barlett et al. (2001), could be generalised. A comparative illustration of these indicators, showing improvement in the region's economy, is provided in Figure 18 for Kareeberg. During the indicated period, there was an increase of 57% in average income per capita and 35% in income per household. However, nationally, the average household income rose by a factor of 1.15 from R48 000 in 2001 to R103 205 in 2011, and the average income per capita had increased by 28% from R27 866 in 2001 to R38 734 in 2011 (Stats SA, 2013). These figures showed that the average rate increase in income per household in the Kareeberg area was slower than the national increase. In contrast, the average income increase rate per capita in the Kareeberg area was higher than that of the

country. Similar results apply to Karoo Hoogland and Joe Morolong (Appendix D.4 Table 43 and 44).

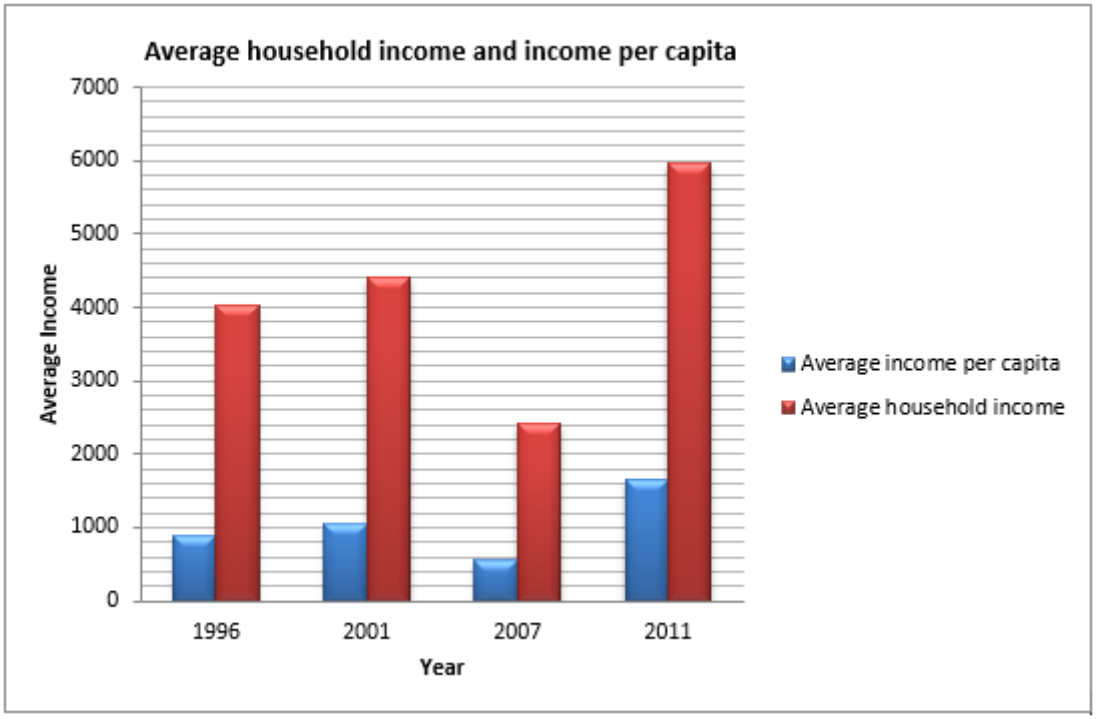

Figure 18. Average Kareeberg Household Income and Income per Capita

5.2.1.1 Employment Rate and Dependency Ratio

The census data for 2001 and 2011 indicated an increase in the rate of employment of 23% from 2001 to 2011 for Kareeberg, 18% for Karoo Hoogland, and 27% for Joe Morolong. This employment rate increase was confirmed by the decrease in the dependency rate in the Kareeberg area from 69,5 in 2001 to 59,9 in 2011, the results were similar for Karoo Hoogland and Joe Morolong (see Appendix E Table 53). In 2001, more people were dependent on others or state assistance for their livelihood than in 2011, when dependency was reduced by approximately 16% for Kareeberg, 10% for Karoo Hoogland and 19% for Joe Morolong (Appendix D.4 Table 44).

5.2.1.2 Models

The Location Quotient (LQ) was calculated using regional data and Local Municipality data from censuses 1996 and 2001 (therefore, before the implementation of MeerKAT) and 2011. The LQ from censuses 1996, 2001, and 2011 are plotted on the graph presented in Figure 19 for comparison (see calculations in Table 43 in Appendix E.2). An LQ positive change was observed, predicting a positive difference in regional economic benefits in the Kareeberg area. Similar results were derived for both Karoo Hoogland and Joe Morolong.

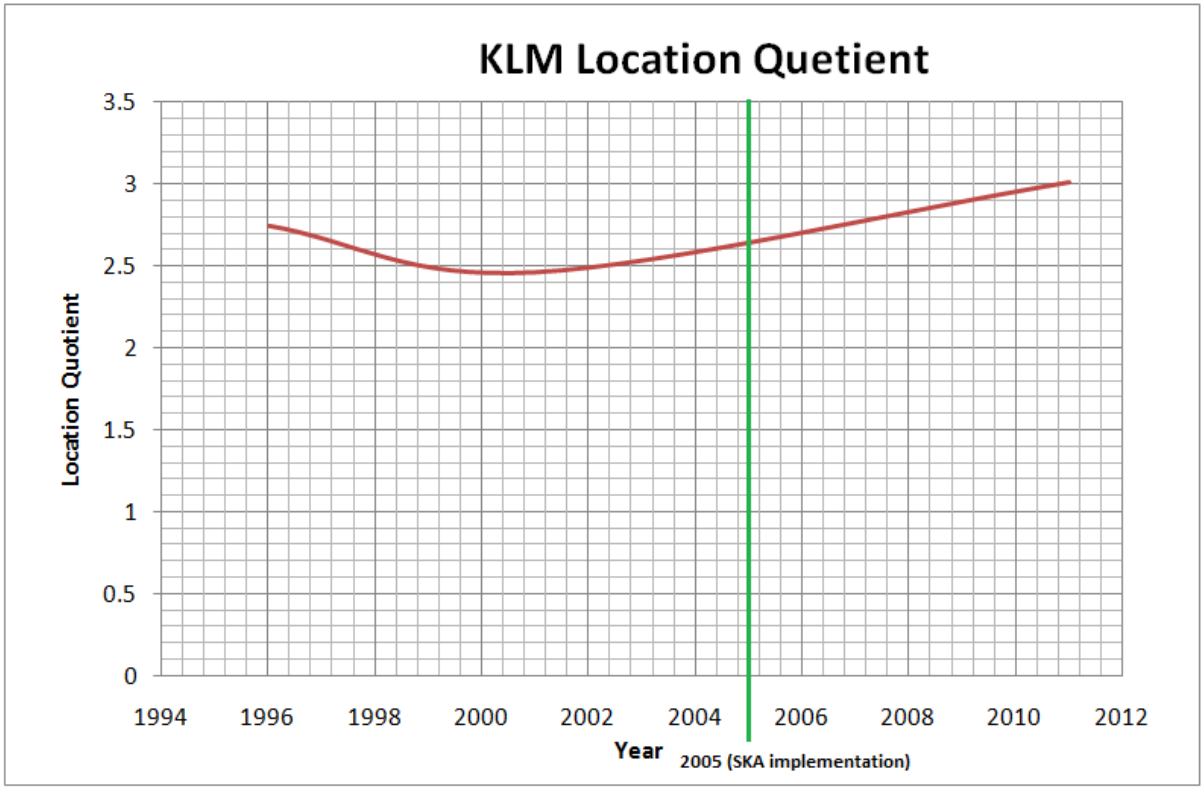

Figure 19. Kareeberg Location Quotient

Using the modified SSA model, the change in employment in the Kareeberg area between 2001 and 2011 was calculated at 23% (see Appendix E for calculations), proving that employment in the Kareeberg area had grown by 23% from 2001 to 2011. Employment growth in the Pixley Ka Seme District Municipality area was 14% in the same period (2001

to 2011), which was slower than in the Kareeberg area. Therefore, employment in the Kareeberg area had increased above average compared to the rest of the municipal areas in the region. On the other hand, the statistics showed that the national employment growth was 35% in the same period (2001 to 2011), indicating that despite the implementation of the MeerKAT project, the rate of increase in employment in the Northern Cape was still lower than in the rest of the country.

The change in employment, as expressed in the SSA model in equation (4) (Appendix E.2), consisted of the national share (NS) value, expressed as equation (5) (Appendix E.2), to show the impact of the increase or decrease in employment rate in the Northern Cape compared with the effects in the local municipal area of Kareeberg area. The SSA model also consisted of area mix (IM), expressed as equation (6) (Appendix E.2), to get a sense of the impact of economic development in the area on the district (Pixley Ka Seme District Municipality) compared to the impact on the province (Northern Cape). It was established that the district's economic benefits had shrunk compared to the local area's economic benefits; hence, the calculations pointed to a negative value. Lastly, regional shift (RS), expressed as equation (7) (Appendix E.2), indicates the difference the MeerKAT project had made to the local municipal area of the Kareeberg area compared to the district (Pixley Ka Seme District Municipality). The results showed that the Kareeberg area had contributed positively to the community and that, if it had not been for the positive growth in the KLM area, the economic benefits in Pixley Ka Seme District Municipality could have shrunk more (for calculations, see values NS, IM and RS in Appendix E.2). The same calculations were done for Karoo Hoogland and Joe Morolong, which yielded similar results. In the Kareeberg area, the economic benefits in Pixley Ka Seme District Municipality had shrunk more (Figure 20, for calculations, see values NS, IM and RS in Appendix E).

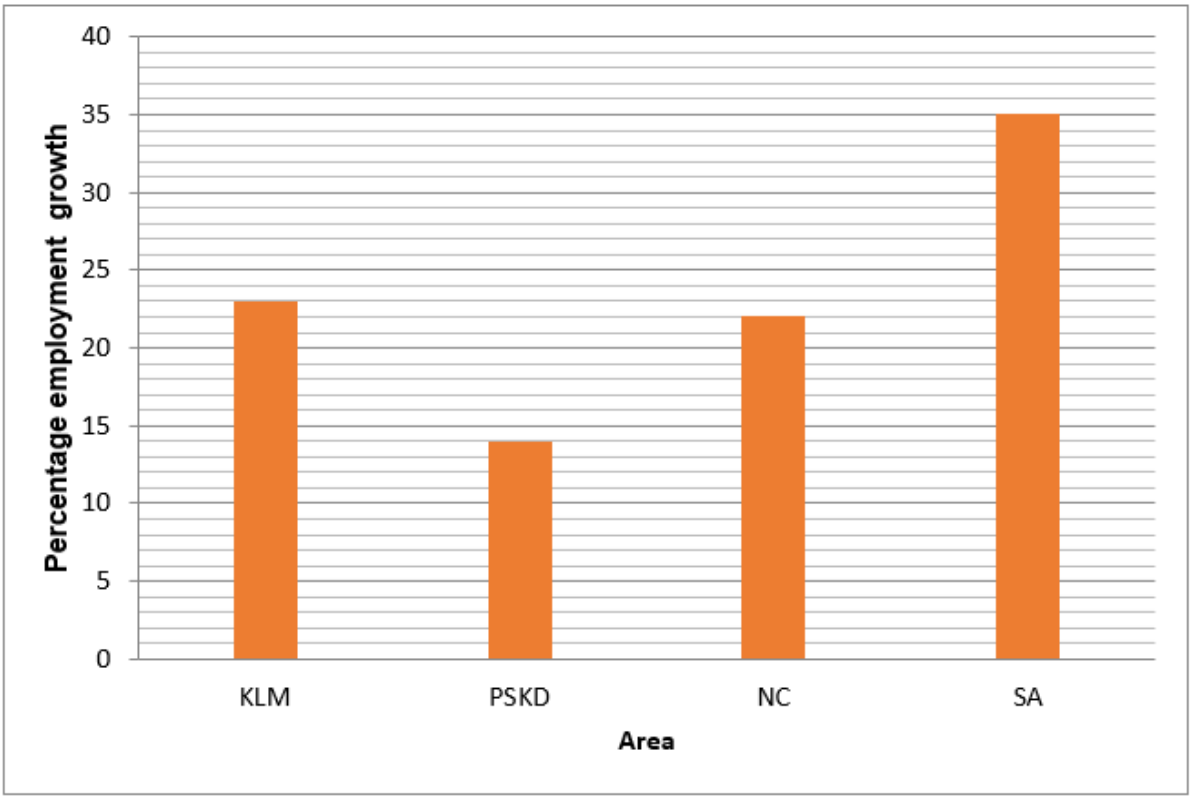

Figure 20. Percentage of Employment Growth
KLM – Kareeberg Local Municipality, KHLM – Karoo Hoogland Local Municipality, PSKD – Pixley Ka Seme District Municipality, NC – Northern Cape, and SA – South Africa

The sub-section that follows gives MeerKAT and SALT financials.

5.2.2 MeerKAT and SALT Financials

Table 27. MeerKAT/SKA Financials*

Financial year	MeerKAT/SKA capital	MeerKAT/SKA current	Astronomy	Total
2005/6	-	R8 000 000.00	-	**R8 000 000.00**
2006/7	-	R19 435 000.00	-	**R19 435 000.00**
2007/8	R80 000 000.00	R25 500 000.00	-	**R105 500 000.00**
2008/9	R264 264 000.00	R25 496 000.00	-	**R289 760 000.00**
2009/10	R490 293 000.00	R12 000 000.00	-	**R502 293 000.00**
2010/11	-	R12 624 000.00	-	**R12 624 000.00**
2011/12	-	R11 282 000.00	-	**R11 282 000.00**

Financial year	MeerKAT/SKA capital	MeerKAT/SKA current	Astronomy	Total
2012/13	R218 738 000.00	R11 842 000.00	-	**R230 580 000.00**
2013/14	R628 107 000.00	R12 458 000.00	-	**R640 565 000.00**
2014/15	R645 199 000.00	R6 400 000.00	-	**R651 599 000.00**
2015/16	R687 415 000.00	R13 165 000.00	-	**R700 580 000.00**
2016/17	R652 756 000.00	R13 881 000.00	R14 069 000.00	**R680 706 000.00**
2017/18	R693 931 000.00	-	R29 348 000.00	**R723 279 000.00**
2018/19	R709 412 000.00	-	R30 639 000.00	**R740 051 000.00**
2019/20	R686 974 000.00	-	R32 789 000.00	**R719 763 000.00**
2020/21	R780 778 000.00	-	R34 364 000.00	**R815 142 000.00**
2021/22	R456 583 000.00	-	R37 514 000.00	**R494 097 000.00**
2022/23	R1 095 216 000.00	-	R41 715 000.00	**R1 136 931 000.00**
Grand Totals	**R8 089 666 000.00**	**R172 083 000.00**	**R220 438 000.00**	**R8 482 187 000.00**

Source (Department of Science and Innovation, 2022)

*Please note the amounts in this table exclude the in-kind contribution by partners, the SKA international body, or contract funds due to additional work done by the Observatory.

Table 28. SALT Financials Estimates*

Financial year	Parliamentary grant - core	Parliamentary grant – ring-fenced	Total Strategic Research Infrastructure Grants allocation (SRIG)	Inter-BU contribution from SAAO or DSI	Total
2006/7	R3 648 202.00	R600 000.00	R400 000.00	-	**R4 648 202.00**
2007/8	R3 922 798.00	R700 000. 00	R500 000.00	-	**R5 122 798.00**
2008/9	R4 218 062.00	R800 000.00	R600 000.00	-	**R5 618 062.00**
2009/10	R4 535 551.00	R900 000.00	R700 000.00	-	**R6 135 551.00**
2010/11	R4 876 937.00	R1 000 000.00	R800 000.00	-	**R6 676 937.00**
2011/12	R5 244 018.00	R1 200 000.00	R900 000.00	-	**R7 344 018.00**
2012/13	R5 638 729.00	R1 500 000.00	R1 000 000 00	-	**R8 138 729.00**
2013/14	R6 063 149.00	R2 000 000.00	R2 000 000.00	-	**R10 063 149.00**
2014/15	R6 519 515.00	R2 200 000.00	R3 000 000.00	-	**R11 719 515.00**
2015/16	R7 010 231.00	R2 500 000.00	R4 000 000.00	-	**R13 510 231.00**
2016/17	R7 537 883.00	R3 000 000.00	R5 000 000.00	-	**R15 537 883.00**
2017/18	R8 105 250.00	R3 200 000.00	R6 000 000.00	R26 650.00	**R17 331 900.00**
2018/19	R8 518 000.00	R3 500 000.00	R8 000 000.00	R722 452.00	**R20 740 452.00**
2019/20*	R8 977 000.00	R4 000 000.00	R8 488 883.00	R99 210.00	**R21 565 093.00**
2020/21*	R9 469 000.00	R4 200 000.00	R9 487 221.00	-	**R23 156 221.00**
2021/22*	R10 131 830.00	R4 500 000.00	R10 151 327.00	-	**R24 783 157.00**
2022/23*	R10 841 058.00	R5 000 000.00	-	R10 861 920.00	**R26 702 978.00**
Grand Totals	**R115 257 213.00**	**R40 800 000.00**	**R61 027 431.00**	**R11 710 232.00**	**R228 794 876.00**

Source (M. Qobela, personal communication, 22 June 2020)

*Note the highlighted in Table 33 above are estimates based on a 7% annual inflationary increment. There might be higher or lower in some instances.

These amounts stared and highlighted in Table 28 were partially (51%) for the SALT operation. The other reminder (49%) of the funds were from international partner

institutions. The funds' percentage for operation from international partners kept decreasing as the partners exited the partnership due to other new international instruments in other countries. As a result, the South African percentage kept growing to close the gap left by those partners that exited. The value for construction was excluded, which was R100 million, of which R50 million was from South Africa's government, and the other half was secured from partner institutions (Buckley et al., 2005). They also exclude the funds received as a result of contract work done.

The Astronomy mandate is funded mainly through the budget Vote 35 either via NRF or DSI for their astronomy projects or to projects directly, in the case of SKA (Government Technical Advisory Centre, 2021). SAAO and SARAO's core budgets are from the budget votes. They also receive external funding from telescope projects owned by private companies (such as SALT) to aid in the development, advancement, and research of astronomy in South Africa (Department of Science and Innovation, 2021; Department of Science and Technology, 2012, 2014; Government Technical Advisory Centre, 2021).

Funding from international sources comes either from external funding agencies, in the case of Development in Africa with Radio Astronomy, the Newton Fund in the United Kingdom, jointly funded with the DSI for the joint implementation of human capital development initiatives or other astronomy agencies for investment into specific radio astronomy projects (i.e. in the case of MeerKAT, delivery of some receivers from Max Planck Institute in Germany, or backend equipment from other institutes around the world, or other international facilities hosted at South African sites such as the Hydrogen Epoch of Reionization Array).

For the 2020/21 year, the total DSI budget was R7.278 billion. R2.553 billion was transferred to the NRF to fund various programmes, including the astronomy mandate

projects such as MeerKAT and other astronomy projects directly or via the SAAO or SARAO. NRF transferred R18.3 million to SAAO (seen as internal income in SAAO) and R25.5 million to SARAO – Hartebeesthoek Radio Astronomy Observatory as government grants. NRF also transferred the entire portion from DSI for SKA via a Parliamentary grant of R531 million to SARAO. This figure was significantly less than the medium-term expenditure framework figures and may have been affected due to the COVID-19 re-prioritisation of budgets. SARAO returned approximately R324 million to the National Fiscus due to delayed commitments. The DSI transferred a once-off ad hoc amount of R9.5 million to SAAO for an infrastructure project. This former amount was not a regular income. The DSI also transfers money directly to the African Astronomical Society, National Astrophysics and Space Science Programme operations, and the Office of Astronomy for Development (OAD) via SAAO. Figure 21 below shows the flow of funds.

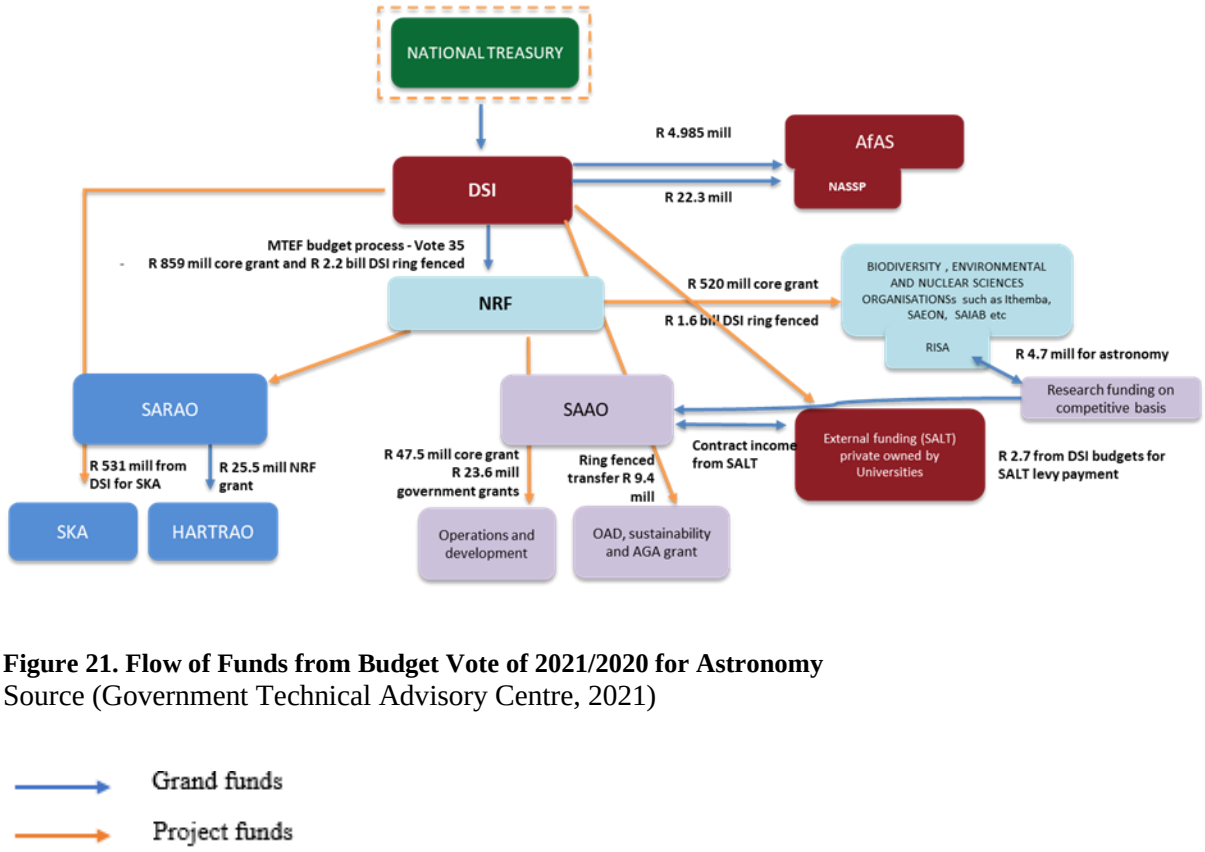

Figure 21. Flow of Funds from Budget Vote of 2021/2020 for Astronomy
Source (Government Technical Advisory Centre, 2021)

AfAS – African Astronomical Society, AGA – Astronomy Geographic Advantage, DSI – Department of Science and Innovation, HartRao – Hartbeeshoek Radio Astronomy Observatory, MTEF – Medium-Term Expenditure Framework, NASSP – National Astrophysics and Space Science Programme, NRF – National Research Foundation, OAD – Office of Astronomy for Development, RISA – Research Innovation Support and Advancement, SAAO – South African Astronomy Observatory, SALT- Southern African Large Telescope, SARAO – South African Radio Astronomy Observatory, and SKA – Square Kilometre Array

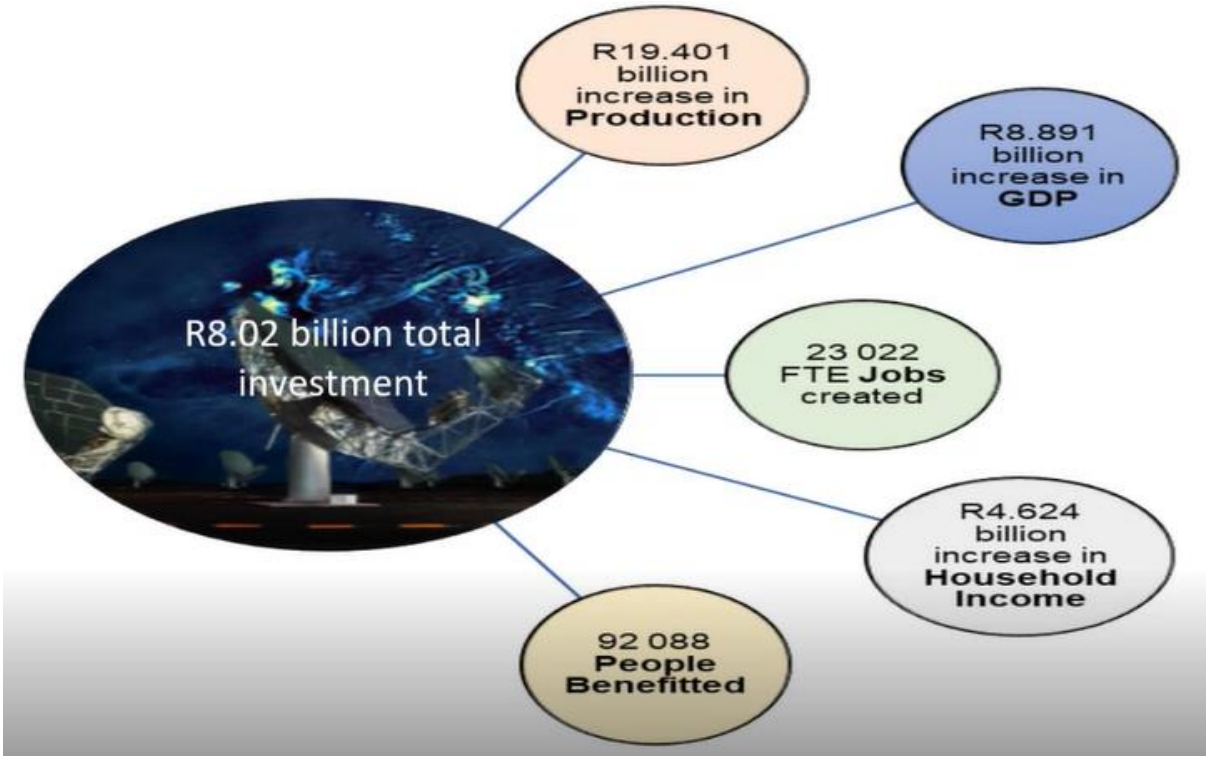

Figure 22. Socio-economic Study by Urban Econ Development Economist
Source (Urban Econ Development Economist, 2023)

FTE – Full-time equivalent, and GDP – Gross Domestic Product

In addition to the above information, Buckley et al. (2005), the Department of Science and Innovation (2022), the Government Technical Advisory Centre (2021), and the South African Radio Astronomy Observatory (n.d.) reported that the NRF manages significant grant funding directly to projects and beneficiaries, such as undergraduate and postgraduate students. Although staff astronomer salaries are core funded, research is funded through competitive grants. Individual SAAO researchers apply to the various competitive NRF programmes. Therefore, researchers' funding is regarded as external to the NRF, and the management and prioritisation of SAAO's research are at the mercy of individual

researchers' applications rather than managed by the institute (SAAO). It is purported that The NRF does not fund SAAO research through core funding.

The Office of Astronomy for Development also receives money from DSI and the International Astronomical Union but is not shown on the schematic of the flow of funds in Figure 22. The NRF also manages funding by the DSI for the South African Gamma-Ray Astronomy Programme, R 3,94 million for the financial year 2021-2022. However, funds for research flow via the Research Innovation Support and Advancement division in the NRF via the NASSP. Funded by the DSI through the NRF via Programme 3, the programme is intended to develop human capital in the country's scarce skills. The Research Innovation Support and Advancement Business Unit of the NRF primarily focuses on supporting, promoting, and advancing research and human capacity development through grant funding and the provision of the necessary research infrastructure.

The NASSP consortium is a multi-institutional postgraduate programme training graduates in astronomy, astrophysics, and space science was launched in the School of Chemistry and Physics and invites applicants on a competitive basis for funds from NASSP Honours and master's programmes in Astrophysics and Space Science. The programme has been successfully run at the University of Cape Town for a decade and has been introduced at the University of KwaZulu Natal and North-West University. The students have been enrolled in physics honours programmes, specialising in NASSP at the School of Chemistry and Physics stream. In contrast, master's students undertake research for two years on either space science or astrophysics topics. It includes data collection from relevant institutes, including SANSA and the SALT.

5.2.3 MeerKAT Secondary Data

This data was gathered from institutional MeerKAT and SALT reports, the StatsSA census reports from 1996 to 2011, and the number of published studies on MeerKAT and SALT. The recent NRF/SARO report (National Research Foundation, 2022) on socio-economic development stated that the MeerKAT/SKA project would undoubtedly bring development to the Northern Cape. The report indicated that the surrounding towns had been positively impacted due to the MeerKAT project. NRF has directly and indirectly invested in the local Northern Cape economies by constructing the MeerKAT and KAT-7. From the inception of KAT-7 implementation to the end of the 2019/20 financial year, R306 million was spent on goods such as building materials, diesel, and general supplies in the broader Northern Cape Province. R156 million of R306 million were spent on local suppliers in Carnarvon, Williston, Brandvlei, and Van Wyksvlei, and the rest (R222 million) was spent on salaries in the Northern Cape.

In the 2020/21 financial year, the National Research Foundation (2022) reported that R31 398 091.00 was spent in local communities for goods and services and R31 283 410.24 was spent on local SARAO staff salaries. Therefore, the total expenditure is R62 681 501.22 in the 2020/21 financial year, which translates. The total spent by the KAT-7 and MeerKAT project to the Northern Cape communities was more than half a billion rand, specifically, R590 681 501.00. The report insinuated that indirect benefits such as tourism were difficult to quantify and calculate. However, anecdotal evidence suggests that astrotourism and the hospitality industry benefitted in Kareeberg.

The National Research Foundation (2022) reported that SARAO established educational programmes in nine schools in the Kareeberg, Karoo Hoogland, and their surroundings: Carnarvon Primary School, Carnarvon High School, Brandvlei Primary School, Brandvlei High School, Nico Bekker Primary School, Williston High School, Delta

Primary School, JJ Booysen Primary School, and Van Wyksvlei Intermediate School. One of the educational programmes that SARAO brought into the schools within the communities and nearby communities in which the MeerKAT is being implemented was the Lego robotics programme. The first World Robot Olympiad and Lego League Provincial competitions were held at Carnarvon High School. Most of the schools from the province took part. The winning team was from Carnarvon High School and was selected to participate in the International Open competition in Uruguay in June 2019. In 2021, SARAO invested R829 000.00 in this programme, reaching 300 learners.

The other educational programmes that SARAO supports are ongoing science engagement interactions, a reading programme, a bursary scheme at the high school level, SARAO-funded educators, and a tertiary bursary. Science engagements with interactions with educators, learners, and the general public are to foster science awareness. SARAO is funding a reading programme at Carnarvon Primary School to assist learners in reading with comprehension. SARAO introduced a learner bursary programme at Carnarvon High School. Bursaries are provided to learners with academic potential who wish to study mathematics and physical science up to Grade 12. Those who are eligible are learners already in Grades 8 to 12. The learners in Grade 7 learners could apply for Grade 8 and Grade 11 learners for Grade 12. The bursary covers school fees, hostel fees for those learners from outside Carnarvon, and a stipend. SARAO has now awarded 181 bursaries to eligible learners in the Kareeberg, Karoo Hoogland, and their surroundings. SARAO was funding three full-time mathematics and physical science educators at Carnarvon High School.

The SARAO Human Capital Development programme has provided 1357 (from 2005 to 2021) scholarships, and grants to tertiary students, artisans, technicians, undergraduate and postgraduate students, and postdoctoral fellows (Table 29; National Research Foundation,

2022). In 2022, 58 more students were added, which means now, as in 2022 the is a total of 1415 students.

Table 29. MeerKAT/SKA Human Capital Development Programme funding from 2005 to 2021

Awards by academic level	
Research Chairs	6
University Positions	24
Post-doctoral Fellows	117
Doctoral Students	172
Master's Students	281
Honours Students	212
Undergraduate Students	269
Bachelor of Technology Students	42
National Diploma Students	81
Interns	9
TVET / Artisan Students	112
Diploma in Engineering Technology Students	16
Bachelor of Engineering Technology Students	16
TOTAL	**1357**
Awards by nationality	
South Africans (81%)	1097
Other African Nationals (15%)	209
Non-African Nationals (4%)	51
TOTAL	**1357**

These are students from all over Africa; however, a certain number of grants and scholarships are ring-fenced each year to be awarded to students from the Northern Cape Province, particularly near the MeerKAT and SALT telescopes. Since 2016, 21 students from Karoo have been awarded scholarships, and four have completed their studies - three attained a bachelor's degree and one, who is continuing with their PhD, attained a master's degree. All four students who completed their studies have secured employment with SARAO. Eight students were awarded the scholarships in 2019, and their studies are in progress. Nine students are not accounted for in the report. In the 2020/21 financial year

circle, 58 scholarships were awarded. This number includes school bursaries for learners attending Carnarvon High School. Two other bursary programmes, Bachelor of Engineering Technology and Diploma in Engineering Technology would provide additional opportunities to the students. Thus far, 110 artisans from the Karoo have been trained.

SARAO collaborated with the DRDLR on economic development in the Northern Cape. Ten learners from Williston were selected to participate in the National Rural Youth Service Corps, a project initiated by the DRDLR that provides character-building programmes consisting of soft and hard skills training. The ten participants completed 12 weeks of the Youth Leadership Development Programme and were undertaking community service. After training, these learners were dispatched to their rural areas to undertake various rural infrastructure and development projects.

In 2017, SARAO established a School Grants Programme in which the schools in Kareeberg, Karoo Hoogland, and their surroundings are offered funding specifically for classroom refurbishments, ICT infrastructure and equipment, photocopying and printing equipment, and science laboratory equipment.

Economic development is one of the strategic pillars in terms of local community development. SARAO developed the programme to facilitate SMMEs' access to opportunities created by the MeeKAT project. In ensuring the optimal SMMEs' optimal beneficiation, SARAO came up with the following initiatives: 50 SMMEs in the Kareeberg, Karoo Hoogland and their surroundings had been trained in entrepreneurship skills and business development. SARAO support them in starting businesses, and those already existing businesses are preparing to grow their businesses. These SMMEs receive continuous business support and are assisted in taking advantage of available opportunities within their local areas to gain access to new markets and other administrative services to ensure that they

meet necessary regulatory framework requirements. Thus far, SARAO has provided R1 350,000.00 in grants.

Another SARAO-established initiative is the MeerKAT Creative Community Initiative. The initiative's main objective is to source craft makers from disadvantaged backgrounds, provide them with creative skills training and essential business and marketing skills, and introduce them to the first steps in running a sustainable business in arts and crafts. Thus far, 19 artists graduated from the initiative: five from Carnarvon, five from Van Wyksvlei, five from Brandvlei, and four from Williston. Nine artists were commissioned to design corporate gifts for the Africa inter-ministerial event and the SARAO bursary conference. Some had been selected to sell their products at the Craft Design Institute stores at the Watershed, the craft and design hub at the V&A Waterfront in Cape Town after the Waterfront management inspected the products to ensure they adhered to the quality and standard of the product sold at the Watershed.

SARAO provided agri support to the local abattoirs to ensure sustainability in the sector. SARAO, in Williston, co-funded the establishment of a feedlot that currently accommodates 6000 sheep. It was done to mitigate the impact of reduced grazing capacity within the area due to the ongoing drought in the Karoo. SARAO also worked with Kaap Landbou to set up Micro Rendering Facilities in Carnarvon to service Williston, Calvinia, and Carnarvon. On environmental projects – SARAO collaborated with Rhodes University and relevant authorities to release a biological agent to assist with *Prosopis* eradication and worked with relevant authorities to eradicate alien species. SARAO is also in partnership with South African National Parks (managing the MeerKAT National Park) to realise crucial scientific research outputs to enable sustainable long-term management of the land and various opportunities for local communities. SARAO supported the initiative to promote astrotourism activities in the Kareeberg, Karoo Hoogland and their surroundings. It intended

to initiate a Star Tours programme employing at least ten unemployed youths from those local communities who would be trained to be Star guides. SARAO planned to provide optical telescopes and training in marketing and business management. The International Astronomical Union and the international SKA Observatory support this initiative.

SARAO continuously rolled out supplementary communication infrastructure to improve access to telecommunication services in Kareeberg, Karoo Hoogland, and their surroundings. It was a long-term project and would be constantly managed over the entire life cycle of the SKA project. SARAO and its collaborators were committed to community development for the Kareeberg and Karoo Hoogland communities. In 2018, SARAO established a formal community development granting programme in Kareeberg and Karoo Hoogland. The granting programme was implemented through a transparent granting process in which critical community stakeholders were included as part of the process. In 2019, the grant programme expanded to 18 grants per year. SARAO funded the spatial development frameworks of the Hantam, Kareeberg and Karoo Hoogland, which enabled the Municipalities to prioritise the development of the three Municipalities. The Verneukpan Soup Kitchen was one of the recipients of the grant. This project fitted well with the Municipal IDP and the SDF, and numerous sector departments would benefit from the project.

SARAO had provided ad hoc grants to the area hospices, community initiatives and sector departments implementing community development programmes. SARAO provided the first free Wi-Fi hotspot at the Kareeberg Library and refurbished a computer laboratory. During the water crisis in Van Wyksvlei, SARAO provided its water tanker truck to the Van Wyksvlei community and subsequently paid for accommodation and diesel for the South African National Defence Force to provide their vehicle for further assistance. SARAO signed a Memorandum of Understanding (MoU) with the South African San Council. The

MoU is for a collaborative process in which SARAO explored opportunities for the promotion and growth of San people. The MoU focused on promoting and protecting the San culture and heritage, protecting the San culture and heritage, and developing the San people's youths. The MoU has recently implemented various activities focused on different aspects of San culture and indigenous knowledge systems. The San Council initiated programmes in their local communities to ensure that San decedents also benefit from the MeerKAT community initiatives. Medicinal plant workshops and San community visits were facilitated.

5.2.4 SALT Secondary Data

As mentioned previously, SALT is the largest optical telescope in the Southern Hemisphere, operated by an international consortium of partners. The telescope has a robust suite of instruments, allowing it to carry out leading-edge and sometimes unique astronomical research. South Africans play the leading role in the scientific and technical leadership for the telescope in addition to hosting and operating it under the Operations Contract between SALT and SAAO. SALT contributes significantly to science engagement and outreach, human capital development, and transformation within South Africa. In addition, SALT is critical in realising the DSI strategy for multi-wavelength astronomy, especially with the operationalisation of MeerKAT.

SALT has demonstrated its scientific competitiveness with other global telescopes in the same class, with well over 300 refereed publications based on SALT data. The socio-economic benefits of SALT are also tangible, with a 30-fold increase in visitors to the Sutherland site and 40 guesthouses and 13 guest farms established where there had been nothing before.

The SAAO has established a Community Centre in Sutherland (converting an unused building previously belonging to the unemployed), which plays a critical role in tackling the challenges of substance abuse, teenage pregnancy, foetal alcohol syndrome and alcoholism. Twenty-six computers with free internet access have been installed in the centre. Community members use them to seek jobs and for their businesses. Learners also use computers for schoolwork and communicating with friends and family.

The SAAO runs many education-based programmes around the country for all learner age groups from pre-primary to high school and conducts various kinds of educator workshops, particularly in training teachers to teach the Earth and Beyond Curriculum appropriately. Several astronomy-based educational programmes are implemented through the SALT Collateral Benefits Programme, including Open Nights and Sutherland Observatory tours to exhibits at Science Centres and Expos.

SAAO, through the SALT Foundation, has recently employed a primary and high school mathematics teacher to improve the standard of Maths teaching in the area. The teacher also facilitates co- and extra-curricular activities based on mathematics and science, such as establishing science clubs and participation in the Science Expo.

The primary data did not positively respond to the main research question, however, the secondary data from the reports and institutions' websites tells a different story. The main research question: '*How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs*?' has been negatively responded to. Table 30 summarises the positive and negative impact of MeerKAT and SALT derived from organisational reports and commissioned studies but does not include the primary data. However, secondary data showed that there was an effort from the projects or institutions to contribute towards the development of the communities.

Table 30. Summary of MeerKAT and SALT's Positive and Negative Impacts

Positive impacts	Negative impacts
Significant capital investment in local businesses (R320 million spent in the Karoo since 2005)	Radiofrequency limitations, especially in the core (i.e., there is an impact on telecommunication) in Kareeberg Local Municipality (Kareeberg)
More than 100 locals were permanently employed in the local communities	Visual pollution
Foreign direct investment through mega astronomy infrastructure projects	130 000-hectares of agricultural land removed from the economy in Kareeberg
More than 7,500 contract employment positions were created, and more were expected for SKA phase one and other projects, e.g., Hydrogen Intensity and Real-time Analysis eXperiment.	R13 000 000 loss of potential revenue in Kareeberg
Hospitality and tourism expanded ten-fold in both Kareeberg and Karoo Hoogland	Loss of employment for those people who were working on the 130,000-hectare agricultural lands in Kareeberg.
Bursaries and school programmes in both Kareeberg and Karoo Hoogland	Non-functional Community Computer Centre in Sutherland
Science engagement and human capital development in most schools in the Karoo	Government departments working in silos
130 000-hectare special reserve declared	Less community involvement in both MeerKAT and SALT
Alternative communication was provided to affected farmers in Kareeberg	Less information sharing with the community both from Kareeberg and Karoo Hoogland
Community development initiatives in both Kareeberg and Karoo Hoogland	Less or no transparency from both MeerKAT and SALT
Greater involvement from other government departments	Bright lighting at night was not permitted in Karoo Hoogland due to impact on the optical telescope
Increased police capacity due to the SKA and SALT sites was declared a national key point that improved communication systems for emergency services.	No additional support for first-year university bursary holders. Those who could not get alternative financial assistance are lost for good in the system. As a result, there is a vast dropout.
MeerKAT engineers appointed by the government to manage the design and mass production of respiratory ventilators nationally	

5.2.5 MAIPs Innovation During COVID-19

The National Integrated Cyber Infrastructure System (n.d.), South African Radio Astronomy Observatory (n.d.), and Square Kilometre Array Observatory (2022) attest that

immediate societal demands could be met by readily transferable skills honed on mega-astronomy or science infrastructure projects such as the MeerKAT and SALT. Recently, for example, the Square Kilometre Array Observatory's partner institutions played a significant assistance role during the COVID-19 pandemic. The South African Radio Astronomy Observatory (SARAO) was appointed by the government because of the project management and engineering skills honed on the SALT, the seven-dish Karoo Array Telescope (KAT-7), MeerKAT Square Kilometre Array (SKA)'s precursor telescope, etc., to manage the design and mass production of respiratory ventilators nationally (National Research Foundation, 2022). The National Integrated Cyber Infrastructure System (NICIS) took part in developing and supporting HealthConnect – a bespoke application (app) store intended for the National Department of Health (NDoH). This app provided all the underlying technology necessary for the NDoH to curate applications specifically for registered health workers. Benefits to the NDoH include a central repository of all sanctioned NDoH apps, free downloads of all applications for health workers, a harmonised set of health metrics, and workforce management tools to ensure productivity. In addition, HealthConnect provided a central electronic patient record and other essential registries necessary for health workers to perform their tasks.

From March 2020 to 2021, countries worldwide, particularly South Africa, were placed in nationwide lockdowns due to the COVID-19 pandemic. In South Africa, this resulted in the closure of all tertiary institutions, such as universities and Technical and Vocational Education and Training (TVET) colleges. Tertiary institutions were aiming to complete the 2020 academic year amid the pandemic. To achieve that, remote and online learning methods were considered by TVET colleges and universities as viable options to salvage the 2020 academic year. However, many higher education students across South Africa faced many challenges that directly impacted their ability to continue with the

academic year remotely and online. These included access to laptops or personal computers and reliable internet connectivity (National Integrated Cyber Infrastructure System, n.d.).

The Council for Scientific Industrial Research (CSIR) had the capabilities to provide geospatial modelling, both in terms of the software and license requirements and the know-how and the capacity to do the analysis (Council of Scientific and Industrial Research, n.d.). These capabilities were built on the previous national geospatial modelling projects the CSIR team had done for the SA Connect and Internet for All. Therefore, to support efforts for the successful completion of the 2020 academic year, the CSIR was requested by Minister Blade Nzimande, the Minister of Higher Education, Science and Innovation, to develop a geospatial modelling capability to identify the level of internet connectivity concerning students' locations within South Africa (Department of Higher Education and Training, n.d.).

The project's purpose was to develop a geospatial map to support teaching and learning to all students in public universities and TVET colleges. Also, to geolocate all complementary infrastructure, such as post offices and public libraries and to geolocate all students from public institutions. The objective was to assess the coverage and quality of telecommunication infrastructure. The study's range for analysis was by 3G and 4G mobile telecommunication. These two mobile telecommunication standards were also used to indicate the quality of service that each student was likely to get and geolocate all university and TVET facilities, including remote campuses (Department of Higher Education and Training, n.d.).

The mapping exercise was followed by analysis to locate students without any coverage (no 3G and 4G) and those with 3G but without 4G coverage. Another investigation determined whether there were nearby facilities, such as libraries, campus sites, and South Africa National Research Network (SANReN)-connected sites, that a student without any

network coverage could access as an alternative learning centre and the distance to such a facility (National Integrated Cyber Infrastructure System, n.d.).

According to the NICIS report (National Integrated Cyber Infrastructure System, n.d.), the analysis was based on a sample of all students registered at higher education institutions, a total of 463573 students comprised of 174665 TVET college and 261908 university students. These were the only addresses that could be geocoded. Of the 436573 student locations analysed, 59 (0.01%) students had no mobile Internet coverage, and 577 (0.1%) had no 4G coverage. While 3G mobile Internet coverage could enable some Internet services, including web browsing, and social media interaction, it is was generally insufficient for popular video streaming services. Hence, it was not suitable for remote learning. In most cases, 4G mobile broadband connectivity was required for effective remote learning. That meant they could not benefit from free data that had been made available (or would be made available) to support distance learning.

The study highlighted the challenge that many South African citizens face when asked to provide a residential address. The current postal code system covers a relatively small percentage of the country's area; even in urban areas, the area covered by a single postal code is quite large. In contrast, many countries have postal code systems that accurately describe where an address is located, sometimes down to neighbour or street level. Plus, Codes and What3Words provide a technical solution to this problem. Still, perhaps a policy intervention is needed to ensure that all citizens have access to an officially recognised address that could be used when proof of address is required (National Integrated Cyber Infrastructure System, n.d.).

Geospatial modelling could offer individualised information dissemination to students whilst having others within the higher education domain, such as relative analysis. This analysis could enable universities and TVET colleges to provide locations of places of

interest close to the individual student's residence. For example, in the case of COVID-19, these institutes could advise students of their closest medical facilities or COVID-19 testing centres. In the future, they could notify students of internships being offered in their area of residence or even the nearest supplier of textbooks or student loans (Department of Higher Education and Training, n.d.; National Integrated Cyber Infrastructure System, n.d.).

In addition, to support the provision of teaching and learning to all students in public universities and TVET colleges, it was essential to resolve the challenges experienced in obtaining students' current, up-to-date, and accurate addresses, as well as obtaining additional fibre data from the public entities. The project was completed, and the outcomes were presented to the Minister. However, given the urgency at the time of the Minister's request and the CSIR's willingness to help, the project was started without a formal funding agreement between the Ministry and the CSIR. The CSIR deployed its resources to develop the model, and the instrument was now available for further development for the abovementioned applications.

Astronomers in Australia at Swinburne University (Swinburne University of Technology, n.d.) developed a COVID-19 symptom tracking app. Meanwhile, the Institute of Astrophysics in Spain developed a portable instrument capable of detecting COVID-19 on surfaces. During the COVID-19 pandemic, much misinformation circulated concerning the pandemic. The National Centre for Radio Astronomy in Asia, India, contributed immensely to the public information campaign to combat the misinformation.

The Science and Technology Facilities Council in Europe (n.d.) and the United Kingdom manufactured 3D-printed personal protective equipment, provided computing resources to the researchers studying the virus, and developed online educational resources for homeschooling. The Italian National Institute for Astrophysics (n.d.) also developed online educational resources for school children. The ENGAGE SKA high-performance

computing infrastructure from Portugal was appointed to support artificial intelligence computing initiatives to improve the public administration response to the COVID-19 pandemic and future pandemics. In Canada, Dr Art McDonald – the Nobel Prize winner in Physics for his solar neutrinos work and a team of many physicists were appointed to manage the design of ventilators to assist in treating COVID-19 (South African Radio Astronomy Observatory, n.d.). The following subsection discusses the current study's presentation of the research results.

5.3 Research Results Presentation Summary

5.3.1 Primary Research Results

The target population was the community members in Kareeberg and Karoo Hoogland. According to the 2011 census and IDPs, Kareeberg had a population of 11 385, and Karoo Hoogland had a population of 116 01 at the time of the study (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020; Stats SA, 2013). Tables 6 and 14 show that 304 and 302 participants completed the questionnaire from Kareeberg and Karoo Hoogland, respectively. The appropriate sample size for Kareeberg and Karoo Hoogland was determined using Table 59 (Appendix F). This research used the confidence level of 90% and 5% confidence intervals.

The data collection methods used for this research were observation, a combination of structured and semi-structured questionnaires, and unstructured interviews. According to Cohen et al. (2011), Fink (2017), and Welman et al. (2005), structured and semi-structured questionnaires collect specific, quantitative data, whereas unstructured interview questions collect qualitative data. A sample of the structured and semi-structured questionnaires and unstructured interview questions is provided in Appendix A.1 and A.2.

I pursued a convergent parallel mixed-methods research strategy. The data processing for the quantitative strategy part of the research was through data coding, data entry onto a computer, i.e., MS Spreadsheet, SPSS, R, and data cleaning. For the qualitative aspect of the study, I transcribed, determined themes theoretically or data-driven (thematic analysis), and analysed data using ATLAS. ti 22. Table 31 summarises the primary data and related information.

Table 31. The Main Research Question, Four Secondary Research Questions and Responses Relating to Kareeberg, Karoo Hoogland and MAIPs

Secondary research questions		Questions within the questionnaire	Response to questions in the questionnaire using primary data	Interview Questions	Response to an interview question	Response to the research question
1.	How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	7. Do you think the MAIPs have led to the development in the area?	Negative response			From the quantitative and qualitative results, no economic infrastructure change was experienced in Kareeberg and Karoo Hoogland since MAIPs were implemented.
		8. If yes, please give examples of the types of development (you can choose more than one answer)	A minority of those who responded that there was development were interrogated further to specify the development			
		8.1. Paved roads	The majority did not agree that the roads were paved			
		8.2. Reliable energy supply	The majority did not agree that there was reliable energy as a result of the MAIPs			
		8.3. Reliable internet connectivity	The majority agreed that there was some connectivity but no reliable			
		8.4. Reliable phone connectivity	The majority agreed that cell phone connectivity was not as reliable as it used to be.			
		8.5. Women development	The majority agreed that there was some women development because many women were also considered for opportunities due to the MAIPs in the area			
		8.6. Tourism routes development	Participants from Karoo Hoogland agreed that something positive had been done to tourism whereas Kareeberg did not agree.			
		8.7. More retails i.e., Wholesales/Supermarkets/Shops	There was no growth in these areas			
		8.8. More lodging places.	Participants from Kareeberg and Karoo Hoogland agreed that there was growth in this area; however, it was not inclusive because only White people benefited			
		8.9. Computer/tablet/iPad access	There was improvement in this area, even though at the Karoo Hoogland the computer lab was not managed well			
2.	How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	6.1. The MAIPs benefited your community	Participants from both Kareeberg and Karoo Hoogland disagreed	3. Do you or have you ever worked for MAIPs (Yes/No)?	Many responded no	Both quantitative and qualitative data, the results after analysis suggested that many respondents believed the MAIPs did not create employment for the people of Kareeberg and Karoo Hoogland
		6.2. The MAIP benefitted your household	There was no agreement on this issue			

		6.3. The MAIPs created jobs for the people in your community	The majority of participants did not agree but agreed that those few jobs created were for the negligible number of people in Kareeberg and Karoo Hoogland.			
		6.10. The MAIPs contributed to the area's economy.	Participants disagreed.	3.1. If yes, did you acquire worthwhile experience that will benefit you in future?	The few participants who responded yes said they acquired a worthwhile experience	
		7. Do you think the MAIPs had led to the development in the area?	Participants did not agree			
		7.7. More retail/wholesale/groceries stores.	Participants disagreed.	3.2. If not, do you know anyone who worked or is currently working on the MAIPs?	The majority of those who did not work for MAIPs were not someone who worked for MAIPs	
		7.8. More lodging places	Participants agreed that there was some growth, but not all sectors of the society benefited.			
3.	How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	6.6. The MAIPs assisted in improving education in the community	There had been some improvement because of the activities that contribute to the MAIPs i.e., funded mathematics teachers, bursaries awarded to students, educational programmes funded	Do you think MeerKAT/SALT benefited the community in the area?	In response to this statement, there was nothing about education.	The data from both qualitative and quantitative research revealed that education prospects did not improve in Kareeberg and Karoo Hoogland since the implementation of MAIPs
		6.7. The MAIPs offered scholarships/bursaries to students in the community	Participants agreed			
4.	How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	6.9. The MAIPs improved tourism in the community	Participants from Karoo Hoogland agreed whereas Kareeberg participants disagreed	6. What do you understand about tourism?	Most people seemed to understand what tourism is.	They indicated that astrotourism in Kareeberg and Karoo Hoogland has not developed since the implementation of MeerKAT and SALT
		7. Do you think the MAIPs Project has led to the development in the area?	No agreement.	7. Do you think tourism in Kareeberg and Karoo Hoogland has improved because of the MAIPs conservatively?	Kareeberg participants did not agree, but Karoo Hoogland agreed	
		7.6. Tourism development	Participants from Karoo Hoogland agreed whereas Kareeberg participants disagreed	8. Are tourism attraction marketing platforms in Kareeberg and Karoo Hoogland?	Many participants from Kareeberg and Karoo Hoogland said there are no tourism attraction marketing platforms	
				9. Are there tour guides from Kareeberg and Karoo Hoogland?	Many participants said there were no tour guides from Kareeberg and Karoo Hoogland	

	People's perceptions in Kareeberg and Karoo Hoogland concerning MeerKAT and SALT? **<u>Questionnaire questions that responded to this research question</u>:** 6.4. Are you satisfied with how the MAIP is implemented? 6.5. Community members are involved in the implementation of the MAIP.	**<u>Interview questions and responses</u>** 1. Do you think MAIPs benefitted the community in the area? 2. Was the community informed of the developments of the MAIPs? 4. How do you feel about the MAIPs project in your area?	**<u>Perceptions about MeerKAT from Kareeberg:</u>** - Respondents were unsatisfied with how the project was implemented. - Respondents reported that community members were not involved in implementing the project.	**<u>Perceptions about SALT from Karoo Hoogland:</u>** - Respondents were unsatisfied with how the project was implemented. - Respondents reported that community members were not involved in implementing the project.

	6.8. The MAIPs brought development to the community. 7. Do you think the MAIP has led to the development in the area? 7.5. Women's development. 10. Are you happy with the implementation of the MAIPs in the community? If not, state why? 11. Do you have comments or suggestions on how the MAIPs can improve your community?	5. Do you think MAIP has improved your life (Yes/No)? 5.1. If so, please explain how MAIP improved your life. 5.2. If no, please explain how MAIP negatively impacted your life. 11. What do you think can be done to improve the implementation of the MAIPs?	- Most participants were not happy with the way the project was implemented. **<u>Comments or suggestions that may be related to the project</u>**: - Respondents wished the project could create more employment, - provide bursaries to more students, not just hand full as was the case at that moment, - provide widespread access to free and reliable Wi-Fi and computers, - develop entrepreneurship skills and provide business opportunities, - assist with the startup business funding, - offer vocational training to the adult population, - transfer vocational skills to the community members, - be transparent and provide regular information to the community, - involve the community more in the project, - provide support to the first-year bursary holders, - provide educational programmes to school-going children, - empower youth and women within the community. - Other towns such as Vosburg and Van Wyksvlei thought they were sidelined and only Carnarvon was being serviced, and - in Carnarvon, respondents thought only people from Rietfontein were preferred over the Carnarvon people. - Coloured people thought only White people were getting employed and vice versa. **<u>Comments or suggestions that may not be related to the project</u>**: - Respondents wished for housing for the community, - fixed roads within the community, - provide health and sports facilities and recreational centres, - provide more ambulances, - provide bursaries for streams other than science and mathematics, - build a technical school and college within the community, - provide food parcels, free water, and electricity to the poor people in the community, - create a shopping mall in the area, - help with the drug problem and make Kareeberg safe,	- Most participants were not happy with the way the project was implemented. **<u>Comments or suggestions that may be related to the project</u>**: - Respondents wished for employment creation - this was at the top of the list, - bright street lights, - a functional Community Computer Centre with free and reliable Wi-Fi and computers, - provide business opportunities to the community, - provide more bursaries and support students from the community, - transfer vocational skills to the community members - be transparent and provide regular information to the community, - provide support to the first-year university bursary holders, - involve the community more in this project, - assist with a crime in the community, - provide an educational program for school-going children, - provide tours of the project to the community. - The people from Fraserberg and Willston, though only people from Sutherland were prioritised, **<u>Comments or suggestions that may not be related to the project</u>**: - Respondents wished for housing for the community, - fixed roads within the community, - provide health and sports facilities and recreational centres, - provide more ambulances, - provide bursaries for other streams other than science and mathematics, - build a technical school and college within the community, - provide food parcels, free water, and electricity to the poor people in the community, - build a shopping mall in the area, - help with the drug problem and make Karoo Hoogland safe, - provide every household with uncapped Wi-Fi, - provide school transport, and - provider sponsorship for community events.

			- provide every household with uncapped Wi-Fi, - provide school transport, and - provider sponsorship for community events.	
Main research question			**Main response**	
How have the local municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs? **Moderating questions** 7. Please identify, if any, the most valuable contribution of the SALT/MeerKAT project in the community (Interview question)			None of the four secondary research questions were positively responded to; hence; the MAIPs did not positively impact the development of the Kareeberg and Karoo Hoogland	

5.3.2 Secondary Research Results

5.3.2.1 Census Data for 1996 and 2011

The secondary data was acquired from the 1996, 2001, and 2011 South Africa censuses, from which information for Northern Cape, Pixley Ka Seme District Municipality, Kareeberg, Namakwa District Municipality, Karoo Hoogland, John Taolo Gaetsawe District Municipality, and Joe Morolong were extracted and used. John Taolo Gaetsawe District Municipality and Joe Morolong were used as a comparison group in this research. Figures 18, 19, and 20 in sub-section 4.2.1 and Table 42 – 52 in Appendix D.4 provide an overview of the average household income, the average per capita income, employment rates, and dependency rates in the Kareeberg, Karoo Hoogland, and Joe Morolong areas, as summarised in Table 32 below. Data for 2001 and 2011 is based on the respective censuses, and data for 2007 is based on a survey undertaken by the University of the Free State for the baseline study on behalf of the MeerKAT South Africa project team (Stats SA, 1998, 2003, 2013; University of Free State, 2007). A comparison of data from the 2007 survey with that from the 2001 and 2011 census data indicated a significant decline in both average household income and average income per capita.

Table 32. Summary of Economic Indicators for Kareeberg, Karoo Hoogland and Joe Morolong

Indicators	Rural Areas (Local Municipalities)		
	Kareeberg	**Karoo Hoogland**	**Joe Morolong**
	Census data from 2001 to 2011		
Average household income	Increased	Increased	Increased
Average per capita income	Increased	Increased	Increase
Employment rates	Increased	Increased	Increased
Dependency rates	Decreased	Decreased	Decreased

5.3.2.1 The Economic Base Theory and Shift Analysis Model

The Location Quotient defined the economic improvement of the research areas based on economic indicators such as average household income, average per capita income, employment rates, and dependency rates worked based on the formula of economic base theory and the shift analysis model in Appendix E.2 and Section 4.2 in this chapter. Table 33 shows the Location Quotient for Kareeberg, Karoo Hoogland and Joe Morolong.

Table 33. Summary of Kareeberg, Karoo Hoogland and Joe Morolong Location Quotient

Year	Location Quotient		
	Kareeberg	**Karoo Hoogland**	**Joe Morolong (comparative group)**
1996	2.749	2.946	2.484
2001	2.467	2.674	2.189
2011	3.0137	3.475	2.843

Chapter 5 is the empirical interrogation and execution which arise from the discussion and execution of data and information collection, collation, processing, and analyses.

Chapter 6

Discussion of Research Findings

6.1 Introduction to Discussion of Research Findings

The following chapter presents an interpretation and analysis of the research findings which were presented in Chapter 4. The research findings were discussed based on the problem statement and main research objective enlisted in Chapter 1. The problem statement among others speaks of the paradox in which there is an expectation for MAIPs to positively impact development in the rural areas where the MAIPs are being implemented, but those areas are preserved through the legislation. This chapter unravels the paradox. The main research objective was to assess the impact of the MAIPs i.e., MeerKAT and SALT on rural development in Kareeberg and Karoo Hoogland. To achieve this objective the four secondary research questions were responded to (Table 1 in Chapter 1).

The African Renaissance movement theory, Gandhian Philosophy, Integration Strategies, and ToC Framework (Figure 8, 9 and Table 2 in Chapter 2). The Gandhian Philosophy emphasises self-reliance, decentralisation, sustainable agriculture, and improved education in Kareeberg and Karoo Hoogland for effective rural development. The African Renaissance movement theory focuses on cultural revitalisation, economic development, and political empowerment.

Furthermore, the research findings are compared to the literature review on the topic of the impact of MAIPs on development in rural areas of the Northern Cape in South Africa. Differences, similarities, as well and any new information or insight that might contribute to the body of knowledge in rural development are identified and discussed. The key theoretical concepts, trends, models, and frameworks identified in Chapter 2 as part of reviewing literature were compared to the actual findings of this research – from the evidence gathered

from articles, documents, reports, surveys, interviews, and observation. Then, the chapter summaries of the analysis.

The convergent parallel mixed-methods research design (discussed in Chapter 3) was used for this research because it allowed the researcher to use, merge and combine different research methods to provide a comprehensive analysis and adequate response to the research questions. This research design was used to triangulate different data sets to find the definitive answer and explain or probe further in case of incongruencies and contradictions in the research findings.

The research knowledge gap, discussed in Chapter 2 is addressed in this chapter. While different studies have provided more valuable insights into the impact of astronomy on rural development, there was a need for more research to examine the long-term and holistic impact of MAIP initiatives on rural communities. Limited research has explored the long-term socioeconomic effects of astronomy-related initiatives on rural communities. Dalgleish (2020) and Sidorenko (2009) also agree that more research is needed to understand how astronomy initiatives empower rural communities. Rural communities need to be empowered by enhancing community capacity for self-governance and decision-making, including studying the impact of astronomy programs on community cohesion, leadership development, and the ability to drive local development initiatives.

A mixed-method research strategy was useful in assessing the impact of the MAIPs on economic infrastructure, employment, education, tourism, and the perceptions of research respondents about the MAIPs. Through this exercise, valuable insights were derived as explained in this and Chapters 6. To fill the research knowledge gap by adequately responding to research questions, the literature review is summarised, and the research conceptual framework is developed and discussed in the following section.

Articles, documents, and reports provided secondary data, while primary data was acquired from surveys, interviews, and observations. Surveys, interviews, and observations were conducted in the Kareeberg and Karoo Hoogland areas. Secondary data is sourced from 1996, 2001 and 2011 censuses for the Kareeberg, Karoo Hoogland, Joe Morolong, Pixley Ka Seme District, John Taolo Gaetsawe District Municipality (Joe Morolong and John Taolo Gaetsawe District Municipality as a comparison group), the Northern Cape, and, in some instances, the rest of the country, SARAO and SAAO reports, previous impact studies conducted related to SAAO and SARAO's activities, and other academic studies undertaken concerning development in the Karoo, specifically in Kareeberg and Karoo Hoogland. The analysis of the results obtained from the survey, interviews and observations linked to the research questions (see Chapter 1) using conceptual methods and methodologies outlined in Chapter 3. Secondary and primary data feedback is quantified and analysed in detail in the following section.

6.2 Discussion of Research Results

6.2.1 Data Analysis and Interpretation

The purpose of gathering primary data through surveys, interviews, and observations in the Kareeberg and Karoo Hoogland areas was to respond to the main research question. It was also to ascertain the perceptions of Kareeberg and Karoo Hoogland residents about the MeerKAT and SALT projects implemented in these areas. A population sample of 304 participants took part in the survey and 33 participants were interviewed in Kareeberg. In Karoo Hoogland, a sample of 302 participants took part in the survey and 33 participants were interviewed. For the survey, sample Barlett et al.'s (2001)'s table, (Appendix F, Tables 54) was used to determine the response accuracy of 90% and 5% confidence intervals.

The result for secondary research question 1: '*How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*'. Economic infrastructures refer to the physical and organisational structures that support economic activities in a place or region (Achten et al., 2019). These infrastructures include transportation systems (such as roads, railways, ports, and airports), communication networks (such as internet connectivity and telecommunications), energy systems (Such as power plants and distribution networks), Water and Sanitation systems (e.g., Dams and water reticulations) and financial institutions (such as banks and stock exchanges). Economic infrastructures play a crucial role in facilitating trade, investment, and economic development by providing the necessary physical and institutional framework for businesses to operate effectively and efficiently (Burnham et al., 2017; David, 2019; Maparu & Mazumder, 2017). The results from Chapter 4, indicated that there was no change in economic infrastructures of Kareeberg and Karoo Hoogland since the introduction of MAIPs. These results agree with some literature, i.e., Atkinson (2019); Gastrow (2017); Gastrow and Oppelt (2019) and Moodley (2022) indicated in their research that MeerKAT and SALT did not bring economic infrastructure that could benefit the Kareeberg and Karoo Hoogland communities.

However, the secondary data sourced from the NRF, SARAO and SAAO reported that SARAO provided agri-support to the local abattoirs to ensure sustainability in the sector. In Willston, SARAO co-fund the establishment of a feedlot that currently accommodates 6000 sheep. This was done to mitigate the impact of reduced grazing capacity within Kareeberg due to the ongoing drought in the Karoo. SARAO was also working with Kaap Landbou to set up Micro Rendering Facilities in Carnarvon to service Williston, Calvinia and Carnarvon. The SAAO facilitated the 130 km road (R354) construction from the N1 national highway in Matjiesfontein to Sutherland and built the access road from Sutherland to the SALT site. These roads are paved. Kareeberg has a well-constructed access road, a 92 km

road from the R63 provincial road to the MeerKAT telescope site. SARAO was continuously rolling out the supplementary communication infrastructure to improve access to telecommunication services in Kareeberg and their surroundings. The supplementary communication project is a long-term project and will be constantly managed over the entire life cycle of the SKA project. The recent report, Scientific Study to Gauge the Socio-economic Impact and Perceptions of MeerKAT Telescope Project, by Urban-Econ Development Economists (2023) agreed with secondary data that, indeed, there was infrastructure that had been brought to Kareeberg as the result of MeerKAT. There is a disjuncture between the primary data and secondary data results. The following is the response for the research sub-question 2 from primary and secondary data.

The result for research sub-question 2. '*How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs*?' This question was negatively responded to in Kareeberg and Karoo Hoogland, meaning that the employment rates and levels of economic participation were not improved since the implementation of the MeerKAT and SALT. These findings were ventilated in recent literature. Gastrow and Oppelt (2019) suggested that the main challenge of the MAIPs in South Africa is the proper management of the development interventions. Atkinson (2019) supported this claim in his article '*When Stars Collide: Competing Development Paradigms in the Central Karoo'* when he confirmed that people from Kareeberg were so frustrated by this project to such extent that they lost hope that the project would bring development in their areas.

However, the secondary data stated that SARAO had provided R1,350,000.00 in grants for economic development in Kareeberg and Karoo Hoogland (National Research Foundation, n.d.; South African Astronomical Observatory, 2021; South African Radio Astronomy Observatory, n.d.; Urban-Econ Development Economists, 2023). Economic development is one of the strategic pillars of local community development. SARAO

developed the programme to facilitate SMMEs' access to opportunities created by the MeeKAT project. In ensuring the SMMEs' optimal beneficiation, SARAO developed the following initiatives: Fifty SMMEs in Kareeberg, Karoo Hoogland, and their surroundings have been trained in entrepreneurship skills and business development. SARAO support them in starting businesses, and those already existing businesses are preparing to grow their businesses. These SMMEs received continuous business support and were assisted in taking advantage of available opportunities within their local areas to gain access to new markets and other administrative services to ensure that they met necessary regulatory framework requirements.

Another SARAO-established initiative, the MeerKAT Creative Community Initiative, aimed to source craft makers from disadvantaged backgrounds, to provide them with creative skills training and primary business and marketing skills, and to introduce them to the first steps in running a sustainable business in arts and crafts. Thus far, 19 artists graduated from the initiative, five from Carnarvon, five from Van Wyksvlei, five from Brandvlei and four from Williston. Below is the response to research sub-question 3.

The responses for secondary research question 3**:** *'How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?'* were demonstrated by showing the baseline versus the period after this infrastructure was built from the secondary data sources. Many participants reported that the MeerKAT and SALT projects did not offer scholarships or bursaries to students in Kareeberg and Karoo Hoogland. Many have shown that education is one of the important pillars of rural development (for example, Alkire & Santos, 2010, 2014; Chambers, 1997; Sen, 1999; United Nations Educational, Scientific and Cultural Organisation, 2003). However, the primary data suggest that education prospects have not improved in Kareeberg and Karoo Hoogland since the implementation of MeerKAT and SALT and this is supported by the literature (ChinigÒ,

2019; Parkington et al., 2019; Twidle, 2019; C. Walker, 2019; C. Walker et al., 2019; M. Walker et al., 2013).

Even though the primary data indicated that the education prospects had not improved, the secondary data told a different story. From secondary data, the National Research Foundation (2022, n.d.); South African Astronomical Observatory (n.d.); Southern African Large Telescope (n.d.), and South African Radio Astronomy (2020) reported that SALT was the largest optical telescope in the Southern Hemisphere, operated by an international consortium of partners. The telescope has a robust suite of instruments, allowing it to carry out leading-edge and sometimes unique astronomical research. South Africans play the leading role in the scientific and technical leadership for the telescope in addition to hosting and operating it under the Operations Contract between SALT and SAAO. Hence, SALT contributes significantly to science engagement and outreach, human capital development, and transformation within South Africa. In addition, SALT is critical in realising the DSI strategy for multi-wavelength astronomy, especially with the operationalisation of MeerKAT.

The SAAO runs many education-based programmes around the country for all learner age groups from pre-primary to high school and conducts various kinds of educator workshops, particularly in training teachers to teach the Earth and Beyond Curriculum appropriately. Several astronomy-based educational programmes were implemented through the SALT Collateral Benefits Programme, including Open Nights and Sutherland Observatory tours to exhibits at Science Centres and Expos.

SAAO, through the SALT Foundation, has recently employed primary and high school science teachers to improve the standard of Mathematics and Physical Science teaching in the area. The teachers also facilitated co- and extra-curricular activities based on

mathematics and science, such as establishing science clubs and participation in Science Expos within the country.

SARAO established educational programmes in nine schools in the Kareeberg, Karoo Hoogland, and their surroundings. SARAO brought the Lego robotics programme into the schools where the World Robot Olympiad and Lego League Provincial competitions were held at Carnarvon High School. The team from Carnarvon High School did well in that competition and was selected to participate in the International Open competition in Uruguay. SARAO had invested R829000.00 in this programme, and 300 learners were reached.

Science engagements with interactions with educators, learners, and the general public foster science awareness. SARAO supported the ongoing science engagement interactions, a reading programme, a bursary scheme at the high school level, SARAO-funded educators, and a tertiary bursary. SARAO Human Capital Development has provided 1357 scholarships and grants to tertiary students, artisans, technicians, undergraduate and postgraduate students, and postdoctoral fellows. These were students from all over Africa, but a certain number of grants and scholarships were ring-fenced each year to be awarded to students from the Northern Cape Province, particularly in the vicinity of the MeerKAT and SALT telescopes. Since 2016, 21 students from Karoo have been awarded scholarships, and four have completed their studies; all are employed by SARAO. Eight students were awarded the scholarships in 2019, and their studies are in progress. Nine students are not accounted for in the report. Two other bursary programmes, Bachelor of Engineering Technology and Diploma in Engineering Technology were being established. There was hope that they would provide additional opportunities to the students and that the number of students funded would significantly increase.

SARAO collaborated with the DRDLR on economic development in the Northern Cape. Ten learners from Williston were selected to participate in the National Rural Youth

Service Corps, a project initiated by the DRDLR that provides character-building programmes consisting of soft and hard skills training. After training, those learners were dispatched to their rural areas to undertake various rural infrastructure and development projects. There is also apprentice training that SARAO fully funds, and thus far, 110 artisans from the Karoo have been trained.

SARAO had established a School Grants Programme in which the schools in the Kareeberg, Karoo Hoogland, and their surroundings are offered funding. The schools could apply for this funding specifically for classroom refurbishments, ICT infrastructure and equipment, photocopying and printing equipment, and science laboratory equipment. Again, the primary data does not find resonance in the secondary data. SARAO planned to provide optical telescopes and training in marketing and business management. The International Astronomical Union and the international SKA Observatory support this initiative.

This education assistance is small considering the colossal education problem in the Karoo area. Even 42.9% unaccounted for or dropout is too high, and something must be done to avoid or reduce it. However, all that said, it is not correct to insinuate that nothing at all had been done. There has been some intervention, done even though that work might not have been sufficient. The impact of MAIPs was measured by sourcing primary and secondary data to respond to secondary research question 4, as stated below.

The results for secondary research question 4. '*How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' indicated that the MeerKAT and SALT projects did not improve tourism in Kareeberg and Karoo Hoogland. The secondary data (Department of Science and Innovation, 2021; South African Astronomical Observatory, n.d.-b, 2021; South African National Roads Agency Limited, 2008; South African Radio Astronomy Observatory, 2020; Urban-Econ Development Economists, 2023) indicated that the socio-economic benefits of SALT are tangible, with a

30-fold increase in visitors to the Sutherland site and 40 guesthouses and 13 guest farms established where there had been nothing before. SARAO supported the initiative to promote astrotourism activities in Kareeberg, Karoo Hoogland, and their surroundings. It initiated a Star Tours programme employing at least ten unemployed youths from those local communities. Those ten unemployed youths would be trained to be Star guides.

SARAO signed a MoU with the South African San Council to explore opportunities for the promotion and growth of the San people. The MoU focused on promoting the San culture and heritage, protecting the San culture and heritage, and developing the San people's youths. The MoU has recently implemented various activities focused on different aspects of San culture and indigenous knowledge systems. The San Council initiated programmes in their local communities to ensure that San decedents also benefit from the MeerKAT community initiatives. The medicinal plant workshops and San community visits were facilitated. There is a disjuncture between the primary data and secondary data because they disagree. Lastly, it was important to deal with the perception of the ordinary residents of Kareeberg and Karoo Hoogland concerning the MeerKAT and SALT.

The perceptions from the Kareeberg were, that MeerKAT did not hire people from the Kareeberg but brought people from outside the Kareeberg community. Employment advertisements and applications were not transparent, and only a few selected community members secured employment. The Kareeberg community was poorer with MeerKAT. The people from Van Wyksvlei and Vosburg strongly believed those employed were those from Carnarvon. The people outside Carnarvon thought only Carnarvon people got employed, while those from Carnarvon thought people from outside Carnarvon were the ones being employed. The White people also think only Coloured people were being employed.

The interview participants dominantly raised 12 themes, with ‘creation of employment' the most suggested, followed by 'providing more bursaries', 'access to free,

reliable Wi-Fi and computers', 'provide business opportunities', 'offer vocational training to the adult population', 'transfer skills to the community', 'be transparent and provide regular information to the community', 'provide support to their first-year bursary holders', 'involve more into the project', 'provide an educational program to the school going children' and lastly 'empower youth and women'. These themes were considered relevant to the research questions, another twelve themes were raised but are not within the project's ambit (see Chapter 4). Raising issues that fall outside the project mandate indicated that the participants failed to understand the project's purpose. Overall, the respondents' perception of Kareeberg and MeerKAT was negative.

Most Karoo Hoogland respondents believed there were no benefits of SALT because people are still the poorest of the poor. "*We sometimes feel like we are not Black people and not White people because now it is like things a dedicated to Black people while some time ago, they were dedicated to White people."* Since the advent of democratic South Africa, Coloured people think they are not considered. They feel like opportunities are only reserved for Black people. During the apartheid era, opportunities were reserved for White people; at the time, the Coloured were not White enough to be considered. In the new dispensation, they are not Black enough to be considered. The other issue raised by many was that Coloured people own nothing in Karoo Hoogland: "…*Coloured people own nothing. You will not find coloured people's shops, no spaza shops, not a little fruit garden, nothing. There is nothing coloured people own because there has never been any help in terms of development for Coloured people."*

The contentious issue was the Community Computer Centre, which was not functioning as expected. "… *the Computer Centre in town. It's a white elephant. You won't find any of our children in that Centre because there is a person, a staff member from SALT, sitting there every day. Still, there are no computer programs for children. The government*

officials go there and look down upon them and think people from Karoo Hoogland are expecting handouts which were not correct." "*Another very frustrating thing, people come here, and they use, you do not have businesses. We do not know if we can give you money. We do not know what you will do with that money. I have got a small business. We are ten small businesses in Sutherland that nobody has ever come and asked who these SMMEs are in Sutherland." "It is like SMMEs in Karoo Hoogland are not trusted by the government and are not considered legitimate. Hence, SMMEs from outside Karoo Hoogland are bought into Karoo Hoogland to do business there and are only offered labourers' jobs. Those in authority do not involve them in decision-making but decide what the rest of the community needs."*

Ordinary people from Kareeberg and Karoo Hoogland had a negative perception of MAIPs. Recently, a study, the Scientific study to Gauge the Socio-economic Impact and Perceptions of MeerKAT/SKA Telescope Project (2023) by Urban-Econ Development Economists was commissioned. The study aimed to gauge the perception of the MeerKAT/SKA in the Karoo. The study found that people have positive perceptions about the project because they responded positively to the questions or statements that were put to them. This study's findings conflicted with the current study's primary data findings. It was also fitting to have a broader view of the development in Kareeberg and Karoo Hoogland; hence the census data was used to determine the extent of development in Kareeberg and Karoo Hoogland. Census data from Joe Morolong was used as a comparative group.

In this paragraph, reference is made to the results obtained from the analysis of secondary data acquired from the 1996, 2001 and 2011 censuses for Kareeberg, Karoo Hoogland, Pixley Ka Seme District, Namakwa District Municipality, the Northern Cape, and South Africa as a whole, as well as to the results of interviews conducted in the Kareeberg and Karoo Hoogland areas. The results obtained from analysing the secondary data are discussed concerning the first to fourth secondary research questions. In contrast, the results

obtained from analysing the primary data are discussed concerning all four secondary research questions. Most people living in the Kareeberg area are Coloured, followed by White, and then Black. This was different to the demographics of Joe Morolong in which the majority is Black, followed by Coloured and then White.

A comparison of data from the 2007 survey (University of the Free State, 2009) with that from the 2001 and 2011 censuses (Stats SA 2003, 2013) indicated a significant decline in both average household income and average income per capita. These results did not corroborate the primary data.

A comparative illustration of these indicators, showing improvement in the region's economy, is provided in Chapter 4. During the indicated period, there was an increase in average income per capita and income per household. However, nationally the average household income had also risen in 2011, and the average income per capita had increased by 2011 (Stats SA, 2013). These figures showed that the average rate of increase in income per household in the Kareeberg, Karoo Hoogland and Joe Morolong areas was a bit slower than the national increase. In contrast, the average income increase rate per capita in the Kareeberg, Karoo Hoogland and Joe Morolong areas was higher than that of the country.

6.2.1.1 Employment Rate and Dependency Ratio

There was an increase in the rate of employment rate by 23% from 2001 to 2011 (Stats SA 2003, 2013). This increase was confirmed by an improvement in the dependency ratio in the Kareeberg area from 69,5 in 2001 to 59,9 in 2011 (Appendix D Table 52). In 2001, more people were dependent on others or state assistance for their livelihood than in 2011, when dependency was reduced by approximately 16%. The overall picture portrayed by these dependence ratio figures confirmed the inadequacy of the economy of the Kareeberg area to support its inhabitants sufficiently; hence, more people were dependent on social

grants. However, the recorded improvement of 16% in the dependency rate is a good indication that economic benefits increased in the Kareeberg area, with fewer residents depending on the state for their livelihood, and that more of them were employed and earning an income to provide for themselves. The data indicated that more job opportunities were available in the area, which cannot be correlated with the increased employment rate recorded per the survey. It cannot be directly related to the MAIPs in the area.

6.2.1.2 Models

The LQ was calculated using regional data and Local Municipality data from censuses 1996 and 2001 censuses (therefore, before the implementation of MeerKAT) and 2011 (the year under review). The LQ (Chapter 4 Figure 4.8), predicts a positive difference in regional economic benefits in the Kareeberg area in the year under review.

Employment growth is an indicator of economic benefits; therefore, this growth was assessed to determine if the Kareeberg area had derived financial benefits from implementing the MeerKAT project and if the employment growth could be attributed to the MeerKAT project (unless the opposite could be proved). Using the modified SSA model, the change in employment in the Kareeberg area between 2001 and 2011 was calculated at 23% (see Appendix E for calculations), proving that employment in the Kareeberg area had grown by 23% from 2001 to 2011. Employment growth in the Pixley Ka Seme District area was 14% in the same period (2001 to 2011), which was slower than in the Kareeberg area. Therefore, employment in the Kareeberg area had increased above average compared to the rest of the municipal areas in the region. On the other hand, the statistics showed that the national employment growth was 35% in the same period (2001 to 2011), indicating that despite the implementation of the MeerKAT project, the rate of increase in employment in the Northern Cape was still lower than in the rest of the country.

The change in employment, as expressed in the SSA model in equation (4) (Appendix E.2), comprised of the NS value, expressed in equation (5) (Appendix E.2), was calculated to show the impact of the increase or decrease in employment rate in the Northern Cape compared to the Kareeberg area. The SSA model also comprised IM, expressed as equation (6) (Appendix E.2), to get a sense of the impact of economic development in the area on the district (Pixley Ka Seme District) compared to the impact on the province (Northern Cape). It was established that the district's economic benefits had shrunk compared to the local area's economic benefits; hence, the calculations pointed to a negative value. Lastly, RS, expressed as equation (7) (Appendix E.2), indicates the difference the SKA project made to the Kareeberg area compared to the district (Pixley Ka Seme District). The results had to be interpreted because the footprint results were like those for the comparative group; hence, little was said about them. The results were not informative concerning the impact of the MAIPs in Kareeberg and Karoo Hoogland. Improvement in the Joe Morolong (comparative group) makes it unclear whether the MAIPs are responsible for the economic indicator improvement. The improvement in the whole region and country left the research questions inconclusive.

6.3 Conclusion for Discussion of Research Findings

The main research question aimed to explore the impact of development due to the MAIPs. To respond to the main research question, four secondary research questions were developed. Secondary Research questions were based on four themes which were economic infrastructure, employment, education, and tourism. The fifthly secondary research question also assessed Kareeberg and Karoo Hoogland people’s perceptions concerning MeerKAT and SALT, respectively. According to the primary data gathered through a survey, interviews,

and observations, there was no impact of MAIPs on development in the Kareeberg and Karoo Hoogland.

However, the convergent parallel mixed-methods research design allowed qualitative research analysis in which other themes that were not part of the originally planned themes emerged and were followed up by further interview questions or discussions with the participants that raised these themes. An example is the response to an interview question 2. '*Was the community informed of the developments of the MeerKAT?'* The result was that participants (55.2%) agreed that they were regularly notified of what was happening within the MeerKAT. C/S003, said, "*Yes, the community was timeously informed of the development within the MeerKAT [project] through regular community meetings and flyers were regularly handed out.*" Even though most people did not agree that the project brought development in the Kareeberg area, they agreed that they were regularly informed of the project's developments, meaning the consultation took place even if it was only to inform. Going forward, it would be beneficial to consider Kareeberg people as important stakeholders, not just to inform but also to involve them in decision-making. Following a bottom-up strategy and Community-driven development approach is supported by the African Renaissance movement model and Gandhian philosophy.

Another important theme identified from secondary data which is also touted for successful rural development, is the sustainable development approach, supported by the African Renaissance movement theory and Gandhian philosophy. However, this was beyond the scope of this research. The data suggested that some MAIPs were participating in environmental projects, which benefits rural development. SARAO collaborated with Rhodes University and relevant authorities to release a biological agent to assist with Prosopis eradication and with relevant authorities to eradicate alien species. SARAO was also in partnership with South African National Parks (managing the MeerKAT National

Park) to realise crucial scientific research outputs for enabling sustainable long-term management of the land and various opportunities for local communities.

Interview Question 3. '*Do you or have you ever worked for the MeerKAT/SALT?*' was negatively responded but when the follow-up questions, '*If yes, did you acquire worthwhile experience or knowledge that you think may benefit you in the future*?' and '*If not, do you know anyone who worked or is currently working for the MeerKAT*?' were asked more information. Only seven participants responded to the first follow-up question because they had answered yes to interview question 3. Participant A1 said he had acquired five years of experience and believed that would be useful in future. C/S001 said, "*I had a catering project at the SKA site for some time. However, I do not think the experience will help me in future because I am a pensioner now*." C/S001 was an SMME providing catering services to the project. The participants who were not employed by the project (67.7%) responded to the second follow-up question. The numbers improved; 70.8% of the respondents at least knew someone who was employed at the MeerKAT project. Even though the project seemingly did not employ many local people, it still provided jobs for some. Most people were aware of someone from the Kareeberg community employed at the MeerKAT project. Many respondents, however, reported that the MeerKAT project did not contribute to the economy of Kareeberg.

Although secondary research question 3 was not positively responded to, some residents still consider MeerKAT providing bursaries as one of the most valuable contributions to the community. The availability of this financial assistance could greatly improve education prospects within Kareeberg.

The wish of the people in Kareeberg is the improvement of education; hence they wish for more financial assistance to be provided because most people residing in Kareeberg

are poor, and it would be difficult for them to afford tertiary education for their children (Kareeberg Local Municipality, 2020; Karoo Hoogland Municipality, 2020; Stats SA, 2013).

Regarding improving education in Kareeberg, the respondents acknowledged that something is happening concerning education in the area, but more still needs to be done. They advised that more students should be helped financially by improving requirements by reducing the stringency of bursary applications. Respondent C/S007 said, "*...please improve on the requirements concerning the application of the scholarships.*" The belief is that not many students secure financial assistance for tertiary education because requirements are too stringent. If they were relaxed, that would increase the number of students obtaining aid. The other issue related to improving education in Kareeberg is providing free Wi-Fi to the community, especially the youth, to further their studies. The respondents knew that the project had already offered free Wi-Fi to the Kareeberg community but indicated that it should be improved, suggesting that the free Wi-Fi should not only be at the community library (Kareeberg Library) but expanded to other places that can be quickly and conveniently accessed. Respondent C/S004 said, "*The Wi-Fi at the Kareeberg Library must also move to other areas in the community because the library gets closed and when it is closed, the kids stay outside the library at the park to continue accessing the free Wi-Fi. As parents, we fear that something untoward might happen to them because they stay there until the late hours of the night. I wish the free Wi-Fi could be moved to secure areas so that the parents are assured of their safety even when the kids have to stay to access that free Wi-Fi at night."*

The primary data suggest that the impact of MeerKAT on tourism is not so significant, and there is not so much happening to develop astrotourism. Three (9.1%) KLM participants agreed with Question 9: '*Are there tour guides in Kareeberg?*'; C/S003 responded with uncertainty, "*Yes, but very few.*" However, there was overwhelming disagreement from 29 (87.9%) participants who said there was no such. One respondent did not respond to the

questions. Amongst those who disagreed, C/S009 said, "*No, I do not think so, mostly someone from the Municipality offices shows the tourist attractions in town.*" The statement means that there are no tourist guides because the officials from the Municipality do the function of tourist guides. The issue needs to be further investigated to establish its authenticity. The Question 9 responses correspond with earlier responses concerning the issue of tourism growth in Kareeberg. This matter was taken further with the small number of the respondents who agreed that there are tourist guides in Kareeberg: '*Are tour guides trained in Kareeberg?*' Two responded yes, whereas C/S004 disagreed and said the tour guides are not trained in Kareeberg but did not indicate where they are trained.

Responding to question 10: '*Are you happy with implementing the MeerKAT project in your community*?', many respondents (50.0%) said they were not pleased with the project's performance. Therefore, it was interpreted that most people in Kareeberg were not happy with the implementation of the project. The respondents raised many issues ranging from access and social to the economy when responding to the follow-up interview question: '*If the respondent is not pleased, they should state why they are not satisfied*'. Respondent C/S04 complained about access to the site saying, "*I am not happy because there is no access at the MeerKAT/SKA site for the community members*."

Respondent C/S19 and many other respondents murmured concerning the number of issues that prevailed as the result of the project in their community. One of them said, "*I am not happy with the implementation of MeerKAT because they only offer bursaries to students who are good in science and mathematics and exclude others who are not good in those subjects but talented at others*." They further protested that since the MeerKAT was implemented in the Kareeberg, the cost of living had increased, and housing and domestic product prices had significantly increased. Participants believe the cost of food, especially meat, had risen drastically because the MeerKAT/SKA project had procured several farms.

The people working in those farms that MeerKAT/SKA expropriated are now unemployed. In addition, they reported nepotism in the MeerKAT because only selected people from Kietfontein, the small area outside Carnarvon, were employed by the MeerKAT project. Respondent C/S19 informed that job advertisements and applications were not transparent because only a few community members were notified. Respondent C/S28 concurred by saying the Kareeberg community members did not secure permanent employment, but those in permanent positions are from outside the Kareeberg community. C/S91 support this perception by stating, "*No because MeerKAT brings people from outside the Kareeberg to work and does not do much for the Kareeberg community.* "The other alarming accession was from respondent C/S80, who expressed unhappiness, saying, "*I'm not happy because the project only benefits a few people and businesses within the community. The community is poorer than before the MeerKAT arrived.*" It meant that MeerKAT did not uplift the community and other community members felt they were better off before the arrival of MeerKAT.

One respondent referred to the Community Computer Centre in Karoo Hoogland as "*a white elephant*" It was a great initiative that could have earned the SALT project some points from the community, but it dampened the morale of the community because it is not optically functioning. The Community Computer Centre significantly boosted education in Karoo Hoogland, but the impact was minimal because it was not working. In improving education within the Karoo Hoogland region, the theme *'Community Computer Centre*' and *'access to free Wi-Fi'* featured prominently among the interviewed respondents.

All the interview participants responded to: '*Do you think tourism in Karoo Hoogland has improved due to the SALT astronomy mega infrastructure project?*' 45.5% believed tourism in Karoo Hoogland had improved due to the SALT project. This response was better compared to 28.1% of participants in Kareeberg who believed the MeerKAT project had

improved tourism in the region. Respondent E1 from Karoo Hoogland confirmed, "*Yes, because more quest houses were built, and more people came into our town. More people from the community work in those quest houses.*" S023 concurred, "*Yes, more guest houses were opened, and the shops did more business. Tourism has improved our area….*" However, some respondents did not agree that tourism increased. S013 complained, "*No because tourism is still only happening in Sutherland*." C/S016 explained, "*No because no one is coming to Fraserberg, and nothing is happening here.*"

An interesting aspect raised during the interviews that are further interrogated in Chapter 6 is the aspect of White areas that experience the impact of astrotourism, whereas the Coloured regions do not experience an effect or are left unchanged. According to participant S028*, "Yes, tourism improved our community, but only in White areas, not the location where the majority of Coloured people are residing."* Participant S006 corroborated these accessions in response to question 11 from the interview instrument: "*We are so poor here that white people still manage 99% of businesses in this area. Coloured people own nothing. You will not find Coloured people's shops, no 'spaza shops', not a little fruit garden, nothing. There is nothing coloured people own because there has never been any help in terms of development for coloured people.*"

Regarding tourism in Karoo Hoogland, 51.5% of participants agreed that there were tourist attraction marketing platforms in the region, which improved from Kareeberg with 33.3%. While 39.4% of respondents disagreed that there are no tourist attraction platforms in Karoo Hoogland, a decrease from Kareeberg's 60.6%. One respondent S025 did not know whether or not tourist attractions marketing platforms were available in Karoo Hoogland. Another respondent, C/S030, did not respond to this interview question. Those who responded positively, like S027, said, "*Yes, the planetarium and SALT.*" S029 replied, "*Yes, we have the Sutherland Planetariums SAAO and SALT.*" It is interesting because the people

from Karoo Hoogland believe SALT is part of the tourism attraction, whereas Kareeberg respondents could not recognise MeerKAT as a tourist attraction.

Regarding tour guides in Karoo Hoogland, an overwhelming 63.6% of participants agreed that there were tour guides in Karoo Hoogland. Even S001 responded, "*Yes, but still busy training.*" However, a few disagreed, with 30.3% of participants who said there was no such. Amongst those who disagreed, S003 said, "*No, only the permanent workers at the SALT.*" Those who disagreed did not substantiate why they disagreed. The primary data suggests tourist guides exist in Karoo Hoogland, and the SALT officials are performing this function. It is like what is happening at Kareeberg. The only difference was that instead of this function being performed by the MeerKAT employees was being done by the Municipality employees. The issue needs to be further investigated to establish its authenticity. The primary data suggests that the impact of SALT on tourism in Karoo Hoogland is significant and there is much happening to develop astrotourism.

The interview participants responded negatively to the fifth sub-research question that aimed to assess the people's perceptions concerning the MAIPs in their areas. Twelve themes were raised dominantly in the interviews. One respondent went so far as to offer solutions to the issues raised. The theme '*creation of employment*' was foremost in the participant's minds. This was followed by *'bright street lights*', '*functional Community Computer Centre with free, reliable Wi-Fi and computers*', *'provide business opportunities*', *'providing more bursaries and support to the students within the community*', *'transfer skills to the community'*, *'be transparent and provide regular information to the community*', *'provide support to their first-year bursary holders*', *'involve the community more into the project'*, *'provide an educational program to the school going children*' and lastly *'empower youth and women'*. In addition to the 12 themes considered relevant to the project, other themes were raised that did not fall within the project's ambit, indicating that some participants did not

understand the research purpose. These themes (see Chapter 4) highlight the plights of the people from Kareeberg and Karoo Hoogland, including housing, health, bursaries, education facilities, and food, water, and electricity supply.

Many respondents (46.4%) believe that the statement '*The SALT project benefited your community'* did not apply to them and 35.8% of the respondents disagreed with the statement. Therefore, these results suggested that many respondents did not feel the impact of the SALT project in Karoo Hoogland. Similarly, many (46.0%) indicated that the statement '*The SALT project benefited your household*' did not apply to them and an overwhelming 44.4% of the respondents disagreed with the statement. These results suggested that many respondents believe that the SALT project did not benefit their households in Karoo Hoogland. Therefore, the main research, stated that how the Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs was not responded positively.

However, even though most of the respondents agreed that the SALT project did not benefit the community, some believed the project did help the community in some respects. Respondent S013 had mixed feelings about the project, saying "*No, only the school in our community benefitted*." Respondent S018 agreed, saying "*Not directly, but it helped with the tourism industry in our community*." This response is essential because *'tourism development'* forms the pillar of this study, and it was interrogated further as the study progressed. S020 and S022 also added their contribution by indicating that the SALT project did not benefit the community, but it did employ a few members of the community. S020 said, "*No, not really. They gave some community members some jobs at the Centre.*" While S022 agreed, "*Not really, but they gave some people jobs*." S028 contributed to the discussion and saying, "*Not really, maybe back then when most of the older persons were getting employment, but nowadays, they do not create any employment for the community, especially*

for the youths. The unemployment rate in the community had risen." The primary data suggests that a few community members benefitted even though that number was not satisfactory as per the respondents' expectations.

Both primary and secondary data were further classified into qualitative and quantitative data sets. The data was collected from ordinary community members (within the local areas under study), and as a follow up the primary data was collected from two projects' employees and learned society. Secondary data was collected from the censuses and literature through document analysis. The literature comprised of scholarly, peer-reviewed or academic literature and 'grey' literature.

The main objective of this research was to assess the impact of the MAIPs on the development of Kareeberg and Karoo Hoogland by responding to four secondary research questions. All secondary research questions were answered, which brings us to the conclusion that the objective of the research study was fulfilled. It has been found that all four secondary research questions were negatively responded to using the primary data but positively responded while using secondary data. The primary data collection was through the lens of ordinary community members (lay people), and on those grounds, the results were negative. When using the lens of the learned society (academics, researchers, professionals, and experts within the projects), the results were positive. This is a dilemma because it puts bare the relationship between the learned society and ordinary community members within the MAIPs space.

The interpretive framework, the African Renaissance movement theory, Gandhian Philosophy, and the ToC framework for rural development revealed that the learned society operates at the outcome level of the framework whereas the ordinary community members are at the impact level. The only way to bring both communities to the same level is by forming forums that employ bottom-up and participatory strategies. Encouraging inclusivity

aligns with the African Renaissance Movement theory and Gandhian philosophy. The following chapter summarises the study, offers recommendations for further research, and concludes the current study.

Chapter 7

Summary, Conclusions and Recommendations

7.1 Summary of Research Process and Content

In indicating the importance of the mega infrastructure projects on the development of South Africa, in 2012, the MeerKAT and the SALT projects were considered one of the 18 strategic integrated projects (National Research Foundation, 2022). The strategic integrated projects directly report to the South African Presidential Infrastructure Coordinating Commission, which was a critical driver towards the delivery of the NDP. The NDP was envisaged to transform South Africa's economic landscape by reducing the persistent digital divide, creating substantial employment, strengthening the delivery of essential services, and supporting the integration of African economies (National Planning Commission, 2011).

There was a belief among other society sectors that the MeerKAT and SALT projects had undoubtedly brought positive changes to the Karoo. The projects had direct and indirect impacts at local, provincial, and national levels. The MAIPs reside and are constructed at the local level, and the strategic investments to catalyse socio-economic growth and improve the national innovation system are made at the provincial and national levels. This belief was based on various consultancy studies that had been done to measure the impact of the two MAIPs in local communities. Over the past 14 years, the NRF, through SARAO, has commissioned independent studies by universities, researchers, and government departments nationally and internationally to establish positive and negative perspectives.

Studies include, amongst others, a Strategic Environmental Assessment by the CSIR; a Scientific Study to Gauge the Socio-economic Impact and Perceptions of the MeerKAT/SKA Telescope Project by Urban Econ Development Economist (2023); an Evaluation of Alternative Telecommunication Technologies for The Karoo Central

Astronomy Advantage Area by the Academy of Science of South Africa (2021); an Impact Study of South Africa's hosting of the Hydrogen Epoch of Reionization Array (de Swardt & Zimri, 2022); Socio-economic Assessment of SKA Phase 1 in South Africa (report prepared as part of the Strategic Environmental Assessment for the Phase 1 by Atkinson & Kotze (2017)); an Impact Assessment of SKA and SKA-Related Projects on the Socio-Economic Conditions in the Northern Cape Province, the study conducted by Kayamandi Development Services (2015); Socio-economic Change in Carnarvon and Williston (a follow-up study to the 2007 study and was undertaken by the Centre for Development Support at the University of the Free State (2009)); the South African Square Kilometre Array (SKA) Project: A Study of the Tangible and Intangible Benefits to South Africa from the Design and Construction of the MeerKAT Telescope and its Possible Extension Quotec, 2008); Socio-economic Baseline Study: Carnarvon and Williston (2007) (the study was undertaken in 2007 by the Centre for Development Support at the University of the Free State 2007); and other studies focusing on the impact on the rural agriculture economy, wildlife environment, and the local economies. These studies provided valuable information on how the mega infrastructure project could be managed, particularly in rural areas. They were also pivotal in collecting data was suggesting how general stakeholder engagement should be managed to optimise positive impact.

7.1.1 Research Conceptualisation

7.1.1.1 Research Problem Statement

South Africa's government views the MAIPs not as an end in themselves but as the means for development in general, particularly in the areas where projects are being implemented (Square Kilometre Array, n.d.). Further, the government emphasised that the MAIPs should be an opportunity to put the country and the rest of Africa on a developmental

trajectory because scientific and technological developments are known to be drivers of economic growth (Hauptfleisch & Singlé, 2012; Martin & Tang, 2007; Simmonds et al., 2013; Stimson et al., 2022; Molas-Gallart & Tang, 2011). However, I viewed the analogy of the MAIPs favoured for development, especially in the areas where those projects were implemented, as paradoxical. As much as there is a huge need for development in South Africa's rural areas where those projects have been implemented, there is legislation to protect the astronomy sites and their surroundings from activities that could lead to modern development (The Astronomy Geographic Advantage Act of 2007, 2008). The question, therefore, is: How is it that the government expected MAIPs to facilitate development? The current study demystified the paradox: development should not be looked at through the lens of modernisation but through the lens of the African Renaissance movement theory and Gandhian philosophy.

Another perceived conflict is that MAIPs' proponents proclaim that MAIPs bring about scientific and economic benefits in the host country (Department of Science and Technology, 2002; Smorenburg, 2016). Those opposed to these expensive multinational projects regard them as unaffordable luxurious ventures for only the few science and engineering elites – 'big toys for big boys' - in a country like South Africa, which is riddled with a legion of social challenges, such as inequality, high rates of unemployment and poverty, and a vast underdeveloped area (Bhogal, 2018; Gastrow, 2017; Smorenburg, 2016). The gripe of those who oppose the MAIPs was that the government should not allocate funding for such expensive ventures at the expense of social challenges. The research found that this is not the case because investing in social challenges at the expense of science is perilous for the country's development.

7.1.1.2 Research Purpose Statement

This research study evaluated how MAIPs have contributed to the development of Kareeberg and Karoo Hoogland. While doing so, the research considered the posed contradiction of MAIPs and the preservation legislation, which denoted the preservation of those rural areas against development per the theory of modernisation. It has been found that modernisation theory is associated with dependency theory, trickle-down theory, linear development, and top-down strategies, which encourage more light (light pollution) and radio waves (radio wave interference) within the developing area. Therefore, to determine the impact of MAIPs on development in the areas where the infrastructures were implemented, I studied two projects, i.e., MeerKAT in Kareeberg and SALT in Karoo Hoogland. Since the study investigated the period from 2001 to 2021, the baseline for SALT is the 1996 Census and for MeerKAT is the 2001 Census and 2009 Socio-economic Baseline Study by the University of the Free State (Stats SA, 1998, 2003; University of Free State, 2009). For research questions please refer to Table 1 in Chapter 1 and sub-section.

7.1.2 Conceptual Framework

The African Renaissance movement theory, Gandhi's philosophy, Integration Strategies, and Theory of Change Framework, and FIM-DR for this research as theoretical and conceptual frameworks (refer to Figures 8, 9 and Table 2 in Chapter 2 and Figure 23 in sub-section 6.2.3). Both Gandhian philosophy and the African Renaissance movement theory provide a valuable rural development framework. Gandhian philosophy strongly emphasises the self-reliance of the communities in rural areas, decentralizes MAIPs' initiatives for development in rural areas, encourages, pursues sustainable astrotourism, improves education in rural areas, and encourages young people to get educated. Then, the African Rennaisance

movement theory focuses on cultural revitalisation in rural spaces, rural economic development, and political empowerment for people living in rural areas.

The SSA model was adapted by introducing a three-component model of change from the local area IM, RS and NS. After that modification, the model was referred to as the Ashby model, named after the inventor. In the current study, IM is adopted as a local or rural mix rather than an industrial mix (as the originator called it). The calculations may be done per locality rather than per industry.

Regional economic impact is based on local economic development defined by the World Bank (Phuravhathu, 2014; Molas-Gallart, 2015; Tiplay & Hickman, 2008; World Bank, 2020). The regional economy is also described as a procedure in which private, public, and civil organisations work together to form platforms for socioeconomic development. It measures a drive and enhancement to generate employment opportunities in local communities through large-scale science and engineering infrastructure projects (Phuravhathu, 2014; Molas-Gallart & Tang, 2011; World Bank, 2020). Projects are implemented in rural communities to address local economic development needs in several ways. First, community members are active participants in those projects; second, by attracting investment to their community; third, by lobbying developmental projects to come to the community; and last, by increasing the rate of employment and participation of local labour in the projects (Phuravhathu, 2014; Ruegg & Feller, 2003).

7.1.3 Research strategy, design, procedure, and methods

7.1.3.1 Research Strategy

I proposed using a mixed-method research strategy for this study because of my interest in triangulating qualitative and quantitative data sets. Even though the mixed-method

research strategy was the preferred method for this research, it is worth noting that it is not an easy research strategy due to its inherent many challenging factors (Bryman, 2012; J. Creswell & Plano Clark, 2007; Molina-Azorin, 2016). A mixed-method research strategy was chosen over qualitative or quantitative research strategies as it expanded comprehension of the research problem (J. W. Creswell, 2014; Goles & Hirschheim, 2000; Harrison III, 2013).

7.1.3.2 Research design

Creswell and Creswell (2018) defined the convergent or concurrent mixed-method design as one in which the researcher collects qualitative and quantitative data sets to integrate, merge, compare, contrast, and converge them, giving both sets equal value. Merging and combining qualitative and quantitative data assists in providing a comprehensive analysis and adequate response to research questions. This research design can be used for triangulating different data types to find the definitive answer; however, the researcher could explain or probe further if there are incongruencies and contradictions in research findings. This research design is also used to gain an in-depth knowledge of the topic being studied because qualitative and quantitative components of the study can independently be reviewed, while the results are interpreted together (Demir & Pismek, 2018). The current study followed the concurrent mixed method designs with the feel of ethnography and survey research designs.

7.1.3.3 Research procedure and methods

The target population was community members in Kareeberg and Karoo Hoogland. The characteristics of the population were ordinary community members consisting of the youth aged between 18 and 35 years old; adults, defined as people over the age of 35; any

disabled persons over the age of 18; community leaders such as chiefs and political leaders; farming community members in around Kareeberg and Karoo Hoogland; managers of the MeerKAT and SALT projects; workers for the MeerKAT and SALT projects; business people or entrepreneurs (e.g. guest house; hotel; shops; construction companies) in Kareeberg and Karoo Hoogland. In Kareeberg, a total of 304 respondents were surveyed, and 33 respondents were interviewed. In Karoo Hoogland, 302 respondents were surveyed, and 33 were interviewed.

Since the convergent parallel mixed-method research approach was applied, I deployed basic strategies involving the combination of qualitative and quantitative sampling in this study. The following sub-sub-sections detail this research study's sampling and data collection techniques.

Probability sampling is the probability that the researcher includes any population of research respondents in the determined sample, whereas, in non-probability sampling, the researcher does not specify the probability (Welman et al., 2005). Probability sampling enables the researcher to estimate sampling error while using non-probability sampling for convenience (Welman et al., 2005). I used purposive samples for non-probability sampling. Thus, the current study used a parallel mixed-method sampling approach, incorporating non-probability sampling methods.

7.1.4 Presentation of Research Results

Table 34, below adapted from Chapter 1, shows the secondary research questions and responses from summary of analysis of empirical collected primary data and secondary data. Empirical collected data was analysed in terms of responding to the main research question through the four secondary research questions listed in Table 1 Chapter 1. Both primary and secondary data were further classified into qualitative and quantitative data sets. As earlier

discussed the data was collected from ordinary community members (within the local areas under study), and as a follow up the primary data was collected from two projects' employees, and learned society which I referred to as government employees responsible for astronomy within the National Department i.e., DST and people working in government agencies such as NRF, SAAO and SARAO.

Secondary data was collected from the censuses and literature through document analysis. The literature comprised of scholarly, peer-reviewed or academic literature and 'grey' literature. From the 1996, 2001, and 2011 censuses analysis, the results could not give a conclusive response to the research questions. Kareeberg and Karoo Hoogland's results were the same as the results from Joe Morolong.

As earlier indicated, there was synergy in analysing primary qualitative and quantitative data because they both responded negatively to all secondary research questions. In analysing secondary data from 'grey' literature, all the research questions were positively responded meaning that there was development taking place in Kareeberg and Karoo Hoogland as the result of the MAIPs. There was synergy in all the 'grey' literature but dissonance between primary data and secondary data. In reviewing scholarly literature about the topic that is being studied we could find synergies with some literature and as well as dissonances with other literature.

Table 34. The Secondary Research Questions, Responses, and Solutions

SECONDARY RESEARCH QUESTION		PRIMARY DATA		SECONDARY DATA		PEER-REVIEWED LITERATURE	
		Response from primary data (quantitative data analysis)	**Response from primary data** (qualitative data analysis)	**Qualitative data analysis** (Organisational reports and studies based on Baseline and Socio-economic Studies) – 'Grey' literature	**Quantitative data analysis (**Census data)	**Positive response**	**Negative response**
1.	How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	Economic infrastructures refer to the physical and organisational structures that support economic activities in a place or region (Achten et al., 2019). These infrastructures include transportation systems (such as roads, railways, ports and airports), communication networks (such as internet connectivity and telecommunications), energy systems (Such as power plants and distribution networks), Water and Sanitation systems (e.g., Dams and water reticulations) and financial institutions (such as banks and stock exchanges). Economic infrastructures play a crucial role in facilitating trade, investment, and economic development by providing the necessary physical and institutional framework for businesses to operate effectively and efficiently (Burnham et al., 2017; David, 2019; Maparu & Mazumder, 2017). There has been no change in the economic infrastructures of Kareeberg and Karoo Hoogland since the introduction of MAIPs.	There has been no change in the economic infrastructures of Kareeberg and Karoo Hoogland since the introduction of MAIPs.	- Socio-economic Baseline Study Report: Carnarvon and Williston. (University of the Free State, 2007) - Scientific Study to Gauge the Socio-economic Impact and Perceptions of MeerKAT/SKA Telescope Project (Urban Econ Development Economist, 2023) - Evaluation of Alternative Telecommunication Technologies for The Karoo Central Astronomy Advantage Area (Academy for Sciences of South Africa, 2021) - An Impact Study of South Africa's Hosting of the Hydrogen Epoch of Reionization Array (de Swardt and Zimri, 2022) - Northern Cape Socio-Economic Development Report (National Research Foundation, 2022) - SAAO Annual Review 2019/2020 (South African Astronomical Observatory, 2021) - Integration of socioeconomic impact into the development of the Square Kilometre Array (SKA) in South Africa. OECD Science, Technology and Industry Working Papers 2023/07 (Adams et al., 2023)	- Censuses data list only the economic infrastructure available in the studied municipalities. Data could not be compared because it was incremental. Therefore, the question '*How have the economic infrastructures of Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?*' could not be conclusively answered.	- Bhogal (2018); - Barbosa et al. (2010); - Dalgleisch (2020); - Jacobs et al. (2019); - Jacobs et.al. (2020); - Martin and Tang (2007); - Peterson et al. (2005); and - van Wyk-Jacobs (2018). NB: **There is synergy between this peer-reviewed literature and 'grey' literature (which forms part of secondary data) but dissonance with primary data (this applies to all research questions).**	- Atkinson & Kotze - (2017); - Atkinson (2019); - ChinigÒ (2019); - Gastrow (2017); - Gastrow and Oppelt (2019); - Moodley (2022); - Parkington et al. (2019); - Twidle (2019); and - Walker (2019). NB: **This peer-reviewed literature synergies with primary data but dissonates with secondary data (This applies to all research questions).**

		NB: **There was synergy in analysing primary qualitative and quantitative data.**		NB: **The above-listed reports ('grey' literature) responded positively that MAIPs brought economic infrastructure to Kareeberg and Karoo Hoogland. There was synergy in the 'grey' literature.**			
		NB: **Dissonance arises between secondary data and primary data.**					
2.	How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs	The majority of respondents indicated that the MAIPs did not create employment for the people of Kareeberg and Karoo Hoogland.	The majority of respondents indicated that the MAIPs did not create employment for the people of Kareeberg and Karoo Hoogland.	- Socio-economic Assessment of SKA Phase 1 in South Africa. Report prepared as part of the Strategic Environmental Assessment for the Phase 1 (Atkinson 2017); - An Impact Assessment of SKA and SKA-Related Projects on the Socio-Economic Conditions in the Northern Cape Province (Kayamandi Development Services, 2015); - Socio-economic Change in Carnarvon and Williston, the study was a follow-up study to the 2007 (University of the Free State, 2009); - SAAO Annual Review 2019/2020 (South African Astronomical Observatory, 2021) - The above-listed reports responded positively that employment rates and economic participation improved in Kareeberg and Karoo Hoogland as a result of MAIPs.	- Three censuses were used in 1996, 2001, and 2011 to analyse census data from Kareeberg, Karoo Hoogland and Joe Morolong. Joe Morolong was used as a comparison municipality. The 1996 census was used as the baseline for the SALT project in the Karoo Hoogland and the 2001 census as the baseline for the MeerKAT project in Kareeberg. Four variables, change in employment rates, change in household incomes, change in income per capita and change in dependency rates were analysed. - The change in employment rates, household incomes, and income per capita from 1996 to 2001 decreased but increased from 2001 to 2011. This was corroborated by the dependency ratio which increased between 1996 and 2001 but decreased between 2001 and 2011. This behaviour is applied in Kareeberg, Karoo Hoogland and Joe Morolong. These results were not conclusive. I could not say if MAIPs had an impact or not.		
3.	How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	The data revealed that education prospects did not improve in Kareeberg and Karoo Hoogland since the implementation of MeerKAT and SALT.	The data revealed that education prospects did not improve in Kareeberg and Karoo Hoogland since the implementation of MeerKAT and SALT.	- Scientific Study to Gauge the Socio-economic Impact and Perceptions of MeerKAT/SKA Telescope Project (Urban Econ Development Economist, 2023); - The South African Square Kilometre Array (SKA) Project: A Study of the Tangible and Intangible	- Education prospects improved from 1996 through to 2011. Similar trends applied in all Kareeberg, Karoo Hoogland and Joe Morolong which was concluded as inconclusive as to whether the education prospects in Kareeberg and Karoo Hoogland changed		

				Benefits to South Africa from the Design and Construction of the MeerKAT Telescope and its Possible Extension (Quotec, 2008); - An Impact Assessment of SKA and SKA-Related Projects on the Socio-Economic Conditions in the Northern Cape Province (Kayamandi Development Services, 2015); - SAAO annual review 2019/2020 (South African Astronomical Observatory, 2021. The above-listed report agreed that education prospects in KLM and KHLM improved because of MAIPs' implementation.	since the introduction of MAIPs.		
4.	How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	The respondents believed that astrotourism in Kareeberg and Karoo Hoogland has not developed since the implementation of MeerKAT and SALT.	The respondents believed that astrotourism in Kareeberg and Karoo Hoogland has not developed since the implementation of MeerKAT and SALT.	- Scientific Study to Gauge the Socio-economic Impact and Perceptions of MeerKAT/SKA Telescope Project (Urban Econ Development Economist, 2023); - National Astrotourism Strategy for South Africa (Department of Science and Innovation, 2021); - Northern Cape Socio-economic Development Report (National Research Foundation, 2022). - Situational Analysis Report. Feasibility Study and Business Case Development for the Establishment of an Astronomy Institute or Observatory (Government Technical Advisory Centre, 2021). - SAAO Annual Review 2019/2020 (South African Astronomical Observatory, 2021)	Census data was silent on this question.		

				These reports and strategies above responded positively to the research sub-question 4.			
	Respondents' perceptions in Kareeberg and Karoo Hoogland concerning MeerKAT and SALT?	**<u>Perceptions about MeerKAT from Kareeberg:</u>** - Respondents were unsatisfied with how the project was implemented. - Respondents reported that community members were not involved in implementing the project. - Most participants were not happy with the way the project was implemented. **<u>Comments or suggestions that may be related to the project</u>**: - respondents wished the project could create more employment, - provide bursaries to more students, not just hand full as was the case at that moment, - provide widespread access to free and reliable Wi-Fi and computers, - develop entrepreneurship skills and provide business opportunities, - assist with the startup business funding, - offer vocational training to the adult population, - transfer vocational skills to the community members, - be transparent and provide regular information to the community, - involve the community more in the project, - provide support to the first-year bursary holders, - provide educational programmes to school-going children, - empower youth and women within the community. - other towns such as Vosburg and Van Wyksvlei thought they were sidelined and only Carnarvon was being serviced, and - in Carnarvon, respondents believed people from Rietfontein were preferred over people from Carnarvon. - Coloured people thought only White people were getting employed and vice versa. **<u>Comments or suggestions that may not be related to the project</u>**: - Respondents wished the project would provide housing for the community, - fix roads within the community, - provide health and sports facilities and recreational centres, - provide more ambulances, - provide bursaries for streams other than science and mathematics, - build a technical school and college within the community, - provide food parcels, free water, and electricity to the poor people in the community, - create a shopping mall in the area, - help with the drug problem and make Kareeberg safe, - provide every household with uncapped Wi-Fi, - provide school transport, and - provider sponsorship for community events.	**<u>Perceptions about SALT from Karoo Hoogland:</u>** - Respondents were unsatisfied with how the project was implemented. - Respondents reported that community members were not involved in implementing the project. - Most participants were not happy with the way the project was implemented. **<u>Comments or suggestions that may be related to the project</u>**: - Respondents wished the project could create employment, - Provide bright street lights, - provide a functional Community Computer Centre with free and reliable Wi-Fi and computers, - provide business opportunities to the community, - provide more bursaries and support students from the community, - transfer vocational skills to the community members - be transparent and provide regular information to the community, - provide support to the first-year bursary holders, - involve the community more in this project, - assist with a crime in the community, - provide an educational programme for school-going children, - provide tours of the project to the community. - The people from Fraserberg and Willston believed people from Sutherland were prioritised, **<u>Comments or suggestions that may not be related to the project</u>**: - Respondents wished the project could provide housing for the community, - fix roads within the community, - provide health and sports facilities and recreational centres, - provide more ambulances, - provide bursaries for streams other than science and mathematics, - build a technical school and college within the community, - provide food parcels, free water, and electricity to the poor people in the community, - build a shopping mall in the area, - help with the drug problem and make Karoo Hoogland safe, - provide every household with uncapped Wi-Fi, - provide school transport, and - provider sponsorship for community events.		

Main research question	**Main response**
How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs?	- From primary data, none of the four secondary research questions were positively responded to. - Using secondary data from the 1996, 2001, and 2011 censuses was inconclusive because the comparison municipality was behaving the same way as the studied municipalities. - Using secondary data from institutional reports and studies, I found that the secondary research questions were positively responded to. This is supported by the follow-up interviews of the learnt society for the projects. - The data supporting a positive response sample was from the people who are associated with the project, and the data supporting a negative response sample was from the ordinary members. This called for dissonance in the research sample The response to this research question varied depending on which lens was used raising dissonance. The convergent parallel mixed-methods approach allowed me to look at this research problem all around using different methods. The challenge dealing with the dissonance by bringing the different communities together to ensure that regardless of the perspective used, the results are consistent. Understanding the Theory of Change helped the situation.

Kareeberg: Kareeberg Local Municipality; Karoo Hoogland: Karoo Hoogland Local Municipality; MAIPs: Mega Astronomy Infrastructure Project; MeerKAT: More Karoo Array Telescope; SALT: Southern African Large Telescope.

7.2 Conclusions of the Research

7.2.1 Empirical Research Findings and Perceptions

7.2.1.1 Discussion of the Empirical Research Findings

The qualitative and quantitative analysis of primary data collected from the survey, interviews, and observation found that none of the four secondary research questions were positively responded to. Hence, from the primary data, the MAIPs have not positively impacted development in Kareeberg and Karoo Hoogland. This result had been corroborated by the secondary data in the form of census data which revealed the economic growth that had happened in Kareeberg and Karoo Hoogland could not be justified that it was as the result of the MAIPs. This was so because Joe Morolong, the comparative group, showed similar characteristics as Kareeberg and Karoo Hoogland. I noted that this result was acquired by looking through the lens of ordinary people in Kareeberg and Karoo Hoogland who formed the majority of the sample. Literature that supported this result (Atkinson & Kotze (2017); Atkinson (2019); ChinigÒ (2019); Gastrow (Gastrow, 2017); Gastrow and Oppelt (2019)); Moodley (2022); Parkington et al. (2019); Twidle (2019); Walker (2019) sampled the ordinary community in the current study.

The secondary research questions were positively responded to using secondary data from the organisational reports and authorised studies (studies by consultants), as indicated in Table 34, suggesting MAIPs' positive impact on development in Kareeberg and Karoo Hoogland. Once again, the literature that supports this result (Bhogal (2018); Barbosa (2010); Dalgleisch (2020); Jacobs et al. (2019); Jacobs et al. (2020); Martin and Tang (2007); Peterson et al. (2005); van Wyk-Jacobs (2018)) sampled mostly respondents who were directly involved in the MAIPs. Furthermore, the census data (1996, 2001, and 2011) could not give conclusive answers.

The dissonance between the primary and secondary data poses a question. The convergent parallel mixed-methods approach allowed the researcher to investigate the research problem all around using different methods, further interrogating the main research question by collating a small sample of 16 knowledge respondents within the MAIPs: telephonic interviews were conducted with two government officials from DSI and NRF each dealing with MAIPs daily, two senior managers from SAAO and SARAO each, two middle managers from SAAO and SARAO each, two low-level staff from SAAO and SARAO each. The findings from interviews corroborated the results from the secondary data analysis, suggesting that the reports and studies used to obtain secondary sampled knowledge workers rather than ordinary people.

Therefore, this research revealed that the impact of MAIPs on development in rural areas is based on which lens is used to investigate the problem. If the researcher used the lens of knowledge workers, a positive impact would have been concluded, but using the lens of ordinary people, the results would be negative. How can the results be convergent despite the lens used? This question forms part of the study's recommendations.

7.2.5.2 Perceptions

What are the respondents' perceptions of Kareeberg and Karoo Hoogland concerning MeerKAT and SALT? The Kareeberg respondents perceived that MeerKAT does not hire people from the Kareeberg but brings people from outside the community; job advertisements and applications were not transparent; and only a few selected people were employed. They believe the Kareeberg community is poorer with MeerKAT. The people from Van Wyksvlei and Vosburg have a strong perception that those employed were from Carnarvon. The people outside Carnarvon think only Carnarvon people get employed, while those from Carnarvon

think people from outside Carnarvon are the ones that were being employed. The White people also think only Coloured people are employed.

Most respondents from Kareeberg and Karoo Hoogland did not see any benefits of MeerKAT and SALT because community members were still some of the poorest of the poor in the country. They felt like they were being side-lined for not being Black because today's government only looks after Black people. During apartheid, they were side-lined because they were not White. This perception was born out of misunderstanding or misinformation that MAIPs were government interventions to assist people in alleviating poverty in those areas where MAIPs were being implemented.

The other issue raised was the ownership of means of production, which indicated that community people, predominantly Coloured people, owned nothing in Kareeberg and Karoo Hoogland. For example, there were no grocery stores, even small stores like spaza shops, lodging facilities such as bed and breakfasts or motels, or a little fruit garden for community people. This was insinuated because there had never been any help in terms of development for community people.

The other thorny issue was that the Community Computer Centre, especially in Karoo Hoogland, was not functioning optimally as expected. The respondents murmured that the Computer Centre in town is a white elephant because the users, which are mostly school-going children, did not use the Centre anymore because it was closed most of the time and even when it was open, most or none of the computers were functioning. The Centre was poorly maintained, and no one bore the maintenance responsibility.

The participants also raised that, seemingly, the MAIPs management did not trust the SMMEs in Karoo Hoogland and Kareeberg because the SMMEs were not considered legitimate for contracts. Rather, SMMEs from outside Kareeberg and Karoo Hoogland were

acquired from jobs relating to the MAIPs, even if there were SMMEs that had skills and experience within the communities. The only opportunities they were given were for subcontracting for labourers' jobs. At times, those companies that were brought into Kareeberg and Karoo Hoogland did not hire people from the community but brought their own from outside the community.

7.2.2 Research Knowledge Gap Analysis

The MAIP-favoured development according to modernisation theory, especially in the areas where those projects are implemented, was seen by opponents as paradoxical. To understand rural development using MAIPs, I borrowed some models from economic studies for growth and projects that deal with inputs and outputs of different economic sectors' financial interventions: the African Renaissance movement theory, Gandhian philosophy, Integration Strategies, and Theory of Change to be used as theoretical and conceptual frameworks. Refer to Figures 8 and 9 in Chapter 2. Both Gandhian philosophy and the African Renaissance movement theory provide a valuable rural development framework. While Gandhi's philosophy emphasises self-reliance, decentralisation, sustainable agriculture, and education, the African Renaissance movement model focuses on cultural revitalisation, economic development, and political empowerment.

7.2.3 Contribution to the Knowledge Gap

The literature review found that limited research has explored the long-term socioeconomic effects of astronomy-related initiatives such as MAIPs on rural communities. This assertion has been alluded to by Absher (2022) and Aveni (2009); while some studies have examined the immediate economic benefits of astrotourism, there is a lack of comprehensive research that investigates sustained economic growth, job creation, and

economic infrastructure development resulting from astronomy programmes, such as MAIPs even long after they were gone. This could be brought by building economic infrastructures that would remain in communities many years after the MAIPs were decommissioned. Research secondary question one aimed to establish if there would be a long-term socioeconomic impact of MAIPs in Kareeberg and Karoo Hoogland. The secondary research question was negatively responded to and positively responded to using the secondary data. Considering the interpretive framework, primary data is situated at the impact level, while the secondary data is at the outcome level (refer to Figure 23 below which is a modification of Figure 9 from Chapter 2). The researcher-named FIM-DR is adopted from ToC, the African Renaissance movement theory, and Integration Strategies.

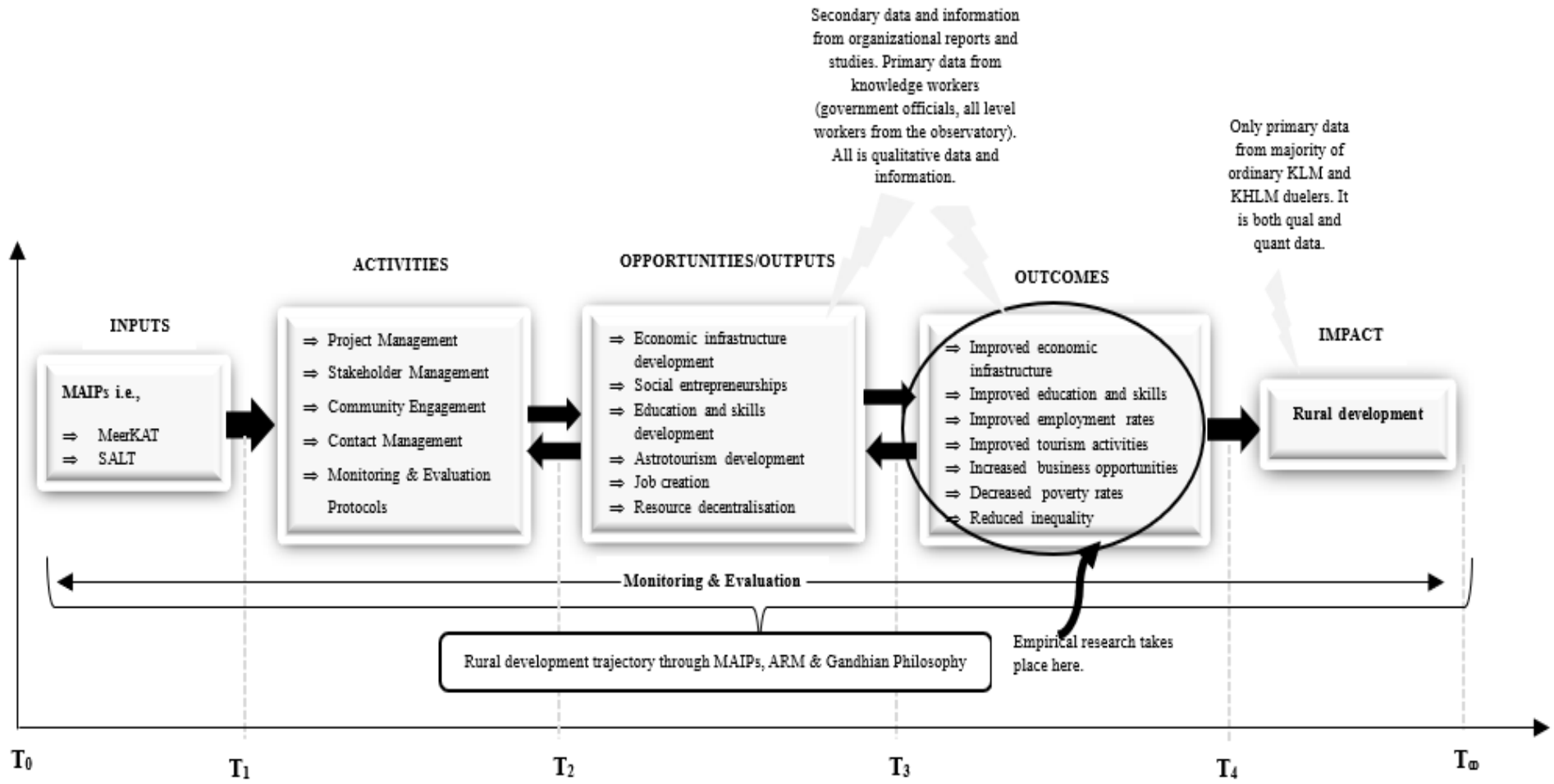

Figure 23. Framework for Impact of MAIPs on Development in Rural Areas (FIM-DR)

Qualitative and quantitative data sampled from most ordinary community members disputed that the MAIPs could have long-term outcomes (impacts) in the areas where the MAIPs were implemented. However, secondary data and information sampled from organisational reports and studies from the knowledge society indicated a positive impact of MAIPs on development in rural areas. This assertion was corroborated by a carefully selected sample of knowledge workers. The difference in sampling brought together two worlds that seemed to be far apart, and the challenge was how to merge them. The FIM-DR is proposed because it has the elements of community-sustainable-human development approaches due to inherent Gandhian philosophy, which brings self-reliance, decentralisation, and sustainability through tourism, and education. The suggested framework is also inherently based on the African Renaissance movement theory which focuses on cultural revitalisation, economic development, and political empowerment.

Dalgleisch (2020) and Sidorenko (2009) agreed that more research was needed to understand how astronomy initiatives empower rural communities such initiatives are taking place. Also, such astronomy initiatives enhance rural community capacity for self-governance and decision-making, including studying the impact of astronomy programmes on community cohesion, leadership development, and the ability to drive local development initiatives. Tourism is the low-hanging fruit for MAIPs; hence, the Department of Tourism should also be involved. According to Fayos-Solá et al. (2014), developers may use tourism to develop rural areas. This possibility becomes real because of MAIPs. Astronomy enthusiasts travel worldwide to visit the MAIPs and for site viewing. According to Fayos-Solá et al. (2014), astrotourism, well managed, may contribute to technological spin-offs, human capacity development, education, school improvement, and rural development and plays a critical contribution to the tourism sector, particularly in areas where MAIPs are situated, the rural part of South Africa. Astrotourism might be key for development in rural

areas. van Wyk-Jacobs (2018) in her thesis addressed tourism routes for the development of the areas; the current study addressed the issue of astrotourism driving rural development.

Another important issue investigated by the current research is the impact of MAIPs on education in rural areas, though the impact of education has been widely investigated. Literature (Alkire & Santos, 2010, 2014; Chambers, 1994; Sen, 1999; World Bank, 2018) has shown that good education could play an important role in rural development; therefore, the current study looked at the impact of MAIPs on education. Further literature has stated that good education is a fundamental driver of rural development, empowering individuals, fostering economic growth, and promoting social progress (Organisation for Economic Co-operation and Development, 2018, 2019; United Nations Educational, Scientific and Cultural Organisation, 2003, 2018). Also, to achieve inclusive and sustainable rural development, it is essential to prioritise education as a fundamental pillar of rural development strategies; hence, it is paramount to investigate how MAIPs impact education in rural areas. It was found that the MAIPs had invested in the education of the communities, but the impact was yet to be felt. Education plays an important role in the suggested framework.

7.2.4 Future Planned Interventions and Projects for MAIPs

According to the NRF (National Research Foundation, 2022) and SARAO (South African Radio Astronomy Observatory, 2020), various opportunities will arise through ongoing development and construction activities over the next few years. The appointed contractor, Concor, was working with local stakeholders to identify and facilitate opportunities. In the short term, significant investment would be undertaken through the MeerKAT+ project, with up to 30% of the value of the infrastructure contract aimed a local contractor participation. The MeerKAT+ has 64 dishes - the MeerKAT expanded by 20

dishes for R800 million. The expansion resulted from a partnership between South Africa, Germany, and China.

SARAO has committed to creating an enabling environment that would position local contractors to participate in opportunities in their local areas. The enabling environment could be done by identifying challenges experienced by SMMEs concerning procurement opportunities made available by the MeerKAT+ project. SARAO has undertaken many interventions to create an enabling environment for local SMMEs to participate in, which include, amongst others: 1. The three-year partnership with the SMME Trust, SARAO formed a partnership with Northern Cape SMME Trust to provide local entrepreneurs with long-term support. It was a natural partnership considering that the Trust's sole mandate is to support the SMMEs in the Northern Cape. The collaboration agreement of SARAO of the Northern Cape SMMEs Trust was to share resources to support the local SMMEs. Northern Cape SMME Trust's contribution to the collaboration agreement was a full-time human resource that would be based in Carnarvon to assist SMMEs from Carnarvon, Van Wyksvlei, Brandvlei and Williston in compiling Request for Quotation (RFQ) documents and tenders advertised in the area by any entity including SARAO and SAAO. This collaboration would also ensure ongoing training and business development support for local SMMEs. 2. SARAO identified the Small Enterprise Financial Agency (SEFA) as a funding partner that would assist local businesses with funding for them to participate in tenders and RFQ. SARAO and SEFA were busy developing a Memorandum of Understanding to support a long-term engagement. 3. SARAO also approached the Small Enterprise Development Agency (SEDA) for a colocation partnership opportunity, ensuring that SEDA avails resources in Carnarvon to assist SMMEs in the Kareeberg. The resources from SEDA and Northern Cape SMME Trust would complement one another in supporting the SMMEs. 4. SARAO was planning to compile a procurement plan that would be shared with all local

SMMEs quarterly detailing the upcoming RFQs so that SMMEs could plan and position themselves for the opportunity. 5. In future, for SARAO tenders, the bid specifications would encompass the following: the appointed main contractor will have a detailed scope of work for subcontractors, and that scope of work should outline how the local SMMEs would participate in the contract and show deliverables, milestones and show how the budget would be distributed to the subcontractors. The monitoring and evaluation plan would be developed by SARAO and discussed with the main contractor before it was finalised. SARAO would facilitate the method with the main contractor to enable subcontractors to access funding from SEFA.

SARAO was working closely with the current MeerKAT+ contractor to ensure local SMME participation in the contract and the established partnerships with Northern Cape SMME Trust, SEDA and SEFA to support the environment. The aim of ongoing training and business support in local communities was to ensure that local suppliers and contractors increase their odds of being able to take part in procurement opportunities. Concerning methods that could be applied in the procurement process regarding SMMEs being actively involved, SARAO would play an oversight role in monitoring achievement against targets.

The DSI, in collaboration with the Department of Tourism, just finalised the National Astrotourism Strategy (Department of Science and Innovation, 2021), in which several tourism projects were suggested. In the next three years, construction projects will emanate from the following projects: Construction of the Hydrogen Intensity and Real-time Analysis eXperiment (HIRAX), a radio astronomy facility funded for R70 million; the SKA-Mid and the infrastructure contract alone have been estimated budget of approximately R1 billion; the MeerKAT National Park fencing at the valued at R60 million; the upcoming SKA visitor centre construction at the value of R60 million. Several local SMMEs would participate in these projects. However, there would be minimum local SMME participation requirements.

SARAO is committed to continuing and intensifying the following programmes: SMME development programmes; the school's projects and grants; the community development grants; and providing supplementary communication methods to the affected farmers. These future projects outlined above will be in addition to SARAO's current programmes. The current and future projects and initiatives will contribute to the country, particularly the Northern Cape, with a specific focus on Namakwa and Pixley Ka Seme Provincial Municipalities and the three Local Municipalities surrounding the SKA site. There would be opportunities to contract, subcontract, or personally work for those projects. The SKA and SARAO projects are envisaged to run for at least the next 50 years, providing long-term opportunities for the local communities on an ongoing basis if things can be done differently as opposed to business as usual.

7.3 Limitations of the Research

The primary data was collected from Kareeberg and Karoo Hoogland. The data collection tools, i.e., interview schedules, survey questionnaires, and observation were compiled in English. English is the language that I, the researcher, and data collector, am competent to use. I then acquired the services of a professional translator to translate the English data collection tools to Afrikaans so that they could be used with ease at the site. Kareeberg and Karoo Hoogland are dominantly Afrikaans-speaking municipalities, meaning that most research participants would be conversant with Afrikaans.

The original plan was to acquire the services of two assistant researchers per site to assist with the collecting of data and translating Afrikaans to English or vice-versa. That plan was to achieve 300 questionnaires and 60 interviews per ten days per Study. The planned allocation was 20 days per site, 21 questionnaires per research assistant per day and one interview per research assistant per day. Due to time and financial constraints for myself to

be on-site, the plan was revised to three research assistants, ten days per site, 30 questionnaires per research assistant per day and three interviews per research assistant per day. The revised plan was successfully executed.

Initially, I was scheduled to be at each site for 20 days, but this was later reduced to 10 per site due to high, unaffordable lodging costs. To balance the budget, the number of days was reduced by half, and an additional research assistant was hired to help with data collection. However, the on-site observation time, which was part of the qualitative research on the site, was also significantly decreased and thus compromised the qualitative part of the research approach. To successfully achieve the revised plan, I could not be in every interview or survey session because of time constraints but I attended more than half of the interviews and surveys.

The three research assistants' minimum qualification was Grade 12, and they conversed in English and Afrikaans and resided in the study-site communities. In most instances, the interviews were conducted in Afrikaans and interpreted back to English. Conducting the survey and interviews in the same community where they lived might have had a positive impact because they could have understood the community's culture. Still, it might have a negative impact because the research respondents might be biased because of their familiarity with the research assistance. To avoid that bias, it was initially planned that the Kareeberg-based research assistants would work in Karoo Hoogland, and the Karoo Hoogland-based research assistants work in Kareeberg, but the research budget did not allow that. The research assistants from Kareeberg had to work in their area to reduce the travel or lodging costs because the areas are far apart.

The minimum qualification for the research assistants was Grade 12. The post-Grade 12 qualifications were advantageous. All six research assistants (three for Kareeberg and three for Karoo Hoogland) were sourced by the Sustainable Tourism Partnership Programme

company, which was going to the Northern Cape and understood the issues. DSI had appointed the company before to do the study in the area. The company was given a brief on what type of people it should source, and after sourcing them, it trained them according to the brief. I observed that the research assistants were well-trained for the task and executed it well. I relied solely on research assistants for interpreting Afrikaans to English. Hopefully, it went well, and there was no loss of the meaning of the expressions while translating from one language to another.

Despite these issues, I still assumed that the data and information collected were not defective but reliable because the research respondents were honest and truthful. The changes in local government in Kareeberg and Karoo Hoogland did not affect the research. The new local government incumbents at the time honoured their predecessors' agreement, permitting me and my research assistants to conduct contact research in the Kareeberg and Karoo Hoogland. The authorities within the Kareeberg and Karoo Hoogland could not become renegade on the predecessor's promise but allowed the study to be conducted within their communities.

The other concerning issue was the latest population and housing census. Census 2022 was done between February to March 2022. This census was expected to be done in 2021, but it was postponed due to the COVID-19 pandemic and lockdown regulations. According to Stats SA (2022), Census 2022 was the first digital population count, and the results are not yet available to the public, so they could not be used in this research. Census 2022 could have enhanced this research.

Leedy and Ormrod (2010) mention that two assumptions form the basis of every study: the investigation of the phenomenon should be comprised of random events that are predictable and lawful, and some cause-and-effect relationships might have accounted for observed patterns in the spectacle. These assumptions also form the basis of the current

study. I aimed to avoid assumptions and be explicit about limitations and assumptions in this thesis.

7.4 Recommendations

To begin, stakeholder management and collaboration initiatives are paramount. Therefore, the primary data has shown that the MAIPs will not be able to immediately impact the development in rural areas where projects reside. For immediate impact, the suggested FIM-DR (Figure 23) and ToC framework for development should be utilised. The policy and strategy should be developed based on the proposed framework and model and all stakeholders must be mapped.

MAIPs have a wide range of stakeholders, from the government (national, provincial and municipal) to anybody interested in directly and indirectly affected; hence the focus is only on critical stakeholders. The key stakeholders (internally or externally) have a direct relationship with the projects and, if not well managed can negatively impact the project. Identifying and addressing the stakeholders can be cumbersome but must be thoroughly done because it can determine the success or failure of the project. (see, for example, according to Nicholas and Steyn (2012) and Steyn et al. (2013)). Refer to Appendix G, Table 55 for the identified internal and external key stakeholders. Table 56 shows the involvement of each stakeholder in the project. This table will assist in analysing the external stakeholders in Table 57 and the strategy for managing the stakeholders with high interest and power in the project is outlined in Table 58.

All stakeholders' involvement (Appendix G) is suggested to be used as a stakeholder mapping tool in which the stakeholder's purpose and the importance of the stakeholder will be noted. The strategy should create a conducive space for internal and external stakeholder management and collaboration. A platform to support all stakeholders should be created in

which all can be engaged as partners in important issues, such as project planning, budgeting, and resource management. It is necessary to invest time in quality meetings and workshops with all representatives of all stakeholders to share information on all aspects of the projects so that all stakeholders are informed of all the project developments.

The SARAO strives for community engagement principles based on responsiveness and reciprocity, inclusivity, impartiality and objectivity, openness, transparency and trust, and respect (National Research Foundation, 2022; South African Radio Astronomy Observatory, 2020). Therefore, it is recommended that SAAO adopt a similar approach as SARAO. To understand that stakeholders' engagement is a two-way process and appreciate the benefits of mutual learning between stakeholders, partners, and the MAIPs. This action is responsiveness and reciprocity. On inclusivity, in which no one has been left behind, the SARAO committed to seeking out and facilitating the involvement of those who are potentially interested or affected by the MAIPs' work, including those that are not easy to reach for reasons such as language, culture, age, or mobility. On the impartiality and objectivity principle, SARAO will ensure that information is accessible and objective and facilitate engagement with all stakeholders who have an interest. On openness, transparency, and trust, SARAO commits to providing timely information so stakeholders can participate meaningfully and foster a culture of sharing ideas. Lastly, with respect, SARAO is willing to value stakeholders and use their input to improve community involvement. The MAIP will actively listen to and understand stakeholder needs, seeking to understand how the stakeholders want to be engaged in their circumstances.

7.4.2 Policy Implication

According to the NRF (National Research Foundation, 2022) and SARAO (South African Radio Astronomy Observatory, 2020), predicting exactly how much money will flow

into local communities is by no means an exact science which means that it is not easy to predict exactly who is going to benefit. That said, it is paramount for local communities and leadership to organise themselves to work with SARAO to position local communities for optimal benefit from MAIPs and their development initiatives. In this regard, the optimal development framework should be developed by SARAO in consultation with the communities.

SARAO is committed to continuing investment and support in the identified strategic areas, which the DSI's District Development model will also guide. These investments are made by different entities in the local communities to be monitored through the DSI's District Development model. The model will ensure that other DSI entities collaborate to provide optimal investment through partnerships.

It should be noted that astronomy is a fundamental science and is not profit-driven. It is a well-coordinated approach across the globe and is structured in line with the researchers' enthusiasm, the capabilities of facilities, and the benefits of collaboration. There is a broad community of scientists collaborating domestically and internationally in areas of interest and where capacities and funding are available.

Pursuing cutting-edge astronomical questions (such as the fundamental nature of physics and reality and planets and life in the universe) requires expensive research infrastructure that is usually beyond individual institutions and requires national and international collaborations. Given the cost of developing and maintaining mega astronomy infrastructure facilities, their provision is dominated by multiple governments and large institutions. As earlier stated, the work of astronomers is also primarily funded by governments and large institutions, and significant research budgets are usually associated with specific research programmes.

Astronomy has specialisations but pursuing science using the best tools (multi-wave and multi-carrier) is pervasive. The 'multi-wave' approach is a reality driven by individual research projects to do the best possible science. In addition to the concurrent use of multiple technologies in research programmes, facilities, and instruments, are co-locating these technologies and increasingly, facilities and instrumentation are being developed with multi-wavelength considerations.

Increasingly, scientific research infrastructure should be seen as part of society, not as a partner. There are benefits to society derived from astronomy, both domestically and internationally, but these do not drive the science strategy; they are a necessary, meaningful, and valuable adjunct to scientific exploration. Although they do not drive the science strategy, they increasingly drive the organisational strategy, delivering a clear, visible impact to society. For example, the National Ventilator Project is hailed globally as an excellent example of the impact of research infrastructure on society. It was only enabled through the availability of a skills profile established to deliver a radio astronomy facility. Retaining such a skills profile depends on ongoing technology development and project delivery. As a result, a broader and increased mandate would enable sustainable retention of such a skills profile.

Countries organise differently to provide for and pursue astronomy – there is no right way. Ultimately, this is essentially a self-organising function with many role players.
In the South African context, the government plays a foundational and enabling role, triggered by broader scientific interests, geographic advantage on the world stage, and recognition of the value of being an international player. There is recognition by the government regarding the importance of and an associated pursuit of human resource development and socio-economic benefits associated with astronomy and derived from astronomy activities. Although supported by the government, the larger fundamental

research output and human capital development implementation are actioned outside of government. The government's most prominent roles are the provision and maintenance of astronomy facilities for broader utilisation, the protection of astronomy geographic areas in pursuit of sustaining clear skies necessary for astronomy, directing resources in support of human capital development, providing a platform for commercial spin-offs from the technical aspects of astronomy, and directing, through the provision of resources, the pursuit of socio-economic benefits derived from astronomy.

These roles by the government are played out on the international stage. The government has proven the significance and relevance of domestic astronomy capability it has enabled over decades. Three perspectives emerge from this: government provides and directs, through the provision of resources, the astronomy strategy of the country in the context of global astronomy. The National Strategy for Multi-Wavelength Astronomy and Decadal Plan epitomises the more recent concretisations of this strategy. Notably, the formulation of these documented strategies, which the DSI owns, is crafted with significant advisory participation of the scientific community.

The astronomy community of government and other scientists use the national research facility capability, alongside additional smaller instruments, worldwide facilities, and collaboration with domestic and international scientists to pursue astronomy. The government implementation of astronomy is distributed among various government role players (DSI, NRF, SAAO, SARAO and, to a degree, SANSA), which in some minds is fragmented and uncoordinated to a degree.

Therefore, the policy to coordinate the government's efforts in astronomy is needed and to be intentional about how to derive societal benefits from astronomy projects. The other thorny issue that needs to be considered is the coordinates of stakeholders as per the suggested stakeholder management. Government departments are working in silos. They

also need some coordination mechanism so that departments can work together to support a common goal of reducing poverty, unemployment, and the highest inequality. The other phenomenon that needs to be avoided is leaving the Kareeberg and Karoo Hoogland towns as ghost towns when the era of astronomy ends. The experience of former mining towns in South Africa is that the cities were left as ghost cities when the mining was done. The towns became so dependent on mining during the mining period, and there was no strategy on what would be done to keep the towns booming when the mining period ended.

7.4.3 Proposed Future Study

There is a disjuncture between what is happening on the ground by MAIPs and the communities. According to the reports, there is much that MAIPs are doing to uplift the communities in their vicinity. Still, the communities did not feel that anything was being done, meaning that the communities did not experience the impact. In the next ten years, another impact study should be undertaken to assess if the positive impact would have been experienced as the MAIPs are long-term projects. For example, the SKA is predicted to be in operation after its completion for 50 years. It will also take a long time to complete the project, 10 to 20 years under construction. The following section concludes this research and describes the study tour to Wits Rural Knowledge Hub, which was established in 1989 and has vast experience in rural development and added immense value to this study.

7.5 Final Concluding Remarks

As this research study focuses on rural development, Prof Mzukisi Qobo (my supervisor) suggested I visit the Wits Rural Knowledge Hub to spend some time and interact with the researchers at the Hub, to get exposure to the work done there, and hope to enrich my research. I visited the Hub for two weeks; the first visit was from Monday, 04 to Friday,

08 April 2022. The second visit was when the Centre on African Philanthropy and Social Investment (CAPSI) hosted a PhD Methodology and Writing Workshop, which took place from Monday, 29 August to Friday, 02 September 2022, at the Hub. The workshop was opened to PhD students registered at any African university looking for coaching to support their academic research and writing development. Students were coached by academics from Wits Business School, one of the leading business schools in Africa (University of the Witwatersrand, 2022a). I applied to attend the workshop and was successful.

The Wits Rural Knowledge Hub is in Acornhoek, Mpumalanga, established in 1989 (Wits, 2022). The plaque outside one of the seminar rooms reads as follows: "This *commemorates the 30th anniversary of the establishment of the Wits Rural Facility in 1989 by its founders, Professor John and Mrs Joan Gear. This campus, and the impactful interdisciplinary research, student training, and community engagement it has enabled and promoted for three decades are a tribute to their vision. The Anglo-American and De Beers Chairman's Fund is acknowledged for a generous donation that enabled the University of the Witwatersrand to purchase the Umbabat property in 1988 and for providing a significant proportion of the funding to the first four years of operation of the Wits Rural Facility (1989 - 1992). The construction of the new meeting, accommodation, dining, and laboratory facilities (2014 – 2019) was funded by the National Departments of Science and Technology and Higher Education and Training to transform the Wits Rural Campus into a Knowledge Hub for Rural Development. This plaque was unveiled on 6 September 2019 by the Vice-Chancellor and Principal of the University of the Witwatersrand, Professor Adam Habib."*

During my first visit to the Hub, I had several meetings with the Head of Research, Prof. Wayne Twine, and several Hub stakeholders. Prof Twine advised that the main research themes of programmes using the rural campus as a base were public health, socio-economic development, and ecology/environmental sustainability.

Prof Twine explained that the Hub had operated for over 30 years as a hub of knowledge – a platform for creating new knowledge. However, he emphasised that the Hub should not be disguised as a development agency, NGO, or local government. He further emphasised that, yes, the community in which the Hub is situated might expect that it delivered societal value. Nalewaik and Williams (n.d.) defined societal value as integrated environmental and social value. Societal value, in a nutshell, is sustainable development its delivery needs are the co-creation of value outcomes with community stakeholders and the environment in addition to the functional benefits of the venture. However, he posited that those expectations were unrealistic and not fair to be put on the Knowledge Hubs or MAIPs. Such expectations need to be closely managed. He advised that the expectations could be controlled by partnering with the communities involved and explaining to those communities the actual mandate of the hubs or the MAIPs.

Prof Twine believed that the hubs and MAIPs should not be expected to fill the gaps left by local government authorities that had failed to provide services to the communities. At times it seemed that the Local Municipalities relaxed with the expectation that the hubs or MAIPS within their vicinity would fulfil its primary constitutional mandate. The local government's direct mandate is to provide service delivery to the communities, which should be done despite whether hubs or MAIPs are in the vicinity. In South Africa's case, there is a legitimate perception of the high rate of corruption in local government, which impedes proper service delivery to the communities.

However, hubs or MAIPs vicinities, most in rural areas, need to assist the communities in their setting. According to Matasane and Zaaiman (2022), societies in rural spaces remain most affected by poverty challenges. They have challenges of access to economic activities, a high unemployment rate, educational challenges, and vulnerabilities. There seems not much done or successfully done to uplift rural people out of extreme

poverty. As much as the knowledge hubs and MAIPs are within the vicinity it's not their primary mandate to lift people out of extreme poverty, but they have a moral obligation to assist those communities where they are implemented. Therefore, the Wits Rural Knowledge Hub, like MAIPs such as MeerKAT/SKA and SALT, are the platform for knowledge development through research. The communities should be research partners, not the research subjects only.

Hubs and MAIPs have a moral obligation to communicate their research results to the community so that the results are helpful to the community – in a simplified way that the community can comprehend and make meaningful use of the research results. The research results could be used to inform policy in general and in the local space. At times, some benefits to the community are intangible, and spin-offs, such as visiting researchers giving talks, can be of interest to the community and sharing research results with the community in a way that can be useful to the community. Students in rural areas do learn science as abstract and facts without practicality. Most schools do not have science laboratories, but interacting with scientists could give the students an idea of what it is to be a scientist and what the scientist is doing. That interaction could come in handy and be of value to the students who may be aspiring scientists. The Wits Rural Knowledge Hub and the MAIPs could bring exposure to their host communities. This exposure would not have been attained if it was not for the Hub and MAIPs. Were these benefits, no matter how small or intangible they were, filtered down to people on the ground? The response: Not as expected. The other challenge with the knowledge hubs or MAIPs was that it could not be predicted before time which societal ills would be able to be dealt with or the MAIPs or hubs' spin-offs, for that matter.

Development in rural areas may improve people's living conditions through access to good amenities, such as roads, reliable energy, water provision and sanitation, education,

health facilities, employment, knowledge and information, and affordable connectivity. Hence, it would be unfair and unrealistic to expect knowledge hubs such as Wits Rural Knowledge Hub and MAIPs such as SALT and MeerKAT to fulfil such development tasks in rural area objectives. That is the work for development agencies, NGOs, local governments, the Department of Land and Rural Development, and the Department of Cooperative Government and Traditional Affairs. The knowledge hubs and MAIPs could assist with coordinating these bodies that are constitutionally tasked to bring development to the area where projects are being implemented. Access to amenities can result from spin-offs, but the knowledge hubs and MAIPs can help with access to knowledge and information and access to connectivity. The MAIPs like knowledge hubs, do vital research that the country and the world need, but they face dire societal challenges. The tussle is how MAIPs focus solely on their mandate to create or develop knowledge and ignore those societal challenges outside their mandate. The other question is how the knowledge they create filters down to the community in a way that can be useful to the community.

Prof Twine warns that South Africa cannot aspire to be a knowledge-based society and move away from heavy reliance on a resource-based economy if it only concentrates on what he referred to as a third-world development. He emphatically indicated that the knowledge economy is still small in South Africa and needs to grow. However, he also cautions against pursuing knowledge development at the expense of social development. South Africa should also invest in what he referred to as first-world developments, such as knowledge hubs and MAIPs.

He added that to expect mega science infrastructure or knowledge hubs to solve societal challenges such as poverty, inequality, and unemployment, is an unrealistic expectation. These MAIPs give bursaries to promising students in the communities and provide the opportunity for internships and learning jobs. Their immediate contribution,

which is aligned with their mandate, is access to information, giving young people confidence about their prospects - which Prof Twine termed a vision of possibilities and self-worth by seeing and interacting with professionals, which could not happen if it was not only for the hub or MAIPs being in their communities. He cautions that most students from rural settings find it difficult to make it through their first year at university. Most of the universities in South Africa are situated in big cities, which is, in most cases, a scare to those young ones who have lived all their life in rural settings. The transition between rural and city, school, and university life is challenging for young people. I also picked up this issue on 22 March 2022 at the Community Meeting and Public Participation in Carnarvon at the Kareeberg Library. Most SARAO-funded students did not make it through the first year of their university study. Those whose parents were poor and did not have the means to pay for their university fees got lost by the system for good and became hopeless. The community was requesting SARAO's intervention in this regard. Prof Twine suggested peer support should be provided to these students, perhaps in the form of senior students, probably those who were also supported by the MAIPs and were successful in their studies. They could assist those in their first year by giving them academic, moral, and support, basically looking after them until they are on their feet.

Prof Twine emphasised that relationships are critical. The MAIPs like Hub, should forge a good relationship with their surrounding communities. The Wits Rural Knowledge Hub has formed a Community Development Forum, which consists of the nearby communities and the Hub's representatives. Regular meetings are scheduled during which community issues are discussed. A similar forum exists in Kareeberg and Karoo Hoogland. Still, the challenge with these, especially in Kareeberg and Karoo Hoogland, was that the community representatives did not filter the information to the whole community. Not

passing on information left community members unaware of the decision made. Hence, the community felt it was excluded from the projects' decision-making concerning themselves.

Sometimes, the Hub uses its connections to assist in some of the community challenges. Prof Twine also spoke of power dynamics where the Hub could use its power to negotiate on behalf of the community. He gave a pragmatic example of when the community was without water for a long time. The solution seemed not to be coming forth. As the Head of Research at the Hub, Prof Twine spoke to the councillor about the lack of water that had persisted for a long time. The councillor immediately telephoned the responsible person dealing with water challenges and handed over the phone to Prof Twine to speak directly about the issue. After their telephone discussion, the community's water issue was resolved a few days later. The solution was achieved by just a telephonic conversation and the involvement of the Prof. This example illustrates the power dynamics that these bodies, the hub and the MAIPs, bring within the community and, if managed well, could bring a positive good to society. As much as the mandate of the hubs and MAIPs is not to tangle development issues that the communities are crippled with but in some instances, they could play a huge role in assisting the communities in solving their challenges. At all times, MAIPs and hubs should be cognisance that when dealing with people's challenges, they are dealing with human rights.

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Appendices

A Appendix A.

Data Collection Instrument (s)

Appendix A.1 Questionnaires

MAIPS (MeerKAT/SALT PROJECTS QUESTIONNAIRE)

MeerKAT/SALT No. ……..

Date: ..... Town: ……

1. What is your gender?
   - □ Female
   - □ Male
   - □ Intersex
   - □ Undefined
   - □ Other (please specify) ……

2. To which group do you belong?[1] (optional):
   - □ Asian
   - □ Black
   - □ Coloured
   - □ White
   - □ Other (please specify) ……

3. How old are you?
   - □ 18 to 35
   - □ 36 to 60
   - □ Over 60

4. Which best represents you?
   - □ Community member
   - □ Community leader
   - □ Business representative
   - □ Farming Community

5. How long have you been residing in this community?.....

6. Do you know or heard of the MeerKAT/SALT Project?
   - □ Yes
   - □ No (*Do not continue with the survey*)

[1] The use of racial terminology is used indicatively to reflect socio-economic patterns of advantage and disadvantage.

MEGA ASTRONMIE INFRASTRUKTUURPROJEKTE (MeerKAT/SALT PROJEKTE VRAELYS)

Datum: ..... Dorp: …….

1. Wat is jou geslag?

□ Vroulik
□ Manlik
□ Interseks
□ Ongedefinieerd
□ Ander (spesifiseer asseblief) ……

2. Aan watter groep behoort jy?[2] (opsioneel):

□ Asiër
□ Swart
□ Kleurling
□ Wit
□ Ander (spesifiseer asseblief) ……

3. Hoe oud is jy?

□ 18 tot 35
□ 36 tot 60
□ Meer as 60

4. Watter verteenwoordig jou die beste?

□ Lid van die gemeenskap
□ Gemeenskapsleier
□ Besigheids verteenwoordiger
□ Boerderygemeenskap

5. Hoe lank woon jy al in hierdie gemeenskap?..... .....

6. Ken of hoor jy van die MeerKAT/SALT-projekte?

□ Ja
□ Nee *(Moenie voortgaan met die onderhoud nie)*

[2] Die gebruik van rasse-terminologie word indikatief gebruik om sosio-ekonomiese patrone van voor- en nadeel te weerspieël.

If yes, please mark the most appropriate answer:

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
6.1	The MeerKAT/SALT project benefited your community					
6.2	The MeerKAT/SALT project benefited your household					
6.3	The MeerKAT/SALT created jobs for the people in your community					
6.4	You are satisfied with the way the MeerKAT/SALT project is being implemented					
6.5	Community members are involved in the implementation of the MeerKAT/SALT project					
6.6	The MeerKAT/SALT project assisted in improving education in the community					
6.7	The MeerKAT/SALT project offered scholarships/bursaries to students in the community					
6.8	The MeerKAT/SALT project brought development to the community					
6.9	The MeerKAT/SALT project improved tourism in the community					
6.10	The MeerKAT/SALT project contributed to the economy of the area					

Indien ja, merk asseblief die mees gepaste antwoord:

		Stem sterk nie saam nie	Verskil	Neutraal	Stem saam	Stem sterk saam
6.1	Die MeerKAT/SALT-projek het jou gemeenskap bevoordeel					
6.2	Die MeerKAT/SALT-projek het jou huishouding bevoordeel					
6.3	Die MeerKAT/SALT het werk geskep vir die mense in jou gemeenskap					
6.4	Jy is tevrede met die manier waarop die MeerKAT/SALT-projek geïmplementeer word					
6.5	Gemeenskapslede is betrokke by die implementering van die MeerKAT/SALT-projek					
6.6	Die MeerKAT/SALT-projek het gehelp om onderwys in die gemeenskap te verbeter					
6.7	Die MeerKAT/SALT-projek het beurse/beurse aan studente in die gemeenskap gebied					
6.8	Die MeerKAT/SALT-projek het ontwikkeling na die gemeenskap gebring					
6.9	Die MeerKAT/SALT-projek het toerisme in die gemeenskap verbeter					
6.10	Die MeerKAT/SALT-projek het bygedra tot die ekonomie van die gebied					

7. Do you think the MeerKAT/SALT Projects have led to the development in the area?

- □ Yes
- □ No

8. If yes, please give examples of the types of development (you can choose more than one answer):

- □ Tired road/s
- □ Reliable energy supply
- □ Reliable internet connectivity
- □ Reliable phone connectivity
- □ Women development
- □ Tourism routes
- □ More retails/Wholesales/shops
- □ More lodging places
- □ Computer/tablet/iPad access

9. Please identify, if any, the most valuable contribution of the MeerKAT/SALT projects in the community.

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……

10. Are you happy with the implementation of the MeerKAT/SALT projects in your area? If not, please state why?

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11. Do you have comments or suggestions on how the MeerKAT/SALT projects improved your community?

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.....
……

Thank you for your time and cooperation

7. Dink jy dat die MeerKAT/SALT-projekte gelei het tot die ontwikkeling in die gebied?

□ Ja
□ Nee

8. Indien ja, gee asseblief voorbeelde van die tipes ontwikkeling (jy kan meer as een antwoord kies):

□ Moeë pad/s
□ Betroubare energievoorsiening
□ Betroubare internetverbinding
□ Betroubare telefoonverbinding
□ Vroue se ontwikkeling
□ Toerisme roetes
□ Meer kleinhandel/groothandel/winkels
□ Meer verblyf
□ Toegang tot rekenaar/tablet/iPad

9. Identifiseer asseblief, indien enige, die mees waardevolle bydrae van die MeerKAT/SALT-projekte in die gemeenskap.

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……

10. Is jy tevrede met die implementering van die MeerKAT/SALT-projekte in jou area? Indien nie, meld asseblief hoekom?

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……
……
……

11. Het jy kommentaar of voorstelle om te maak oor hoe die MeerKAT/SALT-projekte jou gemeenskap kan verbeter?

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……

Baie dankie vir u tyd en samewerking.

Appendix A.2 Interview schedule and question

1. Do you think MeerKAT/SALT benefited the community in the area?

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……..

2. Was the community informed of the developments of the MeerKAT/SALT project?

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……

3. Do you or have you ever worked for the MeerKAT/SALT?
   3.1 If yes, did you acquire worthwhile experience that will benefit you in future?

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……

   3.2 If not, do you know anyone who worked or is currently working on the MeerKAT/SALT project?

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4. How do you feel about the MeerKAT/SALT project in your area?

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5. Do you think MeerKAT/SALT improved your life?
   5.1 If so, please explain how SALT improved your life.

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   5.2 If not, please explain how the MeerKAT/SALT has negatively impacted your life.

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6. What do you understand about tourism?

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……

1. Dink jy MeerKAT/SALT het die gemeenskap in die omgewing bevoordeel?

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.....
.....
.....
.....

2. Was die gemeenskap ingelig oor die ontwikkelinge van die MeerKAT/SALT-projek?
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.....
.....
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.....

3. Het jy, of het jy al vir MeerKAT/SALT gewerk?

3.1 Indien wel, het jy waardevolle ondervinding opgedoen wat jou in die toekoms sal baat?
.....
.....
.....
.....
.....

3.2 Indien nie, ken jy iemand wat gewerk het of tans aan die MeerKAT/SALT-projek werk?
.....
.....
.....
.....
.....

4. Hoe voel jy oor MeerKAT/SALT-projek in jou area?
.....
.....
.....
.....
.....

5. Dink jy MeerKAT/SALT het jou lewe verbeter?

5.1 Indien wel, verduidelik asseblief hoe MeerKAT/SALT jou lewe verbeter het..
.....
.....
.....
.....
.....

5.1 Indien nee, verduidelik asseblief hoe MeerKAT/SALT jou lewe negatief beïnvloed het.
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.....

6. Wat verstaan jy van toeriste?
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7. Do you think tourism in Sutherland has improved as the result of the MeerKAT/SALT project?

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……

8. Are there tourism attraction marketing platforms in Kareeberg/Karoo Hoogland?

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9. Are there tour guides from Kareeberg/Karoo Hoogland?

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10. Have tour guides trained in Kareeberg/Karoo Hoogland?

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……

11. What do you think can be done to improve the implementation of the MeerKAT/SALT project?

……
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……
……
……

Thank you for your time and cooperation

7. Dink jy toerisme het verbeter as gevolg van die MeerKAT/SALT-projek?

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.....
.....
.....

8. Is daar bemarkingsplatforms vir toeriste-aantreklikheid in Kareeberg/Karoo Hoogland?

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.....

9. Is daar toergidse van Kareeberg/Karoo Hoogland?

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10. Is toergidse opgelei in Kareeberg?Karoo Hoogland?

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.....
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11. Wat dink jy kan gedoen word om die implementering van die MeerKAT/SALT-projek te verbeter?

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.....
.....
.....
.....

Dankie vir jou tyd en samewerking

B Appendix B.

The Bio of the researcher

The researcher works for the former Department of Science and Technology (DST), now the Department of Science and Innovation (DSI). DSI is the custodian and the funder of the MeerKAT and SALT projects on behalf of the South African government. The researcher worked for the Department 2010 as the Deputy Director: Project Implementation from 2010 to 2013. In this portfolio, the researcher was overseeing the implementation of European donor-funded science poverty alleviation projects in the rural part of South Africa.

From 2013 to the present, the researcher laterally and internally moved to the Research and Development Infrastructure Unit within the DSI, The researcher's portfolio, as the Deputy Director: Cyberinfrastructure. The researcher's responsibility in this portfolio is to oversee the implementation of research and development infrastructure, mainly focusing on cyberinfrastructure. During the researcher's tenure in this portfolio, the researcher oversaw the development of the South African Research Infrastructure Roadmap (SARIR) and the National Integrated Cyber Infrastructure System (NICIS).

SARIR was developed as a high-level strategic and systemic intervention to provide research infrastructure across the entire public research system, building on existing capabilities and strengths and drawing on future needs. The SARIR development was the initiative through a joint agreement between the South African government and the European Union. This Roadmap was developed as the basis for prioritising the development of South African research infrastructure needs. This roadmap was envisaged to guide the DSI on the strategic development, acquisition, and deployment of research infrastructure as a necessary enabler for

research, development, and innovation (Department of Science and Technology, 2016). SARIR also has placed a great emphasis socioeconomic impact of the projects that are being funded.

The DSI has, since 2007, invested in the provision of cyberinfrastructure (Cl) to enable scientific research, development, and innovation via the Centre for High Performance Computing (CHPC), the Data Intensive Research Initiative of South Africa (DIRISA), and the South African National Research Network (SANReN). These investments were effectively made in discrete projects, constituting DSI's CI programme and implemented as such (Department of Science and Technology, 2013).

In 2012, the DSI commissioned a review of its CI programme. The purpose of the evaluation was to formulate recommendations on the best cooperate governance, managerial and operational structure, and the most sustainable business model for establishing the NICIS. Two key recommendations of the review report were establishing NICIS as a separate legal entity and of 'e-Skills and Training Services' as the fourth pillar of a sustainable CI system (in addition to the CHPC, SANReN and DIRISA). Concerning NICIS as a separate legal entity, the recommendation further stated that DST should consider consolidating all the existing CI components into this separate legal entity and wholly owned by DSI (Department of Science and Technology, 2013).

The NICIS aimed to exploit the enormous synergies that could be derived from integrating national cyber-infrastructure (CI) into a cluster of mutually supporting activities that leverage high-level financial and strategic planning, oversight, and management. This integration opportunity was essential to competitive national science and technology strategies and

implementations, to international scientific and engineering collaborations, and for socio-economic impact (Department of Science and Technology, 2013).

As an overseer of the Cl projects within DST, the researcher works closely with the Astronomy team overseeing MeerKAT and SALT implementation. The researcher has been closely following these projects following their developments. Recently the researcher has been seconded to the Astronomy Unit, which gave the researcher more insight into these projects. The researcher has read most of the SALT and MeerKAT monitoring and evaluation reports and the socio-impact studies that the consultants conducted. All the socio-economic studies the researcher had read were positive, meaning that there were socio-economic benefits derived from MeerKAT and SALT projects. The involvement in the projects, especially MeerKAT, can tint my objectivity in making an unbiased judgement on whether these projects have socio-economically impacted the communities in which they are implemented.

From 2014 to 2015, the researcher did a Master's in project management at the Graduate School of Technology, Faculty of Engineering, Built and Environment and Information Technology, the University of Pretoria (UP). It was coursework which comprised a mini-thesis. The researcher's mini-thesis title was 'Impact of the Square Kilometre Array on Regional Economy of the Northern Cape', which is not much different from the study the researcher is doing now. The research study was in the Kareeberg region. In this study, the researcher used convenient sampling in which the participants were chosen based on their convenience and availability.

C Appendix C.

Ethics documentation

C.1 Appendix C.1 Participant Information Sheet

Dear Sir/Madam,

My name is Daniel Manama Mokhohlane, and I am a PhD student at the Wits School of Governance at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the impact of the Square Kilometre Array (SKA) and the Southern African Large Telescope (SALT) in the areas where the projects are being implemented under the supervision of Prof Mzukisi Qobo. This research aims to assess the impact of mega astronomy infrastructure projects on rural South Africa development.

As part of this project, I would like to invite you to take part in an interview or complete a questionnaire. This activity will involve answering interview questions or filling in a questionnaire physically or online. The interview or completing a questionnaire takes approximately 15-25 minutes. If an interview is done, with your permission, I would like to record the interview using a digital device. Confidentiality and anonymity of participants are maintained as the interview does not ask for any identifiable information like names or personal details. The information you give me will be held securely and be used solely for research purposes. Participation is entirely voluntary, and refusal to participate will involve no penalty. If you decide to participate, you may refuse to answer questions about which you feel uncomfortable. You may withdraw from the study without liability or prejudice in any way whatsoever.

The following steps will be taken to protect data while the research is in progress: the data will be placed on a data production sheet. It will be referred to by a code known only to the researcher. The coding and data will be separated, and the details will be placed in a secure location like the University repository. The study's outcome will be a thesis available on the World Wide Web through Wired Space, accessed through the Wits library website. I will also make a summary of this research public, and should you wish to have it, you will notify me, and I will send it to you. Should you have any queries about this study, please get in touch with me at the cell phone at +27(0) 82 868 2950, email 9604395e@students.wits.ac.za or contact my Supervisor at the cell phone at +27(0) 72 931 1780, email Mzukisi.Qobo@wits.ac.za. However, suppose you have any concerns or complaints regarding the ethical procedures of this study. You are welcome to contact the University Human Research Ethics Committee (Non-Medical) by telephone at +27(0) 11 717 1408 email at hrecnon-medical@wits.ac.za.

Yours sincerely,



Daniel Manama Mokhohlane

C.2 Appendix C.2 A Consent Form

Title of project: The Impact of Mega Astronomy Infrastructure Projects on Development in Rural Areas

Name of researcher: Daniel Manama Mokhohlane

I ……..……..agree to participate in this research project. The research has been explained to me, and I understand what my participation will involve.

I agree that my participation will remain anonymous	YES	NO	(please circle)
I agree that the researcher may use anonymous quotes in his research report	YES	NO	
I agree that the interview may be audio recorded	YES	NO	
I agree that the information I provide may be used anonymously by other researchers following this study	YES	NO	

…….. .(signature)

……... (name of participant)

……... (date)

C.3 Appendix C.3 Ethics clearance certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mokhohlane

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H20/08/33**
PROJECT TITLE	The use of mega astronomy infrastructure projects for development in rural areas
INVESTIGATOR(S)	Mr D Mokhohlane
SCHOOL/DEPARTMENT	Wits School of Governance/
DATE CONSIDERED	21 August 2020
DECISION OF THE COMMITTEE	Approved Risk Level: Minimal
EXPIRY DATE	02 November 2023

DATE 03 November 2020 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Professor I Sarakinsky

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. I agree to completion of a yearly progress report.

Signature Date 05/11/2020

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

D Appendix D.

Primary and Secondary Data

D.1 Appendix D.1 Survey questions mapped to research questions.

Table 35. Survey Questions Mapped into Research Questions

Main research question		
How have the district municipalities of Kareeberg and Karoo Hoogland developed from 2001 to 2021 since the introduction of MAIPs		
Secondary research questions		**Questions from the questionnaire and Interview schedule**
1.	How have the economic infrastructures of Karebberg and Karoo Hoogland changed since the introduction of MAIPs?	From questionnaire 7. Do you think the MAIPs Project has led to the development in the area? 8. If yes, please give examples of the types of development (you can choose more than one answer) 8.1. Paved roads. 8.2. Reliable energy supply. 8.3. Reliable internet connectivity. 8.4. Reliable phone connectivity. 8.5. Women development 8.6. Tourism routes development 8.7. More retails i.e., Wholesales/Supermarkets/Shops 8.8. More lodging places 8.9. Computer/tablet/iPad access. From interview schedule 7. Please identify, if any, the most valuable contribution of the MAIPs in the community
2.	How have employment rates in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	From questionnaire 6.1. The MAIPs benefited your community. 6.2. The MAIPs benefitted your household. 6.3. The MAIPs created jobs for the people in your community. 6.10. The MAIPs contributed to the area's economy. 7. Do you think the MAIPs Project has led to the development in the area? 7.7. More retails/Wholesale/Groceries stores. 7.8. More lodging places. From Interview schedule 3. Do you or have you ever worked for MAIPs (Yes/No)?

		3.1. If yes, did you acquire worthwhile experience that will benefit you in future? 3.2. If not, do you know anyone who worked or is currently working on the MAIPs?
3.	How have education prospects in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs?	From questionnaire 6.6. The MAIPs project assisted in improving education in the community. 6.7. The MAIPs project offered scholarships/bursaries to students in the community. From interview schedule 7. Please identify, if any, the most valuable contribution of the MAIPs in the community
4.	How has astrotourism developed in Kareeberg and Karoo Hoogland changed since the introduction of MAIPs? **Questionnaire questions that will respond to this research question:**	From questionnaire 6.9. The MAIPs improved tourism in the community. 7. Do you think the MAIPs have led to the development in the area? 7.6. Tourism development. From interview schedule 6. What do you understand about tourism? 7. Do you think tourism in Kareeberg and Karoo Hoogland has improved because of the MAIPs conservatively? 8. Are tourism attraction marketing platforms in Kareeberg and Karoo Hoogland? 9. Are there tour guides from Kareeberg and Karoo Hoogland?
	The people's perceptions of Kareeberg and Karoo Hoogland concerning MAIPs? **Questionnaire questions that will respond to this research question:** 6.4. You are satisfied with how the MAIP is implemented. 6.5. Community members are involved in the implementation of the MAIP. 6.8. The MAIPs brought development to the community. 7. Do you think the MAIP has led to the development in the area? 7.5. Women's development. 10. Are you happy with the implementation of the MAIPs in the community? If not, state why? 11. Do you have comments or suggestions on how the MAIPs can improve your community? **Interview questions:** 3. Do you think MAIPs benefitted the community in the area?	

	4. Was the community informed of the developments of the MAIPs? 6. How do you feel about the MAIPs project in your area? 7. Do you think MAIP has improved your life (Yes/No)? 7.1. If so, please explain how MAIP improved your life. 7.2. If no, please explain how MAIP negatively impacted your life. 12. What do you think can be done to improve the implementation of the MAIPs?

Kareeberg: Kareeberg Local Municipality; Karoo Hoogland: Karoo Hoogland Local Municipality; MAIPs: Mega Astronomy Infrastructure Project; MeerKAT: More Karoo Array Telescope; SALT: Southern African Large Telescope.

D.2 Appendix D.2 Description of the sample in Kareeberg towns

Table 36. Carnarvon Demographics Statistics
Participant Demographics (N=185)

Measure	N	%
Sex		
Female	104	56.5
Male	76	41.3
Others	5	2.2
Race		
Coloured	161	89.0
Black	14	7.6
White	3	1.7
Others	3	1.7
Age		
18-35 years (Youth)	60	32.6
36-60 years (Middle age)	95	51.6
Over 60 years (Old age)	30	15.8
Status in community		
Community member	145	78.4
Farming community	14	7.6
Community leader	13	7.0
Business representative	13	7.0
Duration in community		
0 to 20 years	50	27.0
21 to 40 years	74	40.0
41 to 60 years	39	21.1
Over 60 years	22	11.9
Knowledge of MeerKAT		
Yes	162	87.6
No	23	12.4

Table 37. Van Wyksvlei Demographics Statistics

Participant Demographics (N=60)

Measure	N	%
Sex		
Female	33	55.0
Male	27	45.0
Others	0	0
Race		
Coloured	57	95.0
Black	3	5.0
White	0	0.0
Others	0	0.0
Age		
18-35 years (Youth)	20	33.3
36-60 years (Middle age)	25	41.7
Over 60 years (Old age)	15	25.0
Status in community		
Community member	44	73.3
Farming community	9	15.0
Community leader	7	11.7
Business representative	0	0.0
Duration in community		
0 to 20 years	14	23.3
21 to 40 years	17	28.3
41 to 60 years	18	30.0
Over 60 years	11	18.4
Knowledge of MeerKAT		
Yes	49	81.7
No	11	18.3

Table 38. Vosburg Demographic Statistics
Participant Demographics (N=59)

Measure	N	%
Sex		
Female	15	25.4
Male	43	72.9
Others	1	1.7
Race		
Coloured	56	94.9
Black	3	5.1
White	0	0.0
Others	0	0.0
Age		
18-35 years (Youth)	13	22.0
36-60 years (Middle age)	32	54.2
Over 60 years (Old age)	14	23.8
Status in community		
Community member	50	84.7
Farming community	3	5.1
Community leader	5	8.5
Business representative	1	1.7
Duration in community		
0 to 20 years	12	20.3
21 to 40 years	23	39.0
41 to 60 years	18	30.5
Over 60 years	6	10.2
Knowledge of MeerKAT		
Yes	52	88.1
No	7	11.9

D.3 Appendix D.3 Description of the sample in Karoo Hoogland towns

Table 39. Sutherland demographic statistics
Participant Demographics (N=185)

Measure	N	%
Sex		
Female	104	56.2
Male	77	41.6
Others	4	2.2
Race		
Coloured	154	83.2
Black	12	6.5
White	15	8.1
Others	4	2.2
Age		
18-35 years (Youth)	83	44.9
36-60 years (Middle age)	78	42.1
Over 60 years (Old age)	24	13.0
Status in community		
Community member	164	88.6
Farming community	3	1.6
Community leader	6	3.2
Business representative	12	6.6
Duration in community		
0 to 20 years	46	24.9
21 to 40 years	85	45.9
41 to 60 years	33	17.8
Over 60 years	21	11.4
Knowledge of SALT		
Yes	112	60.5
No	73	39.5

Table 40. Williston Demographic Statistics
Participant Demographics (N=59)

Measure	N	%
Sex		
Female	33	55.9
Male	25	42.4
Others	1	1.7
Race		
Coloured	50	84.7
Black	3	5.1
White	6	10.2
Others	0	0.0
Age		
18-35 years (Youth)	20	33.9
36-60 years (Middle age)	30	50.8
Over 60 years (Old age)	9	15.3
Status in community		
Community member	54	91.5
Farming community	1	1.7
Community leader	2	3.4
Business representative	2	3.4
Duration in community		
0 to 20 years	9	15.3
21 to 40 years	34	57.6
41 to 60 years	9	15.3
Over 60 years	7	11.8
Knowledge of SALT		
Yes	31	52.5
No	28	47.5

Table 41. Fraserberg Demographic Statistics
Participant Demographics (N=60)

Measure	N	%
Sex		
Female	27	45.0
Male	33	55.0
Others	0	0.0
Race		
Coloured	57	94.9
Black	1	1.7
White	1	1.7
Others	1	1.7
Age		
18-35 years (Youth)	18	30.0
36-60 years (Middle age)	32	53.3
Over 60 years (Old age)	10	16.7
Status in community		
Community member	55	91.7
Farming community	4	6.6
Community leader	1	1.7
Business representative	0	0.0
Duration in community		
0 to 20 years	10	16.7
21 to 40 years	28	46.7
41 to 60 years	15	25.0
Over 60 years	7	11.7
Knowledge of SALT		
Yes	19	31.7
No	41	68.3

D.4 Appendix D.4 Kareeberg, Karoo Hoogland and Joe Morolong financial state

Table 42. Kareeberg Household Income

Income (per annum)	No. of people Number (%)
No income	280 (8.7)
R1–R4 800	122 (3.8)
R4 801–R9 600	193 (6.8)
R9 601–R19 600	787 (24.4)
R19 601–R38 200	784 (24.3)
R38 201–R76 400	430 (13.4)
R76 401–R153 800	306 (9.5)
R153 801–R307 600	191 (5.9)
R307 601–R614 400	94 (2.9)
R614 001–R1 228 800	18 (0.6)
R1 228 801–R2 457 600	10 (0.3)
R2 457 601 or more	5 (0.0)

Source (Stats SA, 2013)

Table 43. Karoo Hoogland Household Income

Income (per annum)	No. of people (%)
No income	6.3
R1–R4 800	2.4
R4 801–R9 600	5.0
R9 601–R19 600	24.9
R19 601–R38 200	26.2
R38 201–R76 400	13.7
R76 401–R153 800	9.2
R153 801–R307 600	6.2
R307 601–R614 400	3.9
R614 001–R1 228 800	1.5
R1 228 801–R2 457 600	0.4
R2 457 601 or more	0.4

Source (Stats SA, 2013)

Table 44. Joe Morolong Household Income

Income (per annum)	No. of people (%)
No income	18.3
R1–R4 800	6.8
R4 801–R9 600	13.0
R9 601–R19 600	23.9
R19 601–R38 200	20.6

R38 201–R76 400	7.8
R76 401–R153 800	4.8
R153 801–R307 600	3.2
R307 601–R614 400	1.2
R614 001–R1 228 800	0.3
R1 228 801–R2 457 600	0.0
R2 457 601 or more	0.0

Source (Stats SA, 2013)

Table 45. Calculations of the Kareeberg Household Total Income in 2011

Lowest income	**Highest income**	**No.**	**Lowest income by no. of people**	**Highest income by no. of people**
R0	R0	280	R0	R0
R1	R4 800	122	R122	R585 600
R4 801	R9 600	193	R926 593	R1 852 800
R9 601	R19 600	787	R7 555 987	R15 425 200
R19 601	R38 200	784	R15 367 184	R29 948 800
R38 201	R76 400	430	R16 426 430	R32 852 000
R76 401	R153 800	306	R23 378 706	R47 062 800
R153 801	R307 600	191	R29 375 991	R58 751 600
R307 601	R614 400	94	R28 914 494	R57 753 600
R614 001	R1 228 800	18	R11 052 018	R22 118 400
R1 228 801	R2 457 600	10	R12 288 010	R24 576 000
R2 457 601.	R2 457 601	5	R12 288 005	R12 288 005
Total			**R157 573 540**	**R303 214 805**

Calculation of average income and income per capita in the Kareeberg areas in 2001 using the information in Table 44 Karoo Hoogland and Joe Morolong were not calculated because there was not going to make any difference due to the same number patterns as Kareeberg. The interpretation would be the same as the Kareeberg.

Table 46. Kareeberg Average Income and Income Per Capita

The average income per household	R5 962.58
The average income per capita	R1 644.78

Table 47. Average Kareeberg Household Income

Year	Average household income	Average household income per capita
2001	4 406	1 049
2011	5 962	1 645

Table 48. Average Karoo Hoogland Household Income

Year	Average household income	Average household income per capita
2001	4 986	1 358
2011	6 784	1 893

Table 49. Average Joe Morolong Household Income

Year	Average household income	Average household income per capita
2001	3 301	750
2011	4576	984

Table 50. Distribution of Average Household Income

Local, District Municipalities and Province	2001	2011
Pixley ka Seme	37 538	75 237
Kareeberg	39 671	71 465
Namakwa	38 408	84 972
Karoo Hoogland	37 965	82 408
John Taolo Gaetsewe	27 432	66 095
Joe Morolong	28 478	68 546
Northern Cape	39 757	86 158

Source (Stats SA, 2013)

Table 51. Distribution of the Employment Status

Local, District Municipalities, Province, and Country	Employment (%)	
	2001 (%)	2011 (%)
Pixley ka Seme	38.0	24.7
Kareeberg	35.8	25.0
Namakwa	27.4	20.1
Karoo Hoogland	28.6	14.6
John Taolo Gaetsewe	30.0	47.2
Joe Morolong	49.0	38.6
Northern Cape	26.6	31.5
South Africa	25.6	24.7

Source (Stats SA, 2013)

Table 52. Dependency Ratio

Local, District Municipalities and Province	Dependency ratio (%)	
	2001	2011
Pixley ka Seme	62.7	60.4
Kareeberg	69.5	59.9
Namakwa	57.5	51.9
Karoo Hoogland	63.5	60.5
John Taolo Gaetsewe	68.9	60.6
Joe Morolong	90.4	84.6
Northern Cape	60.1	55.7

Source (Stats SA, 2013)

E Appendix E.

The Economic Base Theory and Shift Analysis Models

E.1 Appendix E.1 Formulae of the EBT and SAM

1. Calculating **Location Quotients** (LQ)

$$LQ_{ir} = \left(\frac{E_{ir}}{E_r}\right)\left(\frac{E_N}{E_{iN}}\right) \quad \text{(a)}$$

Where:

E_{ir} = employment in sector i in region r

E_r = total employment in region r

E_{iN} = employment in sector i in the reference area (N = national reference area here)

E_N = total employment in the national reference area

2. Calculating **Total and Differential Shift Models**

The total shift (TS) model is expressed as:

$$TS = \sum_i e_{i,t} - \sum_i e_{i,t-1}\frac{E_t}{E_{t-1}} \quad \text{(b)}$$

Differential shift (DS) represented by:

$$DS = \sum_i e_{i,t-1}\left(\frac{e_{i,t}}{e_{i,t-1}} - \frac{E_{i,t}}{E_{i,t-1}}\right) \quad \text{(c)}$$

Whereby e_i is regional employment and E_i is national employment all in the industry i(local) e(regional) and E (total national employment) in all represented industries, and the initial period is t - 1 and the final period is t of the analysis (Stimson et al., 2006).

3. Calculating **Shift-Share Analysis**

$$SSA = \Delta e_i = e_{i,t} - e_{i,t-1} = NS_i + IM_i + RS_i \quad \text{(d)}$$

Whereby

$$NS_i = e_{i,t-1}\left(E_t / E_{t-1} - 1\right) \quad \text{(e)}$$

$$IM_i = e_{i,t-1}\left(E_{i,t} / E_{i,t-1} - E_t / E_{t-1}\right) \quad \text{(f)}$$

$$RS_i = e_{i,t-1}\left(e_{i,t} / e_{i,t-1} - E_{i,t} / E_{i,t-1}\right) \quad \text{(g)}$$

Hence

$$e_{i,t} = e_{i,t-1} + NS_i + IM_i + RS_i \quad \text{(h)}$$

E.2 Appendix E.2 Application of the EBT and SSA models

For the EBT model: Kareeberg location quotients:

$$LQ_{ir} = \left(\frac{E_{ir}}{E_r}\right)\left(\frac{E_N}{E_{iN}}\right) \quad (1)$$

$$LQ_{KLM_{2011}} = \left(\frac{E_{KLM_{2011}}}{E_{PKSD_{2011}}}\right)\left(\frac{E_{SA_{2011}}}{E_{NC_{2011}}}\right)$$

$$LQ_{KLM_{2011}} = \left(\frac{2751}{42974}\right)\left(\frac{12671564}{269165}\right)$$

$$LQ_{KLM_{2011}} = 3.0137$$

Table 53. The Kareeberg Location Quotient

Year	LQ
1996	2,749024982
2001	2,467225617
2011	3,013686403

Source (Mokhohlane, 2015)

For the SSA model:

Change in regional employment in Kareeberg

$$\Delta e_i \equiv e_{i,t} - e_{i,t-1} \equiv NS_i + IM_i + RS_i \quad (4)$$

$$\Delta e_{KLM} \equiv e_{KLM_{2011}} - e_{KLM_{2001}}$$

$$\Delta e_{KLM} \equiv 2751 - 2235$$

$$\Delta e_{KLM} \equiv 516$$

The Kareeberg national share

$$NS_i \equiv e_{i,t-1}\left(E_t/E_{t-1} - 1\right) \quad (5)$$

$$NS_i \equiv e_{KLM_{2001}}\left(E_{NC_{2011}}/E_{NC_{2011}} - 1\right)$$

$$NS_i \equiv 2235\left(269164/229992 - 1\right)$$

$$NS_i \equiv 2235\left(269164/229992 - 1\right)$$

$$NS_i \equiv 381$$

The Kareeberg regional mix

$$IM_i \equiv e_{i,t-1}\left(E_{i,t}/E_{i,t-1} - E_t/E_{t-1}\right) \quad (6)$$

$$IM_i \equiv e_{KLM_{2001}}\left(E_{PKSD_{2011}}/E_{PKSD_{2001}} - E_{NC_{2011}}/E_{NC_{2001}}\right)$$

$$IM_i \equiv 2235\left(42974/37707 - 269164/229992\right)$$

$$IM_i \equiv -68$$

The Kareeberg regional shift

$$RS_i \equiv e_{i,t-1}\left(e_{i,t}/e_{i,t-1} - E_{i,t}/E_{i,t-1}\right) \quad (7)$$

$$RS_i \equiv e_{KLM_{2001}}\left(e_{KLM_{2011}}/e_{KLM_{2001}} - E_{PKSD_{2011}}/E_{PKSD_{2011}}\right)$$

$$RS_i \equiv 2235\left(2751/2235 - 42974/37703\right)$$

$$RS_i \equiv 204$$

$$\Delta e_i \equiv NS_i + IM_i + RS_i \quad (1)$$

$$\Delta e_i \equiv 381 - 68 + 204$$

$$\Delta e_i \equiv 517$$

F Appendix F

Sample Size for Random Samples

Table 54. Ample Size, Confidence Level and Confidence Intervals for Random Samples

Population size	*Confidence level 90%*			*Confidence level 95%*			*Confidence level 99%*		
	Confidence Interval 5%	*Confidence Interval 4%*	*Confidence Interval 3%*	*Confidence Interval 5%*	*Confidence Interval 4%*	*Confidence Interval 3%*	*Confidence Interval 5%*	*Confidence Interval 4%*	*Confidence Interval 3%*
30	27	28	29	28	29	29	29	29	30
50	42	45	47	44	46	48	46	48	49
75	59	64	68	63	67	70	67	70	72
100	73	81	88	79	86	91	87	91	95
120	83	94	104	91	100	108	102	108	113
150	97	111	125	108	120	132	122	131	139
200	115	136	158	132	150	168	154	168	180
250	130	157	188	151	176	203	182	201	220
300	143	176	215	168	200	234	207	233	258
350	153	192	239	183	221	264	229	262	294
400	162	206	262	196	240	291	250	289	329
450	170	219	282	207	257	317	268	314	362
500	176	230	301	217	273	340	284	337	393
600	187	249	335	234	300	384	315	380	453
650	192	257	350	241	312	404	328	400	481
700	196	265	364	248	323	423	321	418	507
800	203	278	389	260	343	457	363	452	558
900	209	289	411	269	360	468	382	482	605
1,000	214	298	431	278	375	516	399	509	648
1,100	218	307	448	285	388	542	414	534	689
1,200	222	314	464	291	400	565	427	556	727

Population size	*Confidence level 90%*			*Confidence level 95%*			*Confidence level 99%*		
	Confidence Interval 5%	*Confidence Interval 4%*	*Confidence Interval 3%*	*Confidence Interval 5%*	*Confidence Interval 4%*	*Confidence Interval 3%*	*Confidence Interval 5%*	*Confidence Interval 4%*	*Confidence Interval 3%*
1,300	225	321	478	297	411	586	439	577	762
1,400	228	326	491	301	420	606	450	596	796
1,500	230	331	503	306	429	624	460	613	827
2,000	240	351	549	322	462	696	498	683	959
2,500	246	364	581	333	484	749	524	733	1,061
5,000	258	392	657	357	536	879	586	859	1,347
7,500	263	403	687	365	556	934	610	911	1,480
10,000	265	408	703	370	566	964	622	939	1,556
20,000	269	417	729	377	583	1,013	642	986	1,688
30,000	270	419	738	379	588	1,030	649	1,002	1,737
40,000	270	421	742	381	591	1,039	653	1,011	1,762
50,000	271	422	745	381	593	1,045	655	1,016	1,778
100,000	272	424	751	383	597	1,056	659	1,026	1,810
150,000	272	424	752	383	598	1,060	661	1,030	1,821
200,000	272	424	753	383	598	1,060	661	1,031	1,826
250,000	272	425	754	384	599	1,063	662	1,033	1,830
500,000	272	425	755	384	600	1,065	663	1,035	1,837
1,000,000	272	425	756	384	600	1,066	663	1,036	1,840

Source (Barlett et al., 2001)

G Appendix G

Example of Project Stakeholders Management

Please take note the Tables below are not conclusive. They are just examples. More information can be added or removed.

Table 55. Example of Identified Internal and External Key Stakeholders

Internal Stakeholders	External Stakeholders
Department of Science and Innovation (DSI)	Department of Rural Development and Land Reform (DRDLR)
National Research Foundation (NRF)	Department of Energy (DoE)
Project Director	Department of Environmental Affairs (DEA)
SARAO and SAAO	South African Aviation Authority (SAAA)
Kareeberg and Karoo Hoogland Authorities	Department of Arts and Culture (DAC)
Pixley Ka Seme and Namakwa Provincial Municipalities	Department of Defense (DoD)
Kareeberg and Karoo Hoogland communities (Ordinary community members, community leaders, business representatives, and farming communities)	National Energy Regulator of South Africa (NERSA)
Projects contractors	Department of Small Business
Projects sub-contractors	Department of Trade, Industry and Commission (Dtic)
SKAO	Northern Cape government
Partner countries	South Africa Weather Stations (SAWS)
Expropriated farm owners	Eskom
Farmers associations	Department of Agriculture
Etc.	Department of Social Development

Internal Stakeholders	External Stakeholders
	Department of High Education and Training
	Department of Basic Education
	Department of Transport and Roads
	Department of Public Works and Infrastructure
	Department of Tourism
	Department of Water and Sanitation
	Related Provincial Departments
	Related Local Departments
	Wind farms in the projects' vicinities
	Etc.

Table 56. Example of Some Key Stakeholders and their Involvement in Project

Stakeholders	Involvement
DSI	• The project financier, on behalf of the South African national government • Project Owner
NRF	• Project management • Project proposer
SARAO or SAAO	• Managing projects on behalf of the project owner • Acquire the land for the projects
Project Directors	• Leader of the project teams
Kareeberg and Karoo Hoogland Communities	• Project beneficiary • Provide semi-skilled and unskilled labour to the project
Project contractors	• Main project contractors
Project sub-contractors	• Supply sub-contracting services, e.g., construction services, maintenance services, etc.
Eskom	• Connect the projects to the grid • Supply mini sub-station to the project

Stakeholders	Involvement
Department of Social Services	• Provide social services to the Kareeberg and Karoo Hoogland
Department of Tourism	• Develop astrotourism strategy
Department of Rural Development and Land Reform (DRDLR, former Department of Land Affairs)	• Have an interest in the project since it is a rural developmental project, and it falls within the mandate of the Department. • Provide assistance and authorisation in land use planning. • Gave the land
Department of Energy (DoE)	• Have an interest in the project since it is an energy project, and it falls within the mandate of the Department.
Department of Environmental Affairs (DEA)	• Provide environmental authorization in terms of NEMA
South African Aviation Authority (SAAA)	• Provide authorization in terms of the South African Aviation Act
Department of Arts and Culture (DAC)	• Provide guidance and authorization in heritage impact assessment
Department of Defense (DoD)	• Assist in authorisation in terms of the South African Aviation Act
National Energy Regulator of South Africa (NERSA)	• South African energy regulator
Kareeberg and Karoo Hoogland authorities	• Have an interest in the project due to its location. • Provide authorization in terms of the South African Municipality Act • Rezone the project area and supply a rezoning certificate. • Register the project into their Municipality Development Plan
Pixley Ka Seme and Namakwa District Municipalities	• Have an interest in the project due to its location
Northern Cape government	• Have an interest in the project due to its location
South Africa Weather Stations (SAWS)	• Provide weather station to the projects to monitor weather in the area and assist with pollution in the atmosphere
Etc.	Etc.

Table 57. Example of External Project Stakeholders Analysis

	Low Interest	High Interest
High Power	❖ SAAA	❖ DRDLR ❖ DEA ❖ NERSA ❖ DoD
Low Power	❖ West Coast District Municipalities ❖ Western Cape government	❖ DoE ❖ DAC ❖ SAWS

The strategy is developed to manage the external stakeholders with high influential power and interest in the project. Table 63 below shows the developed communication plan with the example of those stakeholders with the project team.

Table 58. Example of External Stakeholders with High Power and Interest and Communication Plan

Stakeholders	Communication Plan
DRDLR	Please provide them with a proposal with all the drawings and plans. Invite them to the project inception and site meetings; Provide them with quarterly progress reports; Anytime telephonic conversation when necessary.
DEA	
NERSA	
DoD	