KAJIADO COUNTY
RENEWABLE ENERGY ATLAS

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ALIN (2020)
Kajiado County Renewable Energy Atlas
Arid Lands Information Network (ALIN)
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This Atlas was prepared by ALIN in close collaboration with the Kajiado County Government, as represented by the Ministry of Water, Irrigation, Environment and Natural Resources with support from the Hivos Green and Inclusive Energy Programme.

About ALIN

The Arid Lands Information Network (ALIN) is a non-governmental organization (NGO) registered in Kenya with over 20 years' experience working on sustainable development issues by providing a grass-root link to policy matters in addition to empowerment activities. ALIN has been championing the use of ICTs to empower communities with usable information and knowledge to improve their livelihoods. **www.alin.net**

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Acronyms and abbreviations

ALIN	–	Arid Lands Information Network
CBO	–	Community Based Organization
CIDP	–	County Integrated Development Plan
EPRA	–	Energy and Petroleum Regulatory Authority
FiT	–	Feed-in Tariff
GIS	–	Geographic Information System
GW	–	Gigawatt
ICT	–	Information and Communication Technology
KNBS	–	Kenya National Bureau of Statistics
KPHC	–	Kenya Population and Housing Census
KVA	–	Kilovolt ampere
KW	–	Kilowatt
LPG	–	Liquefied Petroleum Gas
NAP	–	National Adaptation Plan
NAMSIP	–	National Metropolitan Services Improvement Projects
NCCAP	–	National Climate Change Action Plan
NGO	–	Non-Governmental Organization
PPA	–	Power Purchasing Agreement
RET	–	Renewable Energy Technology
SEforALL	–	Sustainable Energy for All
SDG	–	Sustainable Development Goals

Foreword

My Fellow Kajiado Residents, it is with great pleasure that I present to you this Kajiado County Renewable Energy Atlas, 2020. In my Manifesto 2018-2022, I pledged to support investment in green energy including wind, solar and geothermal power generation. This Atlas is an important first step in achieving this. The Atlas will also inform the preparation of our first energy plan, which will incorporate renewable energy and electricity master plans. It will also help to enhance energy policy development in the county.

Clean, affordable, reliable, sustainable and modern energy is essential for Kenya's sustainable development and is considered an infrastructure enabler for the Big Four Agenda. Kenya through its Nationally Determined Contribution (NDC) aims to achieve a low carbon, climate resilient development pathway through various adaptation and mitigation initiatives which include expansion in geothermal, solar and wind energy production, other renewables and clean energy options.

In Kajiado County, renewable energy in the form of wind, solar, geothermal, hydro and biomass are abundant. The County is one of the frontier counties in the development of green energy, despite them remaining largely untapped. It already has Ngong Hills Wind Power Station, which is connected to the national power grid with a capacity of 25.5MW, with Kipeto 1 and 2 Wind Power project projected to generate an additional 100MW. Magadi solar project and Mt. Suswa geothermal project are also underway.

Through the implementation of the second generation County Integrated Development Plan (CIDP 2018-2022), the county will be investing further and increasing demand for renewable energy. In addition, the Kajiado County Climate Change Bill, 2020 will provide further investment and promotion of climate change adaptation and mitigation initiatives in the County.

The Kajiado County Renewable Energy Atlas is a first step towards understanding renewable energy potential in the county. The Atlas enables us to understand which renewable energy resources exist where and to what extent.

The high quality renewable energy resource data and the other geographic information system (GIS) data are essential for the transition to a clean energy economy that prioritizes local resources, improves resilience and promotes energy independence. This is critical to scaling up to commercial development.

The Atlas also supports the implementation of the Energy Act, 2019 which requires both the National and County Government to collect and maintain energy data, to undertake feasibility studies, and to avail data to developers of energy resources and infrastructure.

In pursuit to this, it is my pleasure to invite all investors to explore more renewable energy forms in the county. My government on its part, promise to coordinate all the stakeholders including Kajiado Residents, investors, development partners, national government and its agencies in the implementation of this Atlas.

H. E. Joseph Ole Lenku
Governor, Kajiado County

Preface

The Kajiado County Renewable Energy Atlas was developed by the County Government of Kajiado and Arid Lands Information Network (ALIN), with support from the Hivos Strategic Partnership-Energy programme.

The Atlas is designed as a resource for use by those interested in furthering the production of electricity, heat and fuels from solar, wind, geothermal, hydro and biomass in the county. These include the public, policymakers, advocates, landowners, developers, utility companies and prospectors.

Renewable energy resources are able in the long-term to provide energy at an affordable cost. Understanding the location and potential of renewable energy resources is, therefore, a crucial pre-requisite to their utilization, and the scale up of clean and secure sources of electricity generation.

The Atlas data is crucial for making informed decisions ranging from policy and investment decisions to reliable power sector planning in the county. The Atlas will help the county to better coordinate the development of different renewable energy resources.

Kajiado County has some of the best renewable energy resources. The Atlas shows that key potential areas for biomass energy in the county include dumping sites, slaughter houses and homesteads with a large livestock herd. Some areas also emerge as high potential for utilization of locally available materials to make briquettes.

It has also shown that some parts of Kajiado County have a high potential for wind energy as they experience high wind speed and air density regularly. Further, high insolation rates in most areas in the county show that it can increase accessibility and share of renewable energy in the national grid.

According to the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, of the 313,218 households in Kajiado County, 67.4 percent are connected to the mains electricity while 15.5 percent use solar as their main lighting fuel. Paraffin tin lamp and paraffin lantern are used by 5 and 3.9 percent of the households respectively.

Efficient production, transmission and distribution of affordable, clean and reliable energy is, therefore, a high priority for the county and would assure the community of accessing clean, reliable and sustainable energy supply. This will contribute to one of the strategic objectives of the second National Climate Change Action Plan (NCCAP) 2018-2022 to ensure an electricity supply mix based mainly on renewable energy that is resilient to climate change and promotes energy efficiency.

The Kajiado County Government would like to express its sincere appreciation to ALIN for the support in the development of the Atlas. We extend special gratitude to the back donor, Hivos through its Green and Inclusive Energy Programme for their financial support to ALIN. We are also grateful for other Non State Actors (NSAs) for contributing valuable information on potential locations for renewable energy sources in the County.

Hon. Michael Semera
County Executive Committee Member (CECM)
Water, Irrigation, Environment, Natural Resources and Climate Change

Acknowledgement

The Arid Lands Information Network (ALIN), is pleased with the successful completion of the Kajiado County Renewable Energy Atlas. The Atlas is a joint product of the Kajiado County Government and ALIN.

The Atlas was developed through a participatory process involving officers drawn from the Kajiado County Government, state corporations and sector stakeholders. The results presented are based on comprehensive data and information gathered during field research, community meetings and multi-stakeholder involvement with the use of Geographic Information System (GIS) technology as the key tool.

We specifically recognise Hon Michael Semera, County Executive Committee Member (CECM), Water Irrigation, Environment, Natural Resources and Climate Change for his strategic support and goodwill throughout the whole process of developing the Atlas.

Similarly, we recognise the technical leadership from Dr James Sankale, Kajiado County Chief Officer, Department of Environment, Natural Resources and Climate Change for his commitment and guidance during the development of the Atlas. We are also grateful to his team who worked tirelessly and diligently in ensuring successful development and finalisation of this Atlas. In particular, special thanks to John Kanini, Ken Oseur, Vivian Mashipei, Joy Pello, Damaris Maina and Sylvia Shirim.

Our gratitude also goes to Kajiado County Assemblies Hon James Waichanguri, Chairperson, Water, Irrigation, Environment and Natural Resources Committee for spearheading the passage of the Kajiado County Climate Change Bill, 2020, Kajiado County Environment Protection Bill, 2020 and the Kajiado County Sand Harvesting and Quarry Bill, 2020, which will help provide an enabling environment for the sustainable use of natural resources in the county.

We also acknowledge the inputs and expertise provided by Non State Actors (NSAs) working on energy access and advocacy on renewable energy in Kajiado County and all the respondents interviewed during the development of the Atlas.

We appreciate the Geoplan Associates team who led in the research and compilation of this Atlas. In particular, special thanks to Alex Mugambi (Team Leader), Jane Nkinduru, Janet Kemuma, Isaiah Wafula and Dennis Mbiti for their technical input in the Atlas.

Finally, on behalf of ALIN, I most sincerely appreciate Hivos through its Green and Inclusive Energy Programme for their financial support towards the finalization of the Kajiado County Renewable Energy Atlas.

James Nguo
Regional Director
Arid Lands Information Network (ALIN)

Executive Summary

ALIN in close collaboration with the Kajiado County Government, as represented by the Ministry of Water, Irrigation, Environment and Natural Resources with support from the Hivos Green and Inclusive Energy Programme designed the Kajiado County Renewable Energy Atlas a resource for the public, policy makers, landowners, developers, utility companies and others stakeholders interested in furthering the production of renewable energy in Kajiado County.

The Kajiado County Renewable Energy Atlas is a compilation of geospatial data focused on renewable energy sites; both existing and potential renewable energy sites and the technology used. It is designed based on field research, community participation and multi-stakeholder involvement with the use of Geographical Information System (GIS) technology as the key tool.

The Atlas supports the implementation of the Energy Act, 2019. Section 74. (1) of the Act mandates the Cabinet Secretary in Charge of Energy to prepare a renewable energy resources map in respect of each renewable energy resources area.

The Act, also mandates county governments to undertake feasibility studies and maintain data with a view to availing the same to developers of energy resources and infrastructure.

The data in the Atlas is presented in five sections focusing on solar, wind, geothermal, hydro and biomass. It captures existing and potential sites for each renewable energy source.

Chapter one provides the county background information on administrative units, demographic features, health and education infrastructure and topography. It also looks at Kenya Power and Lighting Company and borehole distribution in Kajiado County.

Chapter two highlights policies and legal framework governing the Kenya energy sector at the National and County level. This includes the Constitution of Kenya, 2010, Kenya's Vision 2030, Energy Act, 2019, second generation Kajiado County Integrated Development Plan (CIDP 2018-2022) among others.

Chapter three covers existing and potential solar energy sites which shows that Kajiado County has high insolation rates with an average of 5-7 peak sunshine hours. It receives an average daily insolation of 4-6kWh/m^2.

Chapter four looks at existing and potential wind energy sites in the county, which includes the Ngong Hills and Kipeto Wind Farm.

Chapter five looks at three distinct potential geothermal resource regions namely the Mt. Suswa, Lake Magadi Springs and the Kisaju Area 22.

Chapter six highlights the six major seasonal potential hydro sites. Chapter seven looks at the types of cooking fuels in use in Kajiado County and the key potential areas for biomass energy like dumping sites, slaughterhouses ad homesteads with high number of livestock.

The Atlas will help stakeholders to understand which renewable energy resource exist where, and to what extent. This is a crucial pre-requisite to their utilization, and to scale up clean and secure sources of electricity generation.

The Atlas not only provides the Kajiado County Government with high quality, publicly available data on renewable energy resources but also acts as a catalyst to trigger planning and policy development and help attract investors in the renewable energy markets in Kajiado County.

Dr. James Sankale
Kajiado County Chief Officer
Department of Environment, Natural Resources and Climate Change

Chapter

01 Introduction

Photo credit @ Kevin Mungai

Kajiado County has some of the best renewable energy resource. The highest potential being accessibility to solar, wind, geothermal and hydro energy.

Energy sector in Kenya

The energy sector in Kenya is largely dominated by petroleum and electricity, with wood fuel providing the basic energy needs for the rural communities, urban poor, and the informal sector.

Kenya's Sustainable Energy for All (SEforALL) Action Agenda targets to achieve 100 percent electricity access by 2022; ahead of the target set in Vision 2030 and the Sustainable Development Goal (SDG) 7.

Energy plays an important role in driving the economy. With the high demands both in the commercial and domestic sector, the volatile fuel prices are likely to bring about a state of inflation if not regulated.

The renewable energy sector is instrumental to the achievement of the UN Sustainable Development Goals (SDGs), which aim to realize a better and more sustainable future for all. Renewable energy is core to the implementation of SDG 7, which focuses on access to affordable, reliable, and sustainable energy, and SDG 13 on climate action.

Renewable resources will in the long-term provide energy at an affordable cost. Kajiado County has some of the best renewable energy resources such as wind, geothermal, solar and hydro resources. This provides opportunity for investors to better develop the resources locally.

This will assure the community of access to clean, reliable and sustainable energy supply. It will in turn promote energy efficiency thus saving the County's financial budget on non-renewable energy and create more stable and resilient communities. This will accelerate development in the County.

Many renewable energy technologies like solar, wind and micro hydro can be deployed modularly hence are uniquely positioned to expand off-grid electricity access in remote areas where it is expensive to connect communities to centralized electricity grids.

The Kajiado County Renewable Energy Atlas is designed as a resource for the public, policy makers, landowners, developers, utility companies and other stakeholders interested in furthering the production of energy from water, wind, biomass, geothermal and solar sources.

Renewable Energy Usage in Kenya

According to the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, slightly over 50.4 percent of households reported using electricity mains as a source of lighting fuel followed by solar at 19.3 percent.

Data from the Kenya National Bureau of Statistics (KNBS) Economic Survey of 2020 indicates that geothermal remains the major source of electricity in Kenya accounting for 45 percent of total generation. Hydro accounts for 27.6, Thermal oil 11.3 and wind 13.4 percent.

The survey shows that geothermal energy capacity is 828.4 MW, while Hydro is 826.2 MW, Thermal oil is 749.3 MW, Wind is 336.1 MW, solar is 51 MW and co-generation is 28 MW. The installed capacity of electricity in 2019 was 2,818.9 MW.

Energy Usage in Kajiado County

According to the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, the main type of lighting fuel in Kajiado County are mains electricity, solar, paraffin tin lamp, paraffin lantern, solar-charged torch/spotlight, wood and candle.

Out of the 313,218 households in Kajiado County, 67.4 percent are connected to the mains electricity while 15.5 percent use solar as their main lighting fuel. Paraffin tin lamp and paraffin lantern are used by 5 percent and 3.9 of the households respectively. In addition, 1.7 percent use candles while 1 percent use wood.

Kajiado North and Isinya have the highest number of households connected to the mains electricity at 94.9 and 85.5 percent respectively.

Mashuuru has the lowest number of households connected to the mains electricity, at 35.3 percent, followed by Loitokitok at 36 percent.

However, Loitokitok has the highest number of households using paraffin lanterns and lamps at 11.8 and 13.7 percent respectively.

Type of cooking fuel used in the county includes LPG, firewood, paraffin, charcoal, electricity, biogas and solar. LPG and firewood are the most used cooking fuel at 47.2 and 29 percent respectively. In addition, 12.7 percent use paraffin, 9.1 percent use charcoal while 0.7 percent use biogas.

Loitokitok leads in the use of firewood at 66.1 percent followed by Kajiado West at 57.3 percent, Kajiado Central at 51.6 percent and Mashuuru at 50.7 percent.

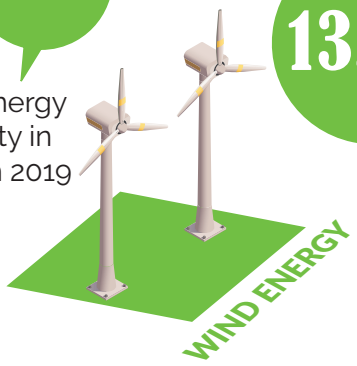
Electricity capacity and generation in 2019

331.1 MW

Wind energy capacity in Kenya in 2019

13.4%

Wind accounted for 13.4% of power generation in Kenya in 2019

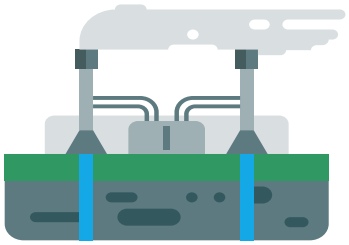


828.4 MW

Geothermal capacity in Kenya in 2019

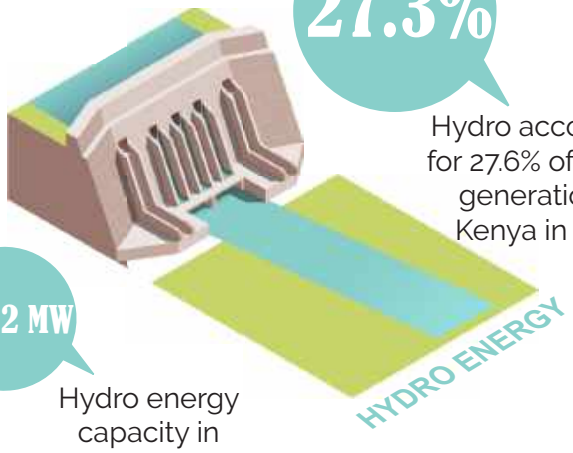
45%

Geothermal accounted for 45% of power generation in Kenya in 2019



27.3%

Hydro accounted for 27.6% of power generation in Kenya in 2019

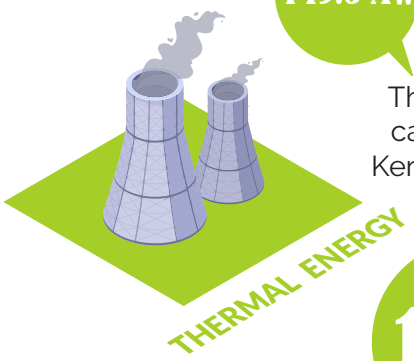


826.2 MW

Hydro energy capacity in Kenya in 2019

749.3 MW

Thermal oil capacity in Kenya in 2019

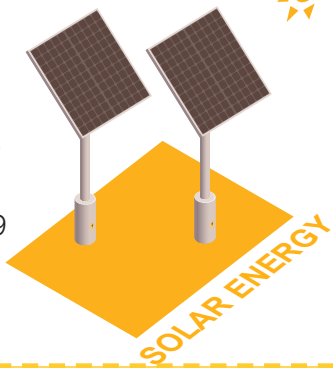


11.3%

Thermal oil accounted for 11..3% of power generation in Kenya in 2019

51 MW

Solar energy capacity in Kenya in 2019



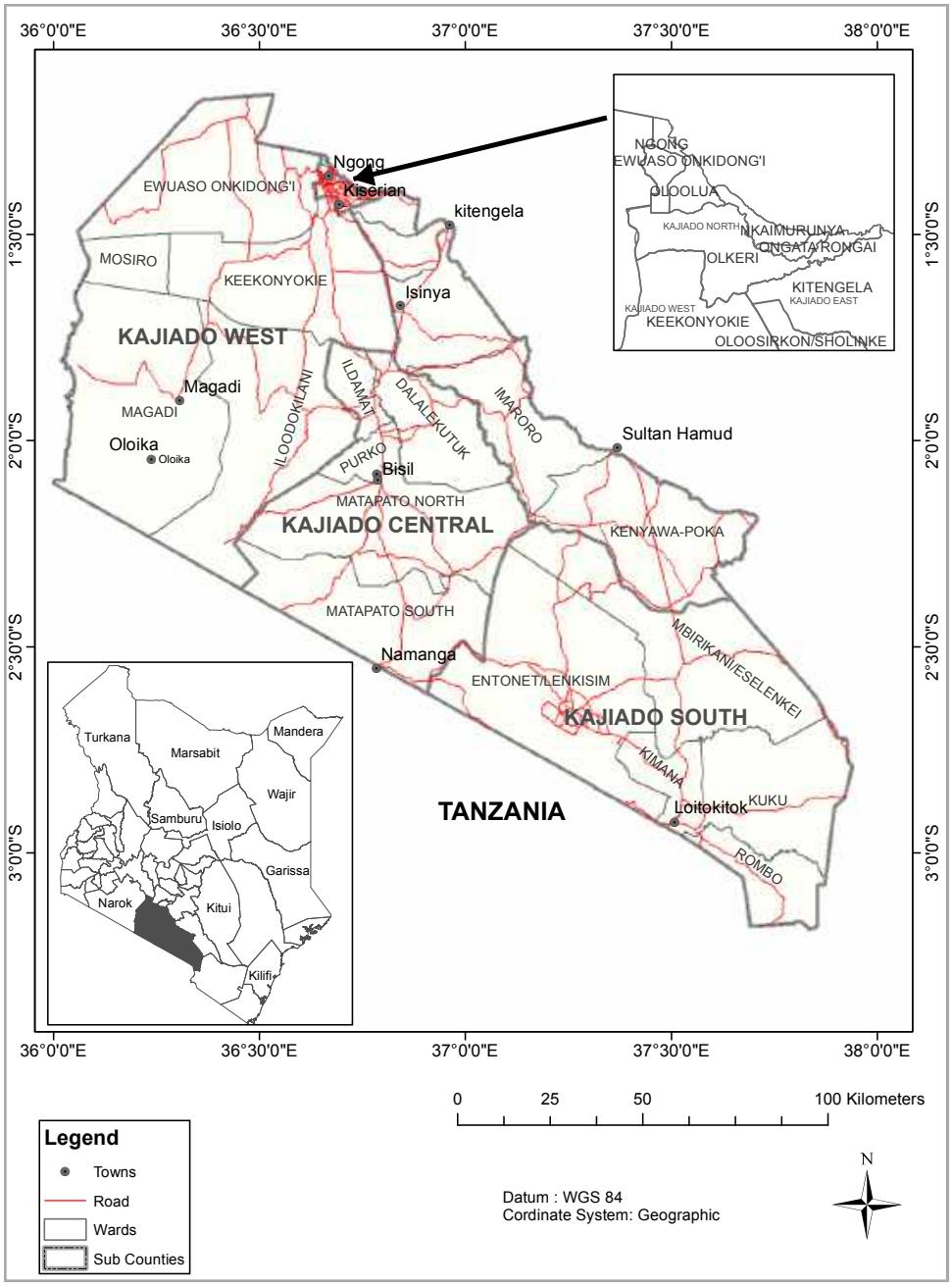
General county information

1.1: Administrative Units

Kajiado County is one of the 47 counties in Kenya with its headquarters in Kajiado town. It borders Nairobi County to the North East, Narok County to the West, Nakuru and Kiambu Counties to the North, Taita Taveta County to the South East, Machakos and Makueni Counties to the North East and East respectively, and the Republic of Tanzania to the South.

It is situated between Longitudes 36^0 5′ and 37^0 5′ East and between Latitudes 1^0 0′ and 3^0 0′ South. The county covers an area of 21,900.9 square kilometers (Km^2). Kajiado County is divided into 5 Sub-Counties and 25 Wards with Kajiado West being the largest and Kajiado North Sub-county being the smallest in terms of area in Km^2:

Sub County	Wards
Kajiado Central	Dalalekutuk, Ildamat, Purko, Matapato North, Matapato South
Kajiado West	Keekonyokie, Mosiro, , Ewuaso Nkidong', Iloodokilani, Magadi
Kajiado East	Kaputiei North, Kitengela, Oloorsirkon/Sholinke, Kenyawa-poka, Imaroro
Kajiado South	Rombo, Kimana, Kuku, Imbirikani/ Eselenkei, Entonet/ Lenkism
Kajiado North	Ngong, Oloolua, Olkeri, Ongata Rongai, Nkaimurunya



1.2 Demography of Kajiado

Population and demographic characteristics analysis is an integral part in planning of renewable energy resources.

For planners to be able to implement plans successfully, they need to develop programs that meet the present and future needs of the different segments of the population in the County.

The socio-economic development projects, such as renewable energy need the study of the changes in the composition of the population.

Kajiado County is experiencing a high average population growth rate of 5.5% per annum (Kenya Spatial Plan 2013-2045).

This population is majorly attributed to immigration into the County from population working within the Nairobi Metropolitan Region and natural growth. The County's average population density stands at 51 persons per square Kilometer.

Kajiado North Sub County has the highest population density while Kajiado West Sub County has the lowest density at 20 persons per Km^2.

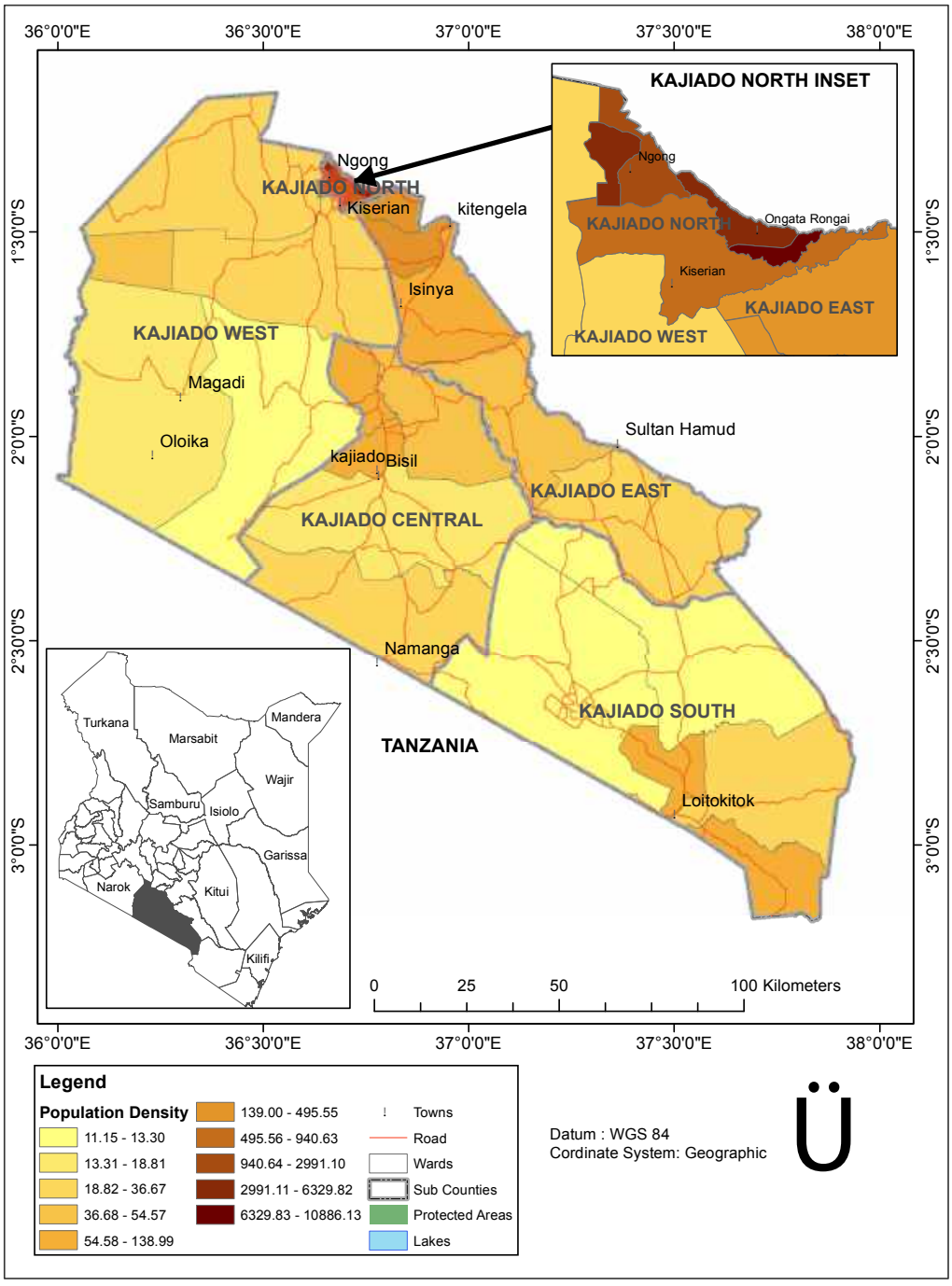


Figure 1.1: Population and distribution.

As indicated in figure 1.1; there is high population density in Kajiado North Wards (Ngong, Oloolua, Olkeri. Ongata Rongai, and Nkaimurunya) and low population density in Iloodokilan, Matapato North, Entonet and Imbirikani.

The County's population has been steadily growing from 687,312 in the year 2009 to 1,117,840 according to 2019 Kenya Popolation and Housing Census (KPHC) report.

The rapid increase in population leads to high demand of energy consumption. Despite the County having a variety of renewable resources of energy which is affordable, clean, efficient and reliable, low effort of adoption has been done by the community members and the County government.

> *Kajiado County is experiencing a high average population growth rate of 5.5% per annum.*
>
> *(Kenya Spatial Plan 2013-2045)*

1.3: Health and Education Infrastructure

The Health and Education sectors are some of the key consumers and target market of energy in Kajiado County. The need to adapt renewable energy sources within these institutions will reduce reliance on KPLC power supply and increase energy efficiency.

1.3.1 Health Sector

Kajiado Referral Hospital is the largest health facility in the County. It has an ultra-modern maternity, equipped laboratory, the radiology and two fully equipped theatres.

There is a full time need for lighting in the different rooms' i.e. wards, laboratories and theatres within the hospital. The radiology and other machines used in the theatres and laboratories consume more than 400KW which is supplied by KPLC.

In the 2018/2019 Financial Year, the Kajiado County Government tendered for the installation of a 400 KVA backup generator in the hospital.

There is need to exploit the natural endowment of varied natural energy sources such as wind, solar and geothermal to help meet growing energy demand. The hospital is thus a huge potential consumer of the energy generated from the renewable energy resources.

Other hospitals in the County that have a high energy consumption include: Loitoktok Sub County hospital, Ngong Sub County hospital, Kitengela Sub County hospital, Ongata Rongai health Centre and New Matasia Health Centre.

Therefore, availability of energy generated from the renewable resources is the infrastructural enabler to attain efficient integrated and high quality affordable health care in the County.

> *Adopting renewable energy sources within institutions will reduce reliance on KPLC power supply and increase energy efficiency.*

1.3.2 Education Sector

According to East African Health Report, over 96 percent of primary schools access to electricity plays a very significant and important role in improved educational attainment. Illumination enables students to study at more flexible hours, and potentially longer.

However, some remote areas in the country still lag behind in terms of efficient connection to electricity. Kajiado County is one of the Counties with most schools in rural areas that are not connected to electricity. Due to the sparse and unevenly distribution population, it is a great challenge for KPLC to ensure that every school is connected to electricity due to high costs of distribution.

Out of 899 education institutions within the County, only 325 are connected to electricity, most of which are secondary schools and institutions of higher learning which only accounts for 36.15% of the total learning centers in the County.

This thus provides a good opportunity for education institutions in the County to adopt the use of renewable energy resources like solar and biogas to supplement their energy demands. Availability of septic tanks and latrines in most schools are potential sources for biogas production but that opportunity has not been exploited.

Due to availability of technology, most schools can convert the human excrement into dry odorless materials, which can be used in the production of methane gas and heat energy that will be used for cooking and lighting.

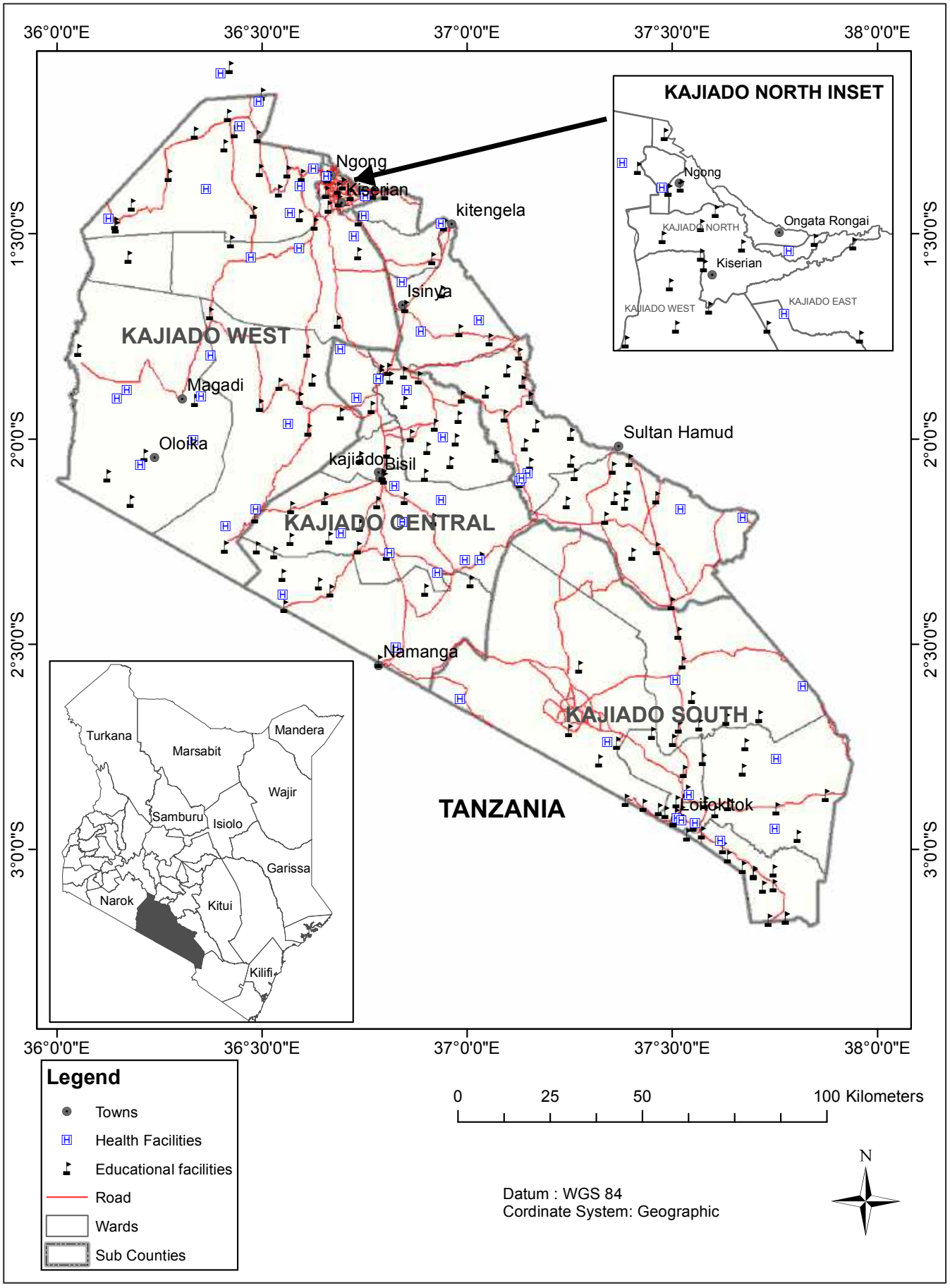


Figure 1.2: Distribution of schools and hospitals in Kajiado County.

1.4: Topography

Kajiado County is characterized by plains, valleys and occasional volcanic hills. These fluctuates in height above sea level, slope.

Hills around the County provide high potential for hydro and wind power in particular where rivers pass through and high wind speed areas. The lowest altitude is about 573m above the sea level at Lake Magadi while the highest is 2554m above the sea level in Ngong hills.

The Landscape within the County is divided into rift valley, Athi-Kapiti plains and central broken grounds.

The rift valley is an elongated depression on the western side of the County running from North to South. It is characterized by steep walls forming plateaus, scarps and structural plains which form features such as Mount Suswa and Lake Magadi.

The Altitude of the lake ranges between 600 and 1740m above the sea level. Mount Suswa is a shield volcano which has a unique double crater with a moat like crater surrounding a tilted block of rock with a high potential of producing geothermal power. Amboseli National park has an altitude ranging from 1580 to 2460m above sea level.

The Ngong hills are the catchment area for Athi River which is fed by tributaries of Mbagathi and Kiserian rivers. These tributaries are a high potential for hydro power if dammed.

The central broken ground is an area stretching 20 to 70km wide from the North-eastern boarder across the County to the South-west where altitude ranges from 1220 to 2073m above sea level.

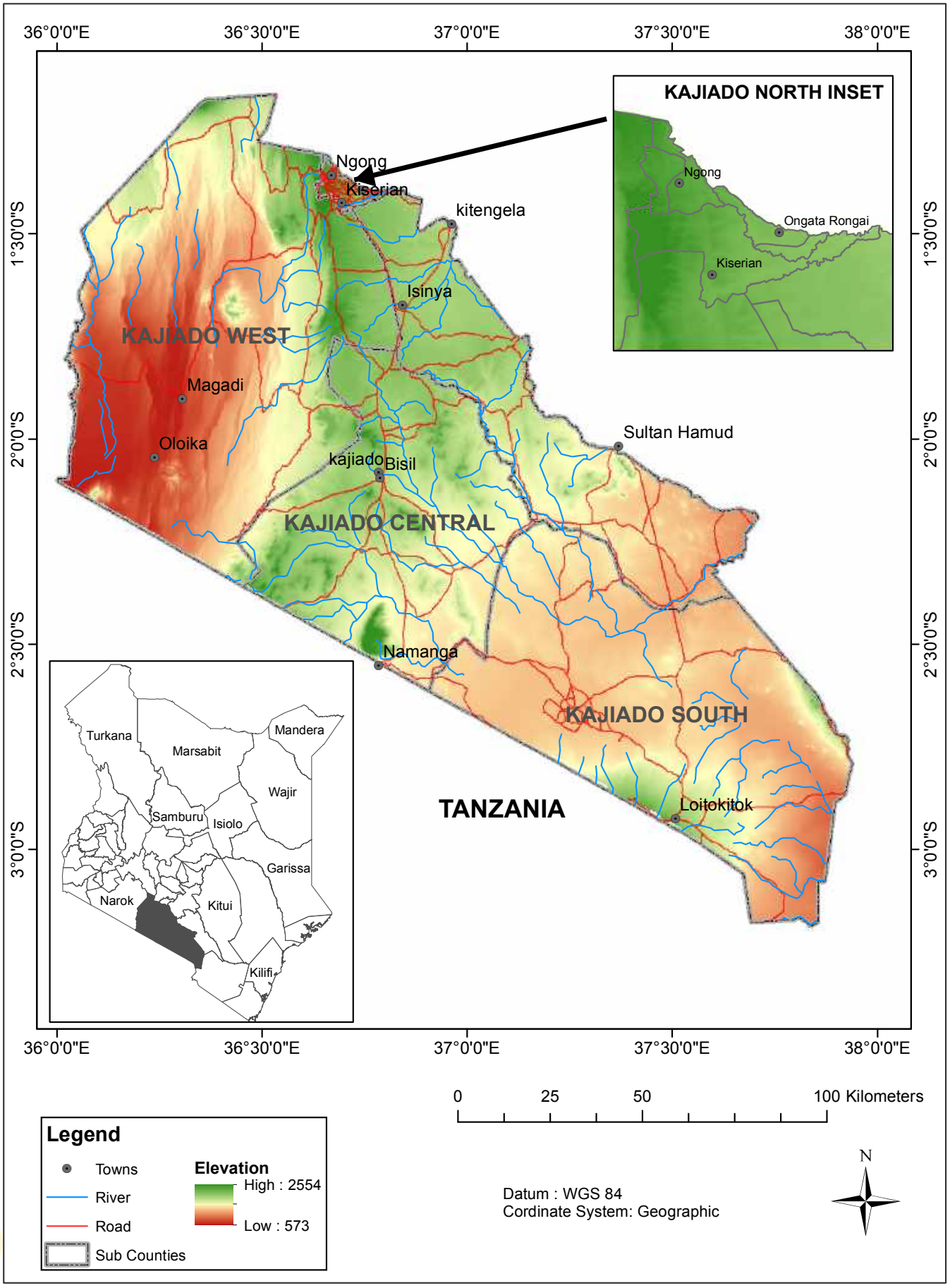


Figure 1.3: Topography of Kajiado County

1.5: KPLC Distribution

According to the Kenya National Bureau of Statistics (KNBS) Economic Survey 2020, the total electricity generation in Kenya increased by 3.9 percent to 11,620.7 GWh in 2019 while the installed capacity of electricity in 2019 was 2,818.9 MW.

Data from the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, shows that 313,218 households in Kajiado County, 67.4 percent are connected to the mains electricity. Kajiado North and Isinya have the highest number of households connected to the mains electricity at 94.9 and 85.5 percent respectively. Kajiado Central and Kajiado West households connected to the mains electricity are 41.6 and 40 percent respectively.

The distribution of power lines has concentration on urban areas where population is high. Kajiado North Sub County has much concentration of power lines due to the high population living within the area. Other Sub Counties also have been served with the power distribution though at a minimal range.

In Kajiado South, power distribution is high to the South East where population of people in the rural areas seems to be relatively high as well as in Kajiado West power distribution is relatively high to the North East due to the same factor.

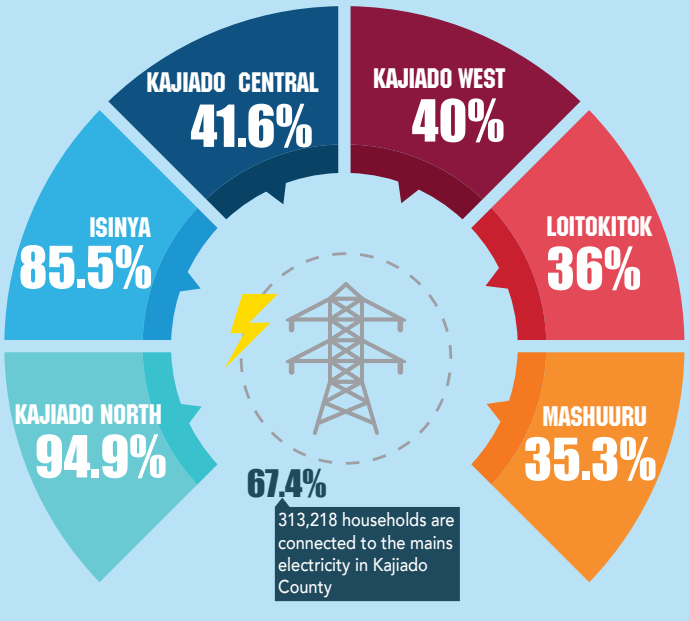
This informs that the Kenya Power and Lighting Company have distributed power in areas with high population because the distribution is relatively cheap to its residents in these areas as opposed to areas which are sparsely populated. Further, areas with various industries within the County such as Techno Steel Industry limited, Norda Industry Factory, and Khaddy Limited have also benefited from the use of Electricity from KPLC.

Power distribution is also high in areas with road networks which provide easier accessibility to different places within the County. Power distribution is also high in Kajiado North simply because of the high population within this Sub-County which is well served by road networks as opposed to other areas with relatively low population distribution.

Mashuuru has the lowest number of households connected to the mains electricity at 35.3 percent, while Loitokitok has the second lowest number of households connected to the mains electricity at 36 percent.

Photo credit @ ALIN-EA

Electricity Connection in Kajiado County



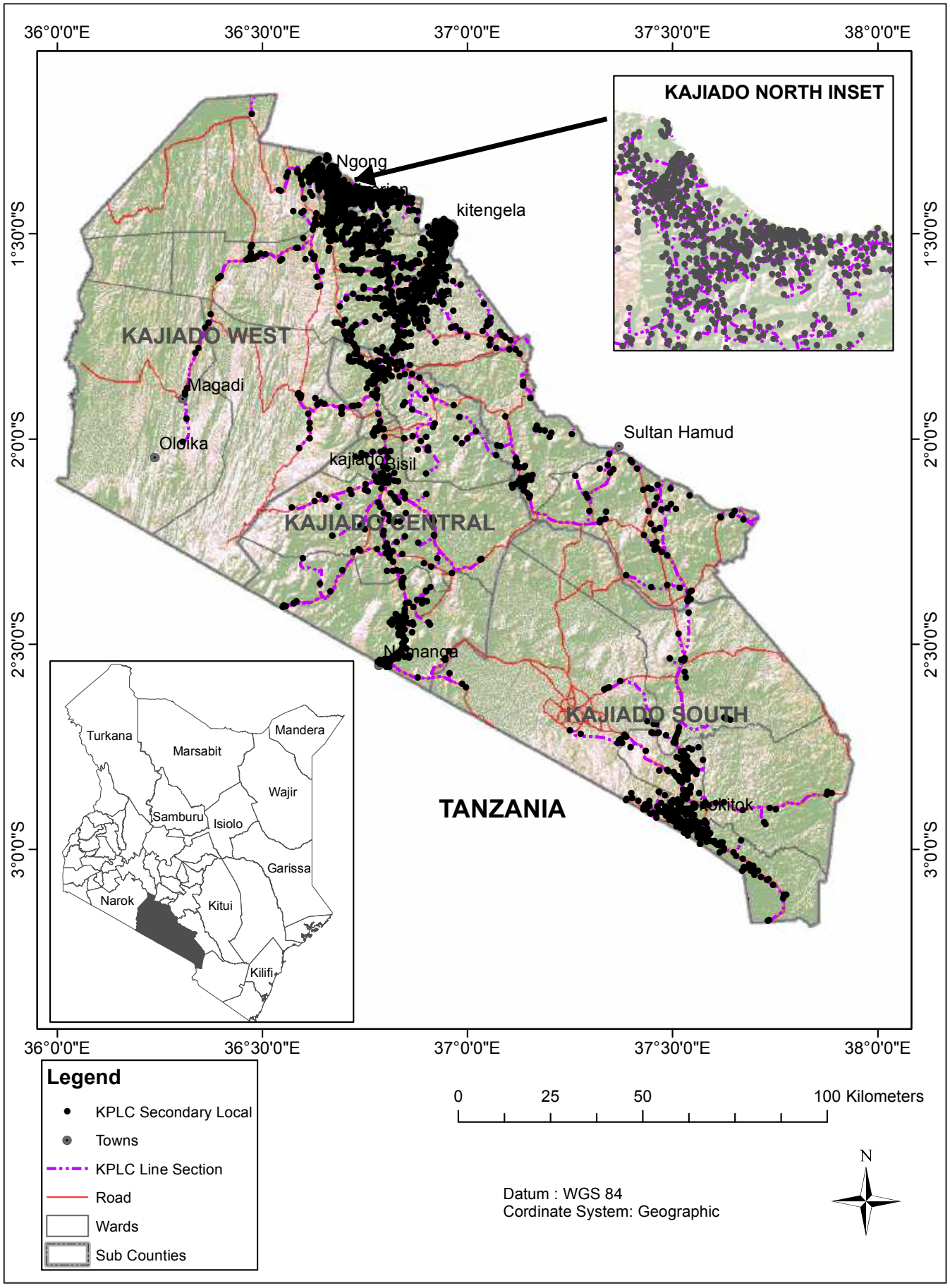


Figure 1.4: KPLC power distribution in Kajiado County.

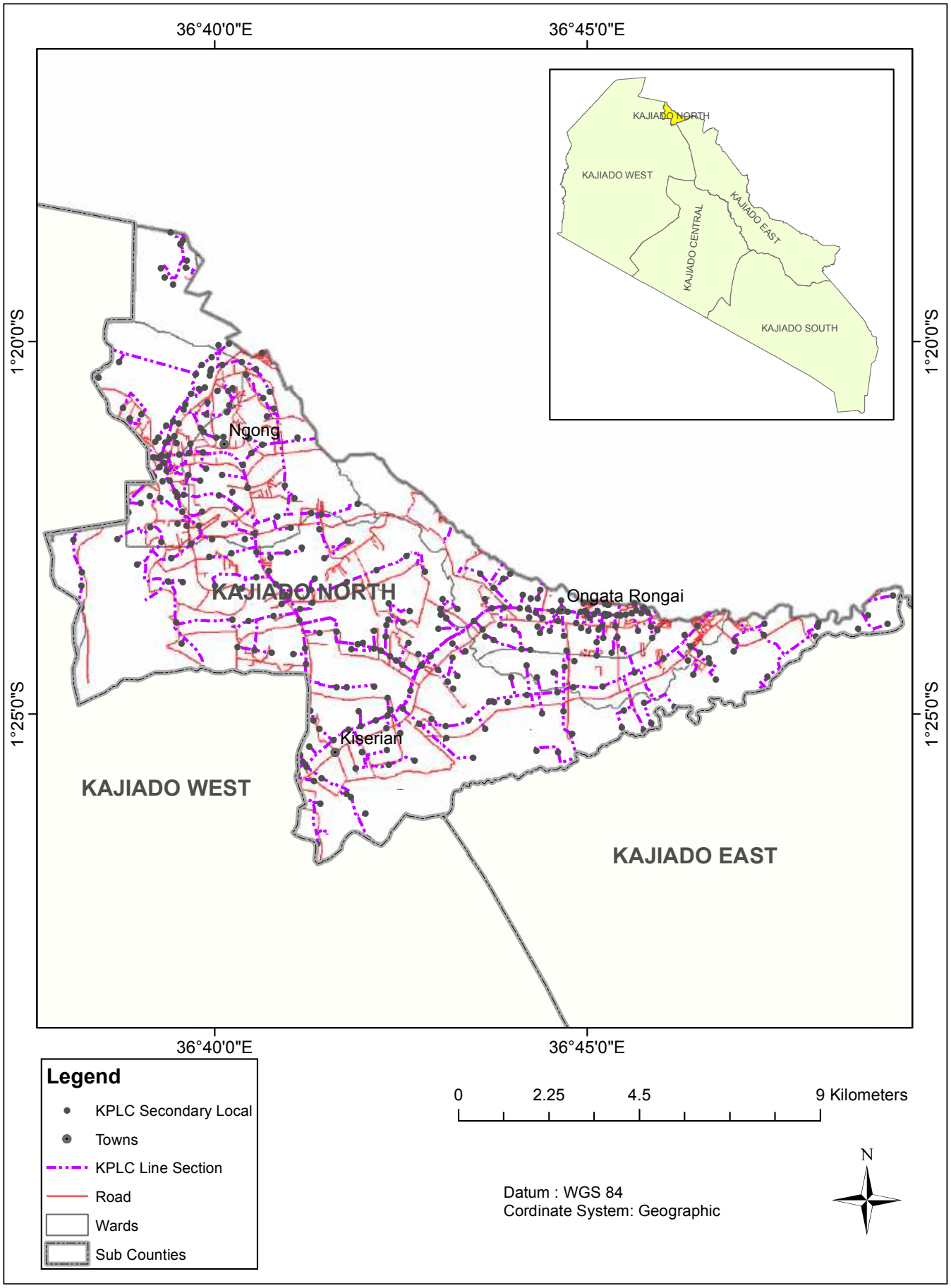


Figure 1.5: KPLC power distribution in Kajiado North.

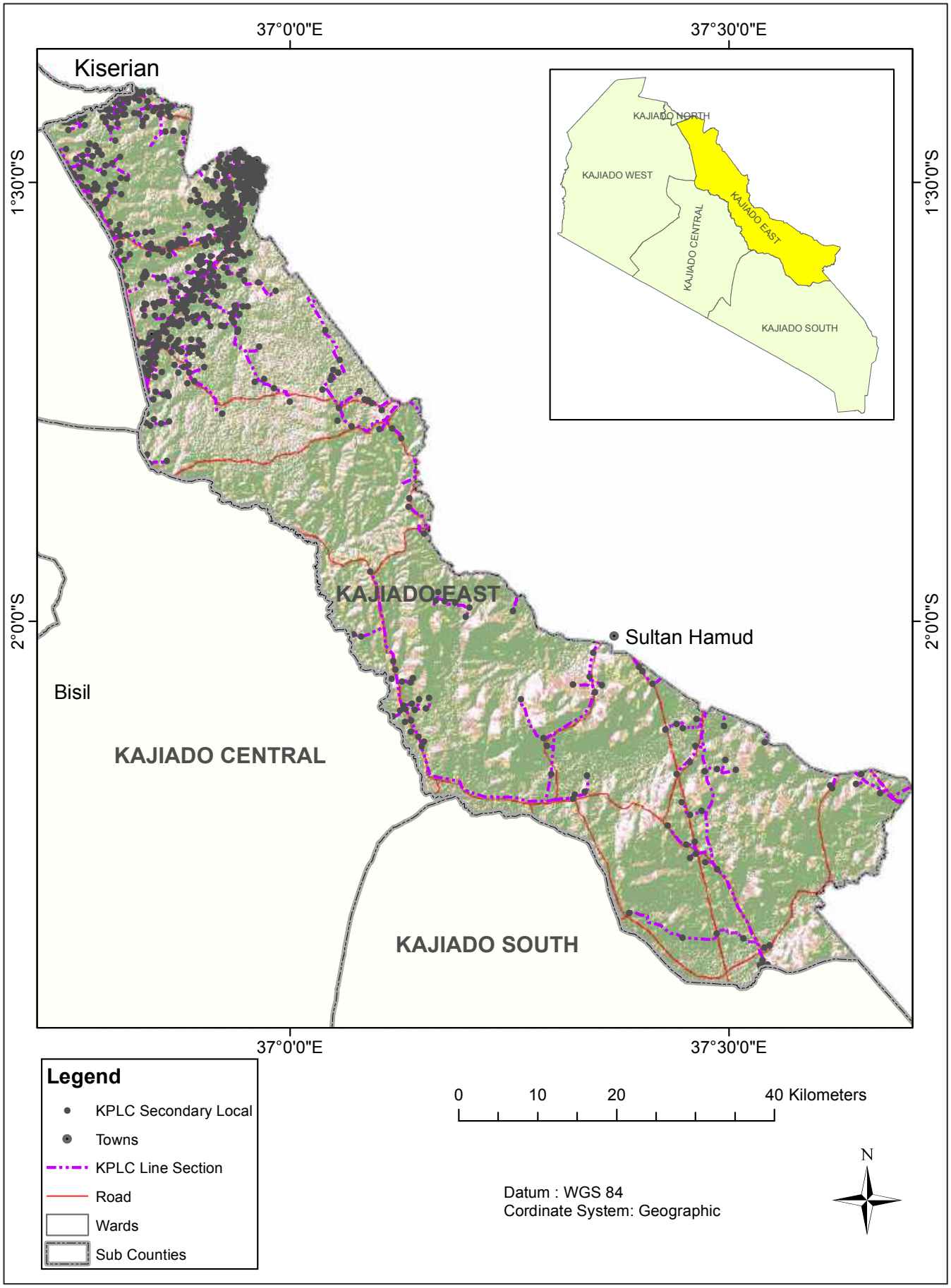


Figure 1.6: KPLC power distribution in Kajiado East.

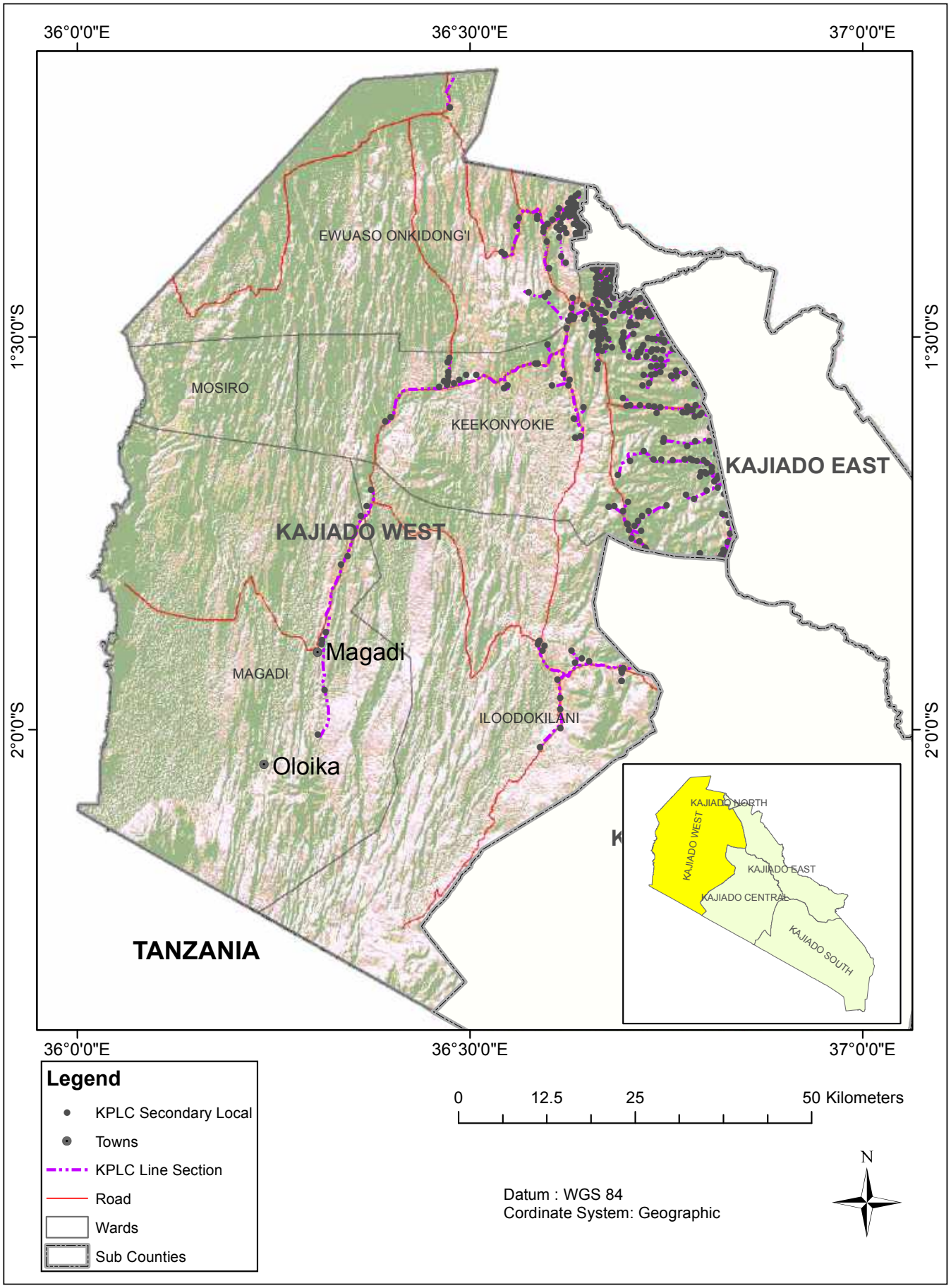


Figure 1.7: KPLC power distribution in Kajiado West.

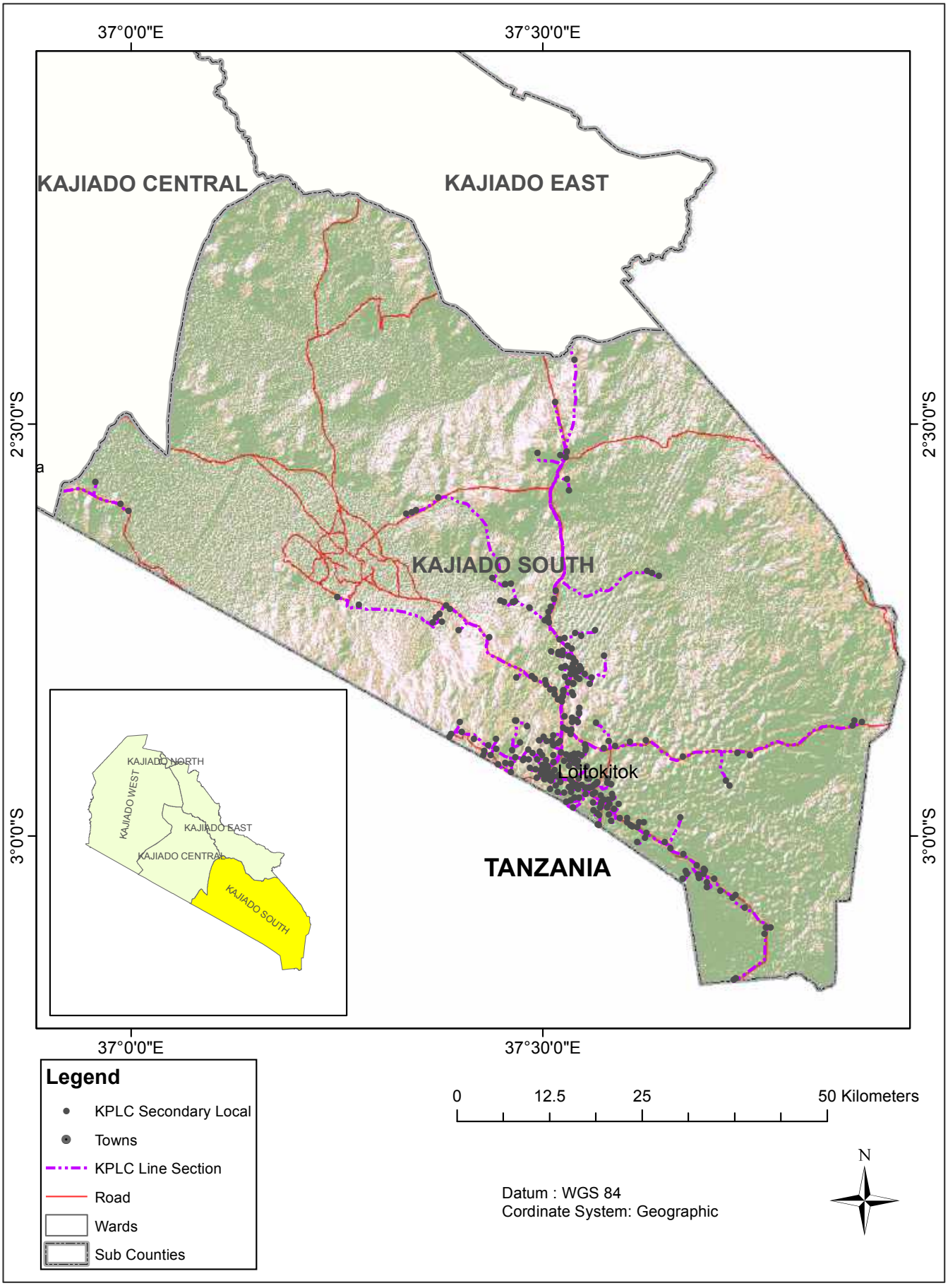


Figure 1.8: KPLC power distribution in Kajiado South.

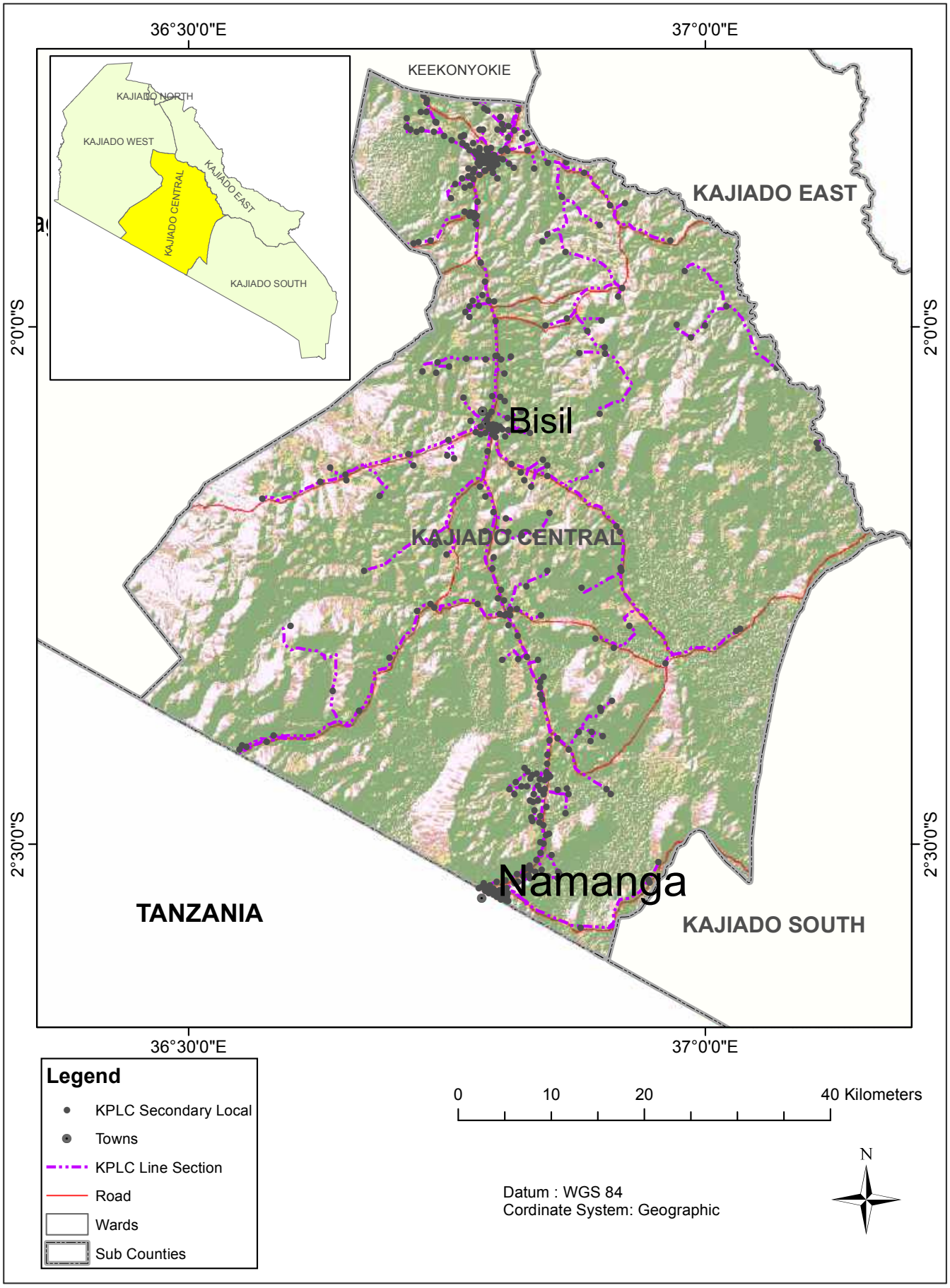


Figure 1.9: KPLC power distribution in Kajiado Central.

1.6: Borehole distribution in Kajiado County

The problem of water scarcity in Kajiado County has been solved by construction of boreholes within the County. A maximum of 1500 boreholes have been constructed to enhance sufficient supply of water within the County. Olo-olaiser Water and Sewerage Company in Kajiado County has four main water sources which include Kiserian dam, Shompole dam, Magathi River and 18 boreholes. The Company produces about 7,500M^3 a day and has a customer base of 11,262 connections comprising 7,460 active and 3,622 inactive connections.

The company also operates 35 water kiosks enhancing accessibility of water to the County residents. Schools and hospitals are potential institutions where such facilities are highly required to effectively serve the learners, staff and patients visiting the public utilities.

The borehole drilling projects can further serve as energy production sites; boreholes up to 2.8 miles deep can extract thermal energy to produce electricity for around 7,000 homes (Ministry of Energy).

However, this has not been explored. Solar energy has been used as an alternative to KPLC to offer pumping solutions. Low day-to-day running costs combined with long-term durability mean that solar powered boreholes are considered cost effective in the long-term. They are also a sustainable and effective method of providing safe water to communities. The surplus energy from the solar units could be tapped for providing energy requirement to public utilities such as schools, hospitals, and streetlights. This will help curb the energy deficit problem within the Kajiado County.

This will reduce the carbon print within the County hence minimizing climate change effect creating a suitable environment to live in.

The borehole drilling projects can further serve as energy production sites; boreholes up to 2.8 miles deep can extract thermal energy to produce electricity for around 7,000 homes.
(Ministry of Energy)

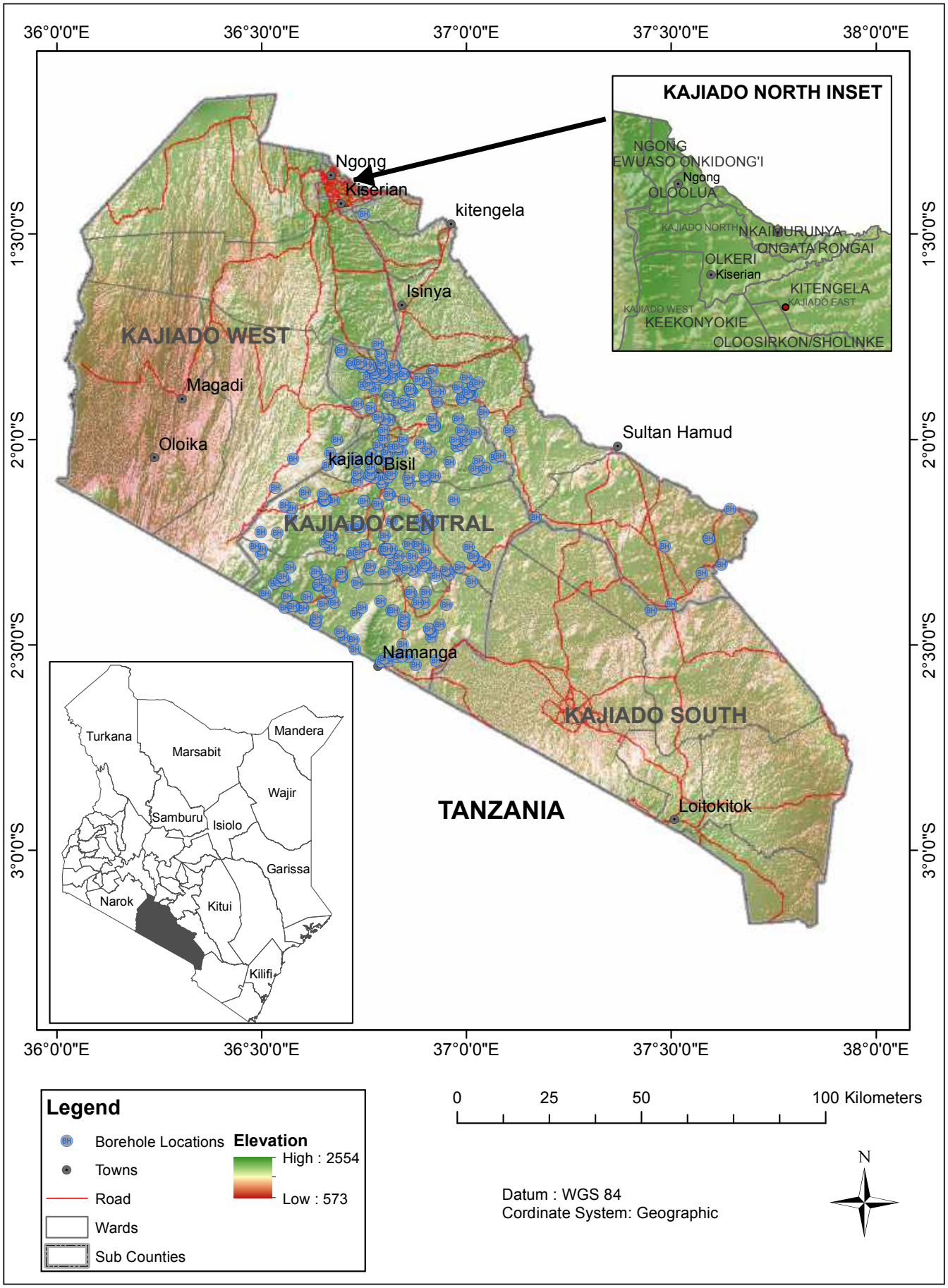


Figure 1.10: Borehole location in Kajiado County.

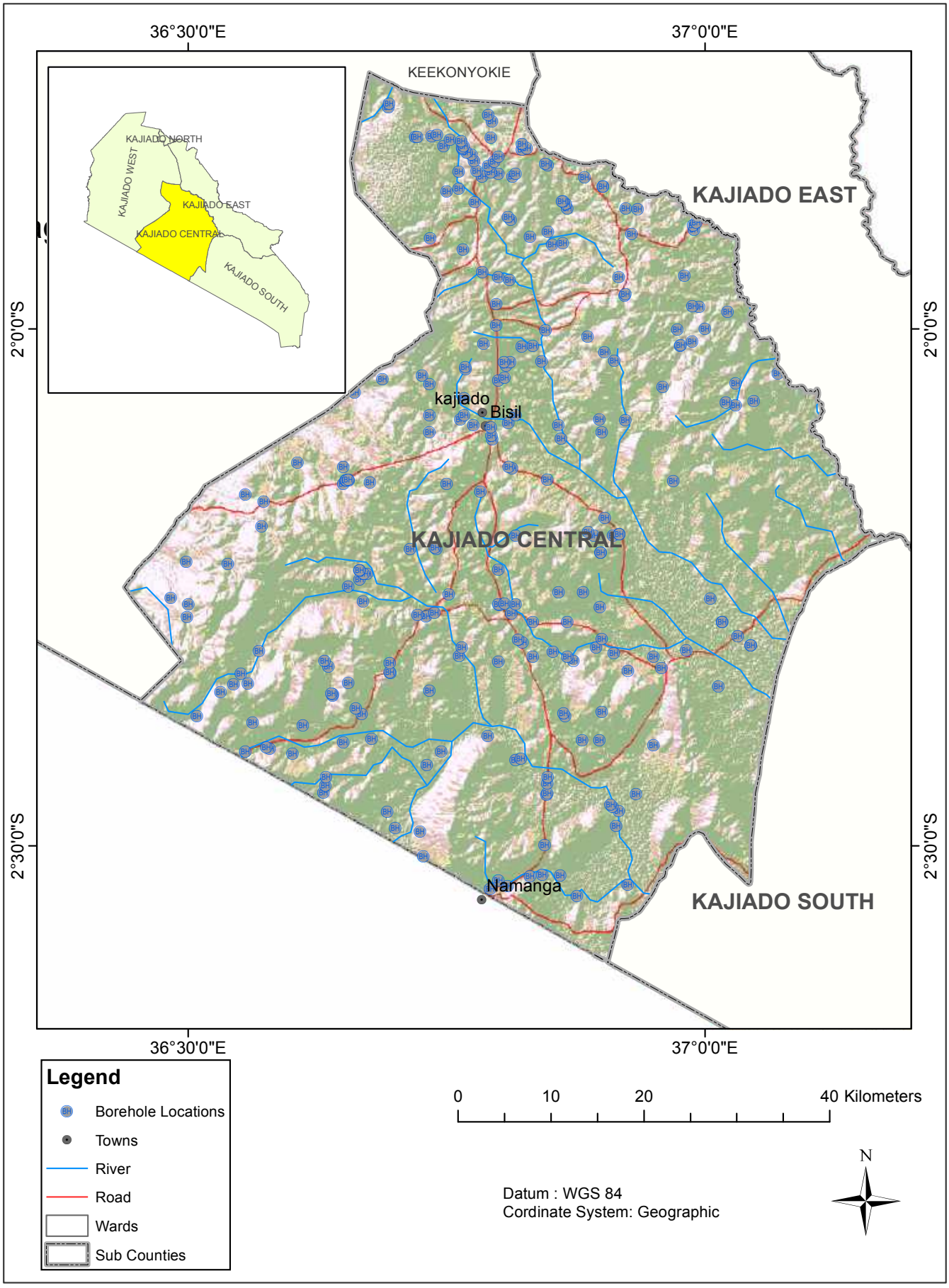


Figure 1.11: Borehole location in Kajiado Central.

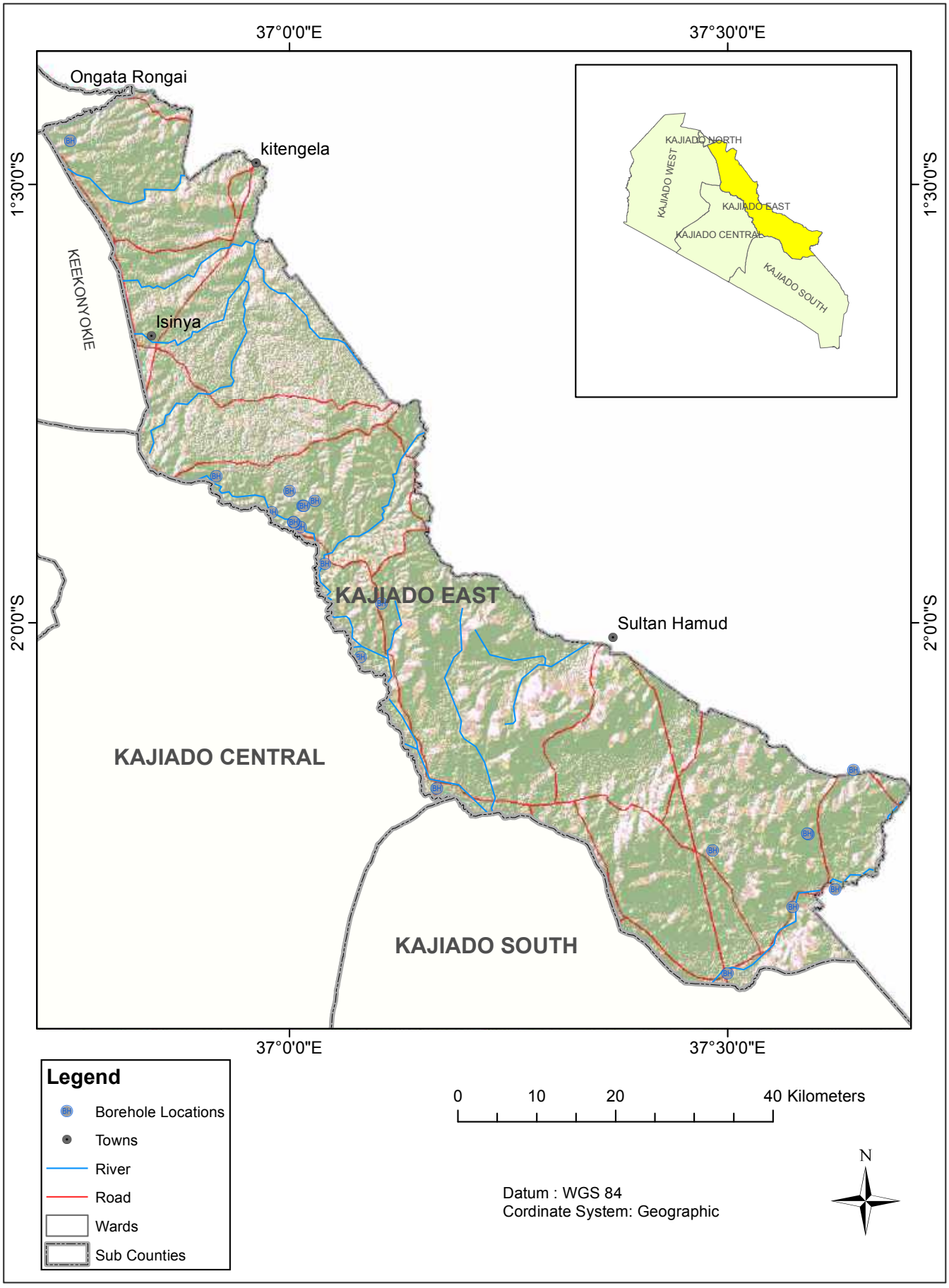


Figure 1.12: Borehole location in Kajiado East.

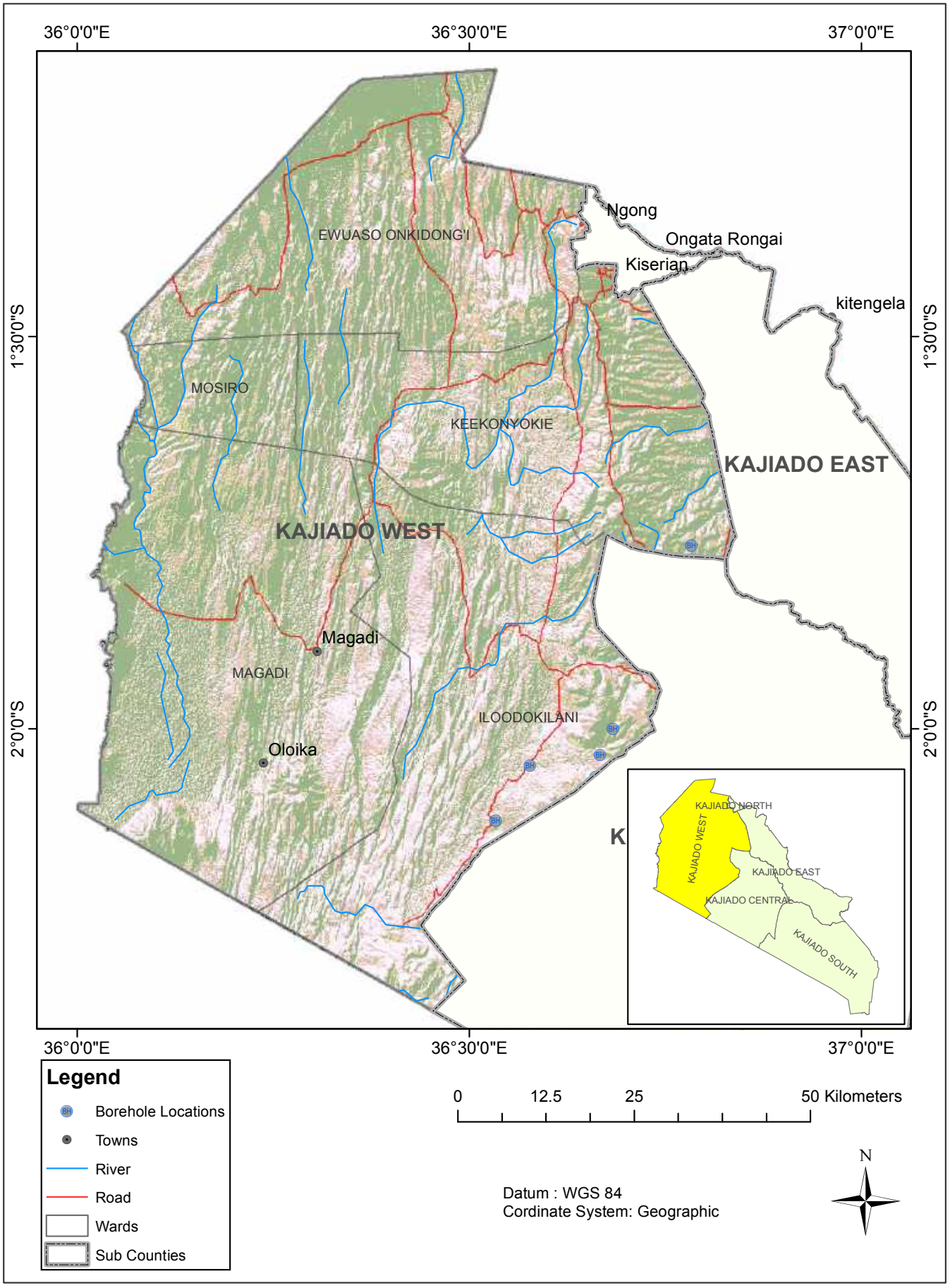


Figure 1.13: Borehole location in Kajiado West.

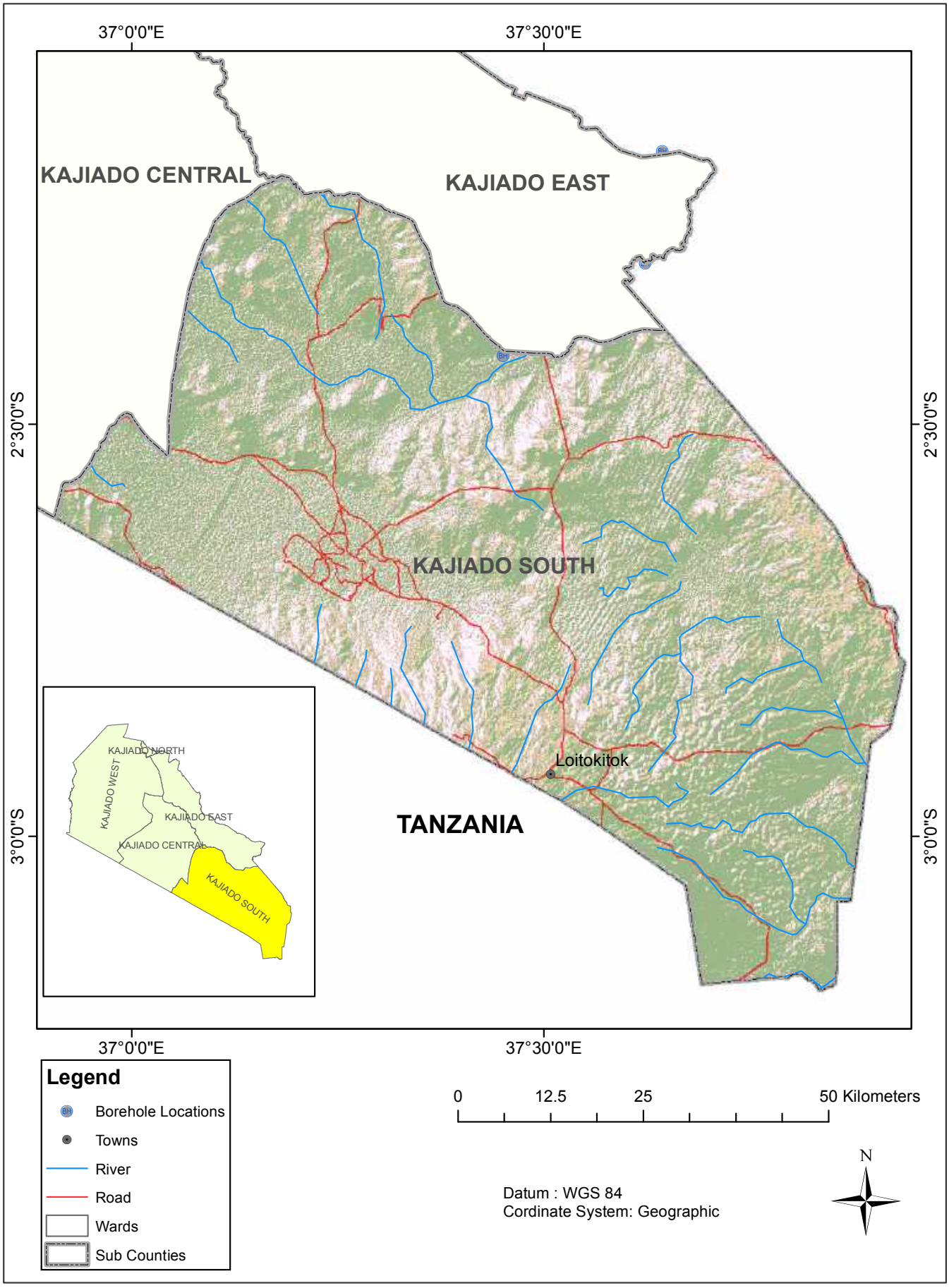


Figure 1.14: Borehole location in Kajiado South.

Chapter

02 Enabling Policy and Legal Framework

The Constitution of Kenya, 2010

The Constitution of Kenya is the supreme law of Kenya. It created the devolved system of government comprised of the National Government and 47 County Governments.

Article 42 provides for the right to a clean and healthy environment for every Kenyan, which includes the right to have the environment protected for the benefit of present and future generations through legislative and other measures.

The Fourth Schedule of the Constitution allocates to the National Government the functions of energy policy, including electricity and gas reticulation and energy regulation, and to the County Governments the functions of county planning and development, including electricity and gas reticulation and energy regulation.

Kenya's Vision 2030

The Vision 2030 is the country's development blueprint that aims to transform Kenya into a newly industrializing, middle income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment.

Vision 2030 notes that currently, the energy costs in Kenya are higher than those of her competitors in the face of growing energy demand. It, therefore, prioritizes the growth of energy generation and increased efficiency in energy consumption.

> *...the energy costs in Kenya are higher than those of her competitors in the face of growing energy demand.*

The Energy Act, 2019

Through the act, the Government is obligated to provide affordable energy services in all areas of Kenya by ensuring all households are connected to electricity by 2030.

The Act obligates the Government to promote the development and use of renewable energy technologies, including but not limited to biomass, biodiesel, bioethanol, charcoal, fuelwood, solar, wind, tidal waves, hydropower, biogas and municipal waste.

The Government is also required to establish an inter-ministerial committee known as the Renewable Energy Resource Advisory Committee.

Section 8. (1) of the act requires the National Government, in collaboration with County agencies to develop a conducive environment for the promotion of investments in energy infrastructure development, including the formulation of guidelines on the development of energy projects.

Section 74. (1) mandates the Cabinet Secretary in Charge of Energy to prepare a renewable energy resources map in respect of each renewable energy resources area while Section 75. (1) requires the Cabinet Secretary to promote the development and use of renewable energy technologies, including but not limited to biomass, biodiesel, bioethanol, charcoal, fuelwood, solar, wind, tidal waves, hydropower, biogas and municipal waste.

The Act, mandates County Governments to undertake feasibility studies and maintain data with a view to availing the same to developers of energy resources and infrastructure.

Sessional Paper No. 4 of 2004

The Sessional Paper No. 4 of 2004 is a policy document that stipulates the liberalization reforms implemented in the energy sector in the mid-1990s. Its vision is to promote equitable access to quality energy services at the least cost while protecting the environment.

The paper, therefore, lays the policy framework upon which cost-effective, affordable and adequate quality energy services will be made available to the domestic economy on a sustainable basis over the period 2004-2023.

The National Energy Policy, 2018

The overall objective of the Policy is to ensure an affordable, competitive, sustainable and reliable supply of energy at the least cost in order to achieve the national and county development needs while protecting and conserving the environment for inter-generational benefits. The Policy proposes to raise electricity generation capacity to slightly over 6,700 MW by 2024.

Kenya National Electrification Strategy

It is the roadmap to achieving universal access to electricity as a key plank of powering the Country's development agenda. Its principal objective is to achieve electricity access for all households and businesses in Kenya over the shortest timetable and at acceptable quality of service.

It focuses on identifying off-grid solutions that can meet the energy needs of lower income remote population centres and housing clusters at reasonable costs and within the government's time-frame.

Feed-in Tariff (FiT) for Renewable Energy (2012)

The Feed-in-Tariffs Policy was created by parliament under Session Paper 1 of 2004 in 2008 to promote the development of renewable energy to supply villages, small businesses or farms, as well as grid supply.

It facilitates resource mobilisation by providing investment security and market stability for investors in electricity generation from renewable energy sources.

The FiT was reviewed in 2010 and 2012. The tariffs apply to grid-connected plants and are valid for 20 years from the beginning of the Power Purchasing Agreement (PPA), with approval of the PPAs granted by the Energy and Petroleum Regulatory Authority (EPRA).

Climate Change Act, 2016

The Climate Change Act, 2016 is the first comprehensive legal framework for climate change governance in Kenya. The objective of the Act is to "Enhance climate change resilience and low carbon development for sustainable development of Kenya."

The Act mandates the Cabinet Secretary responsible for environment and climate change affairs in consultation with the Cabinet Secretary responsible for finance to provide incentives to persons who encourage and put in place measures for the elimination of climate change including reduction of greenhouse emissions and use of renewable energy.

> *"Enhance climate change resilience and low carbon development for sustainable development of Kenya."*
>
> *The Climate Change Act, 2016*

The FiT values for small renewable projects (upto 10MW of installed capacity connected to the grid.

	Installed capacity (MW)	Standard FiT (US $ kWh)	Percentage escalable portion of the tarriff	Min capacity (MW)	Max capacity (MW)
Wind	0.5-10	0.11	12%	0.5	10
Hydro	0.5	0.5-10	8%	0.5	10
	10	0.0825			
Biomass	0.5-10	0.10	15%	0.5	10
Biogas	0.2-10	0.10	15%	0.2	10
Solar (Grid)	0.5-10	0.12	8%	0.5	10
Solar (Off-Grid)	0.5-10	0.20	8%	0.5	1

*For values between 0.5-10MW, interpolation shall be applied to determine tarriff for hydro.

National Climate Change Action Plan (NCCAP) 2018-2022

This is a five-year plan to guide Kenya's climate change actions, including the reduction of greenhouse gas emissions. The action plan aims to ensure an electricity supply mix that is based mainly on renewable energy, is resilient to climate change, and promotes energy efficiency and, encourage a transition to clean cooking to reduce demand for fuelwood.

The action plan targets to develop an additional 2,495 MW of new renewables including geothermal, biomass, hydro, solar and wind by 30th June 2023.

National Adaptation Plan 2015-2030 (NAP)

The NAP is the basis for the adaptation component of Kenya's Nationally Determined Contribution (NDC). The NAP aims to consolidate the country's vision on adaptation supported by macro-level adaptation actions that relate with the economic sectors and county level vulnerabilities to enhance long term resilience and adaptive capacity.

NAP enhances the implementation of an energy generation mix plan that increases the resilience of the current and future energy systems to the impacts of future climate variability and change. It aims to increase the solar, wind and other renewable energy systems network to provide power to off-grid areas and to increase small hydropower and geothermal power generation plants to provide electricity to communities and businesses in the rural areas enabling job creation.

Kenya's Nationally Determined Contribution (NDC) (2016)

Kenya's NDC under the Paris Agreement of the UNFCCC includes mitigation and adaptation contributions. The mitigation contribution "seeks to abate Kenya's GHG emissions by 30% by 2030, relative to the business as usual scenario of 143 MtCO2eq." Mitigation activities include expansion in geothermal, solar and wind energy production, other renewables and clean energy options.

Kajiado County Integrated Development Plan (CIDP) 2018-2022

The second generation Kajiado County Integrated Development Plan (CIDP 2018-2022) outlines policies, programmes and projects which the county intends to implement between 2018 and 2022.

The Plan recognizes energy as an enabler for county transformation with one of its outcomes being increased access to affordable and reliable energy. It advocates for promoting the use of alternative energy such as wind, solar and biogas and also for the establishment of partnership in green energy development.

The Kajiado County Climate Change Bill, 2020

The Kajiado County Climate Change Bill, 2020 provide for a regulatory framework for enhanced response to climate change in Kajiado County. The Bill seeks to establish a County Climate Change Fund which shall be used to fund climate change programs, projects and activities.

The Bill also obligates the County Government to use market-based instruments and other economic inducements to provide incentive (s) for climate change activities including reduction of greenhouse gas emissions and use of renewable energy by local communities.

The Kajiado County Environment Protection Bill, 2020

The Bill provides a legislative framework to ensure a clean and healthy environment in the county and reduce the production of wastes while monitoring pollution within the county. It also promotes the conservation and where appropriate, sustainable use of biological diversity and protection and the protection and conservation of natural resources in the county.

The Kajiado County Sand Harvesting and Quarry Bill, 2020

The principle objective of this Bill is to regulate sand harvesting and quarrying activities which include riverbed sand harvesting. It will also ensure sustainable exploitation and utilization of land in the county.

Chapter 03 Solar Energy

Solar panes at PJ Daves Flower farm in Isinya, Kajiado county

Photo credit @ Kevin Mungai

3.1 Solar and Terrestrial Radiation

According to the International Energy Agency (IEA) Solar PV Tracking Progress 2020, power generation from solar photovoltaic (PV) is estimated to have increased in the world by 22 percent in 2019, to 720 TWh. The increase represented the second-largest absolute generation growth of all renewable technologies, slightly behind wind and ahead of hydropower. With this increase, the solar PV share in global electricity generation is now almost 3 percent.

According to the Kenya National Bureau of Statistics (KNBS) Economic Survey 2020, solar generation rose from 13.7 GWh in 2018 to 92.3 GWh in 2019 as a result of the commissioning of the Garissa Solar Power Plant. The installed solar capacity in the country is now 51 MW.

In Kajiado County, data from the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, shows that 15.5 percent of the 313,218 households in the county use solar as their main source of lighting fuel.

Mashuuru has the highest number of households using solar at 39.2 percent followed by Kajiado West at 35.2 percent. Kajiado Central and Loitokitok has 32.4 and 22.7 percent respectively. Kajiado North has the lowest number of households using solar at 0.7 percent.

Kajiado County has high insolation rates with an average of 5-7 peak sunshine hours. It receives an average daily insolation of 4-6kWh/m^2. Only 10-14 percent of this energy can be converted into electricity due to the conversion efficiency of solar Photo Voltaic (PV) modules.

Since 2006-2007, the Ministry of Energy has been actively promoting use of solar energy for off grid electrification. In particular, it has funded the solar for school's programme and is targeting to extend this to off grid clinics and dispensaries.

Solar irradiation is the most important source of permanent and inexhaustible energy supply in most arid and semi-arid areas. Even though only 50-68 percent (0.7-0.98 kW m^{-2}) of solar energy can be collected in a sun day. The solar energy collected is variable to vulnerable communities in rural areas of the County who have no access to electricity.

"Kajiado County has high insolation rates with an average of 5-7 peak sunshine hours."

3.2 Existing Solar Site

Kajiado County is one of the counties suitable for solar energy generation as it has high isolation rates. Some areas within the County have new commercial and utility developments which are under operationalization of solar energy such as PJ daves flower farm in Isinya and some underway (private farm in Olepolos) in Kaputiei North for water pumping and irrigation purposes; this indicates solar photovoltaic systems may now be economical.

PJ Daves has installed 936 solar panels with maximum power output of 380kWp. A number of schools sponsored by World Bank have installed solar panels which serve the purpose of lighting, running the education digital electronics and charging of other valuables.

There is also a successful installation of 23 solar high mast flood lights in strategic areas within the urban areas through the Nairobi Metropolitan Services Improvement Projects (NaMSIP) and the County Government. These include Sholinke trading Centre, Ilbisil trading centre, Rongai, Ngong town, Kimana town, Nkaimurunya (chief's office Gituguta JCN, Nakeel Grounds) and Embulbul Trading Centre.

Photo credit @ Kevin Mungai

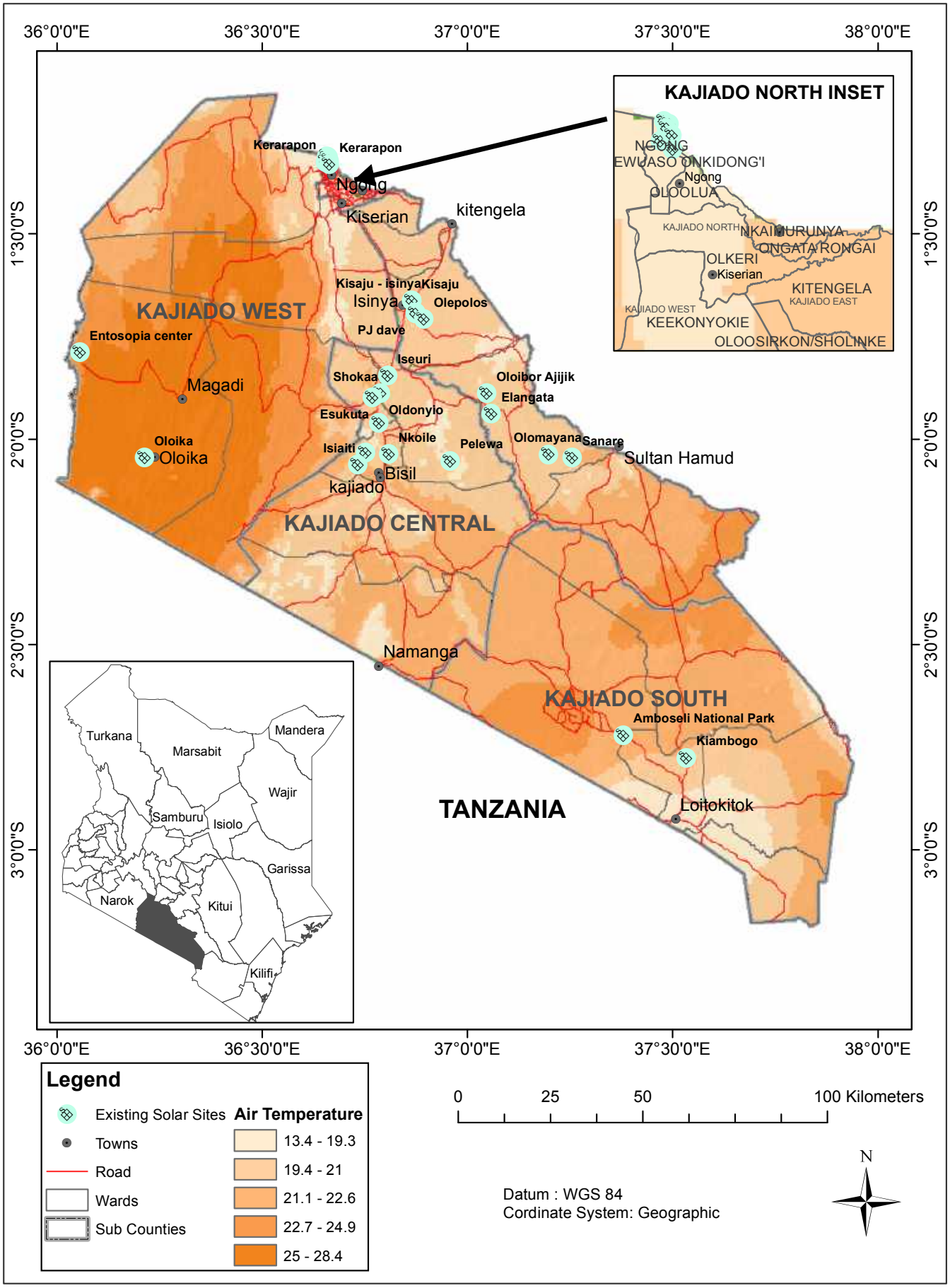


Figure 1.15: Existing Solar Energy Sites in Kajiado County.

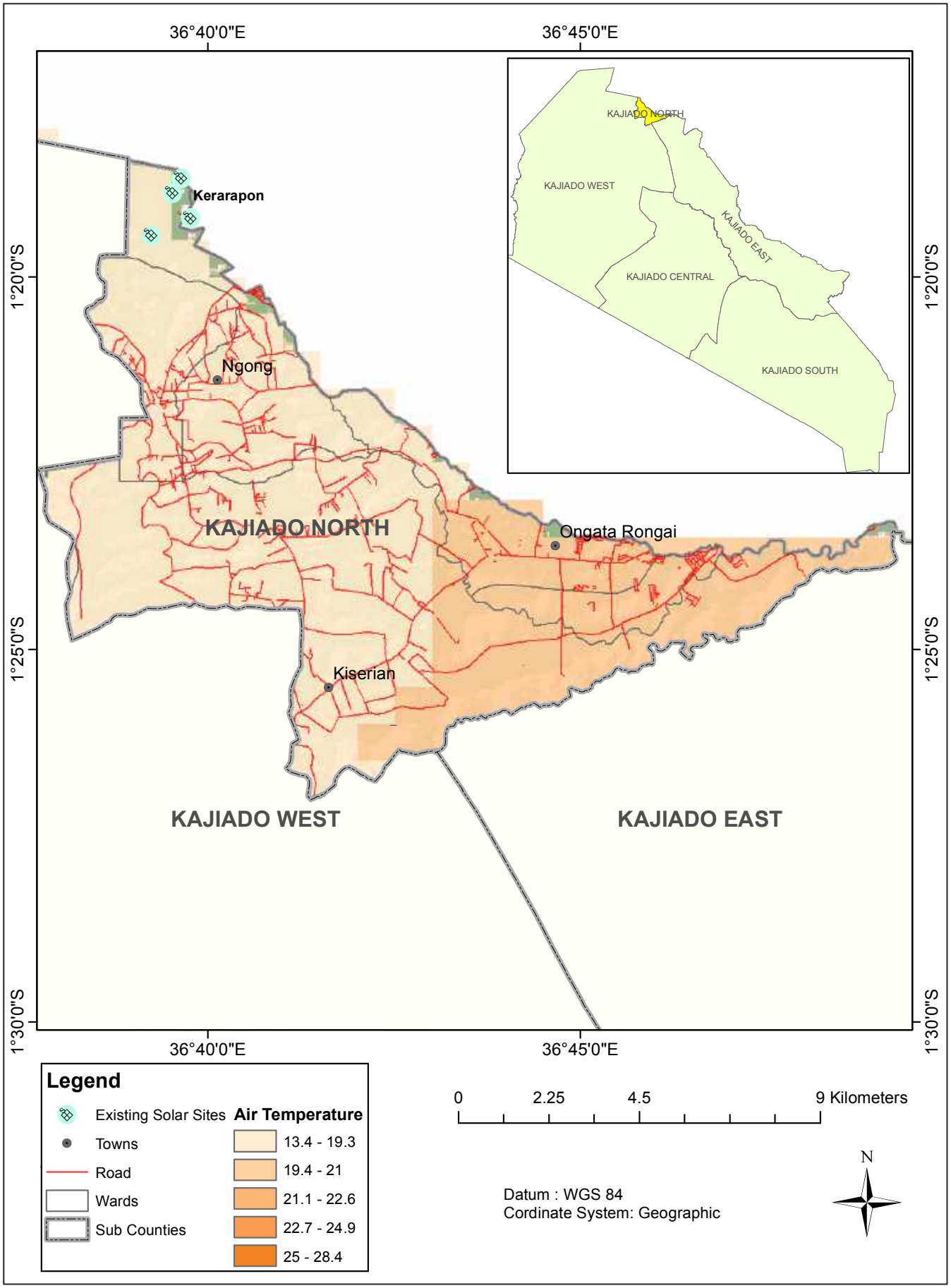


Figure 1.16: Existing Solar Energy Sites in Kajiado North.

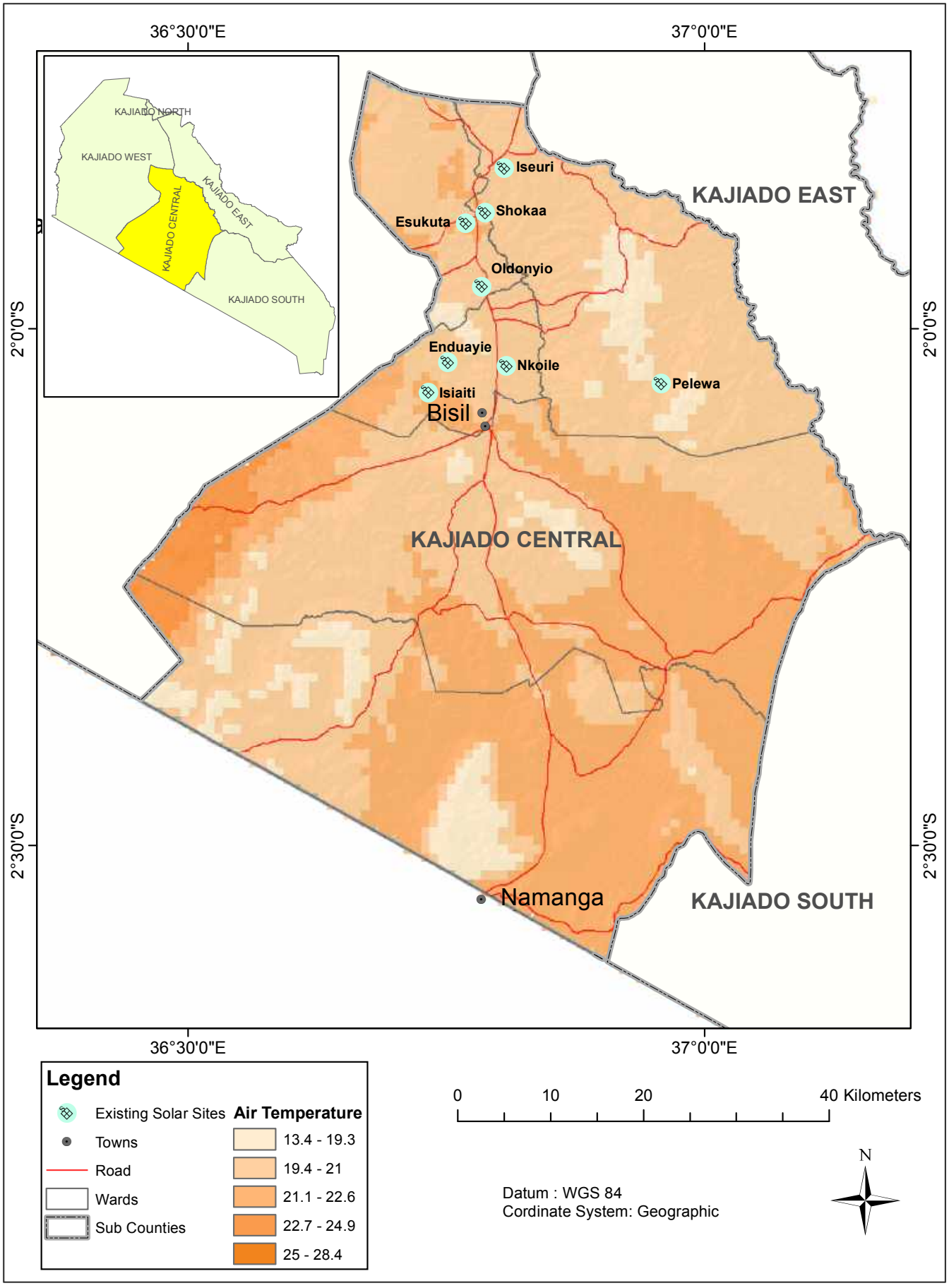


Figure 1.17: Existing Solar Energy Sites in Kajiado Central.

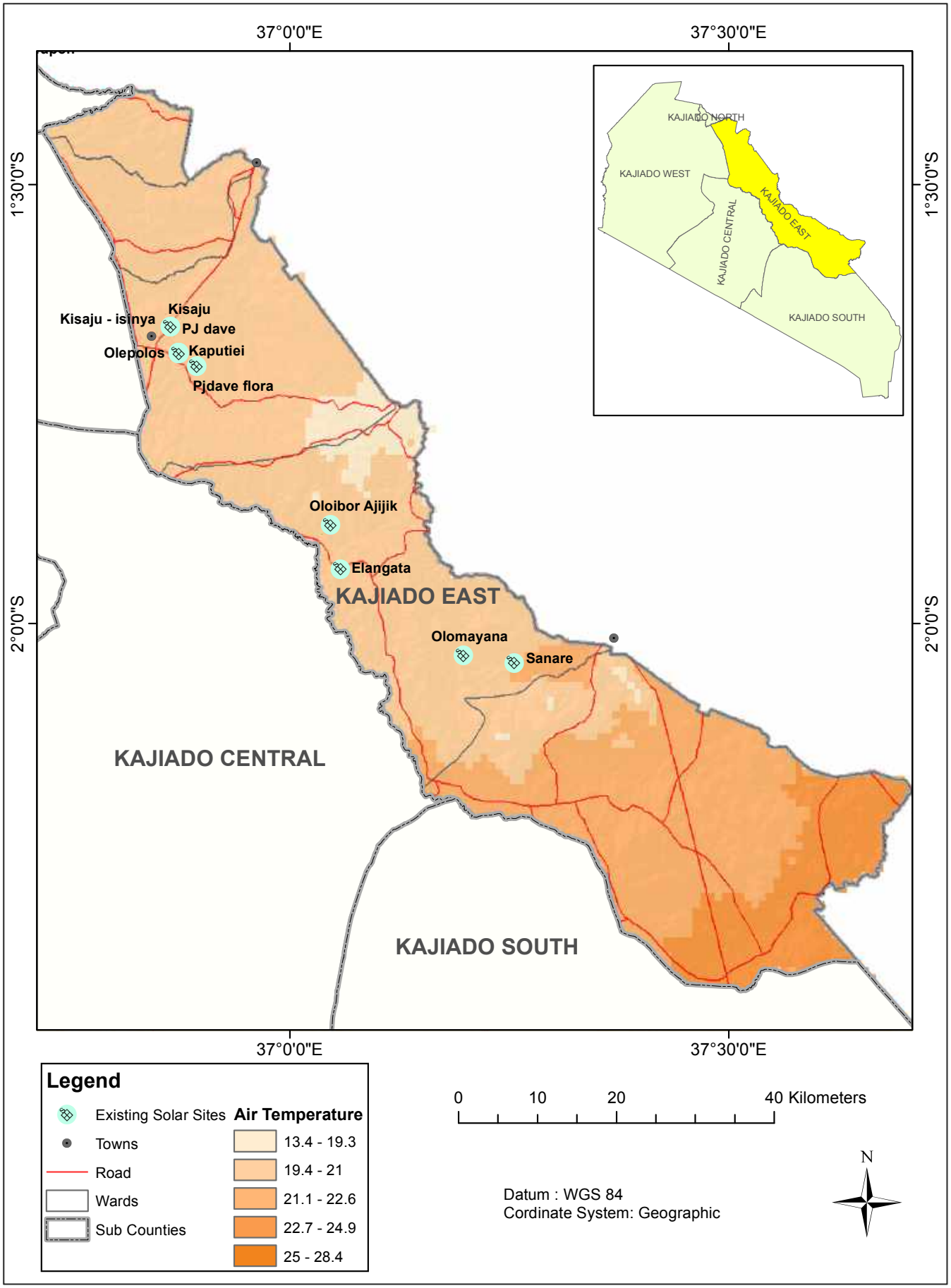


Figure 1.18: Existing Solar Energy Sites in Kajiado East.

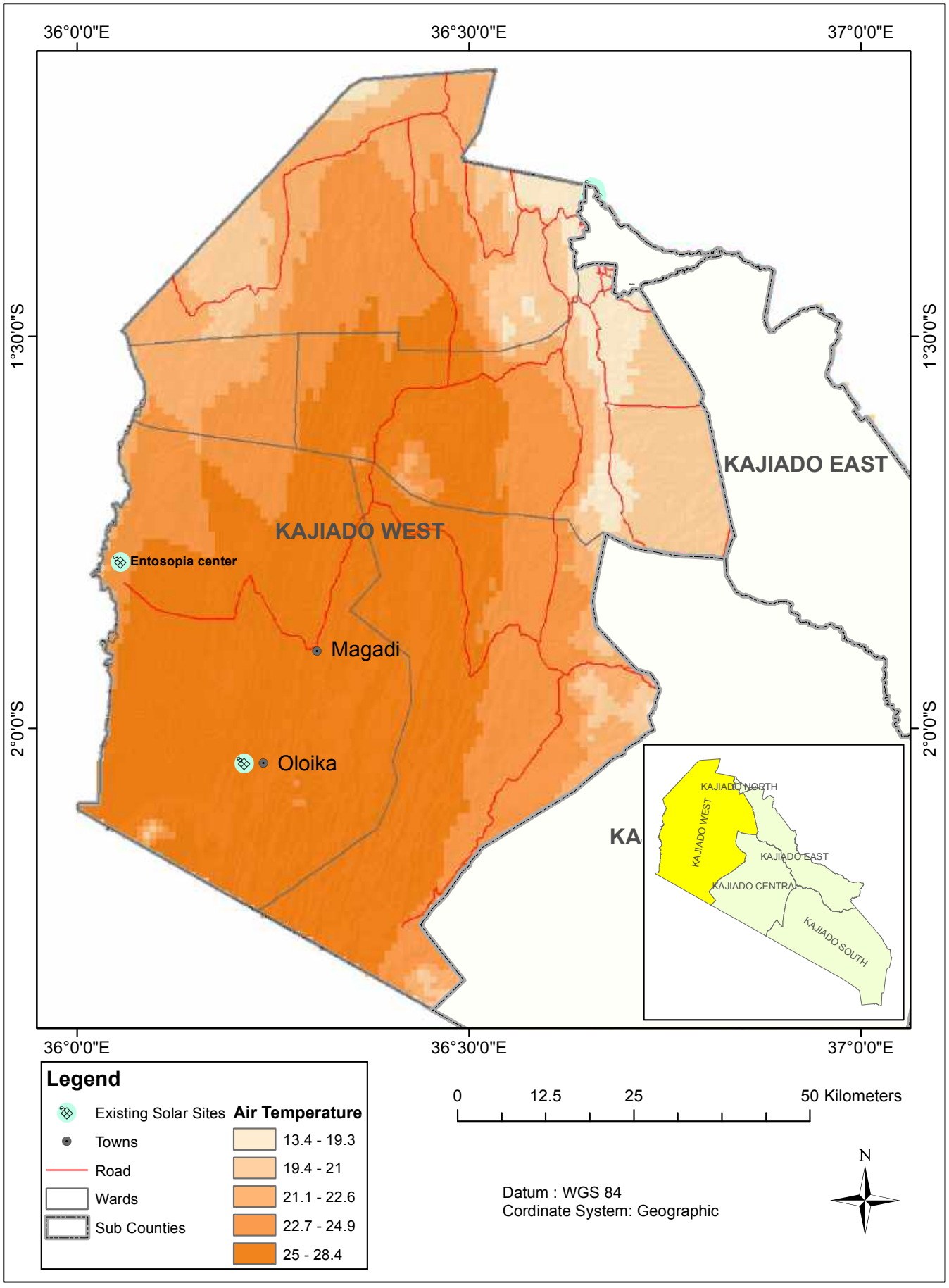


Figure 1.19: Existing Solar Energy Sites in Kajiado West.

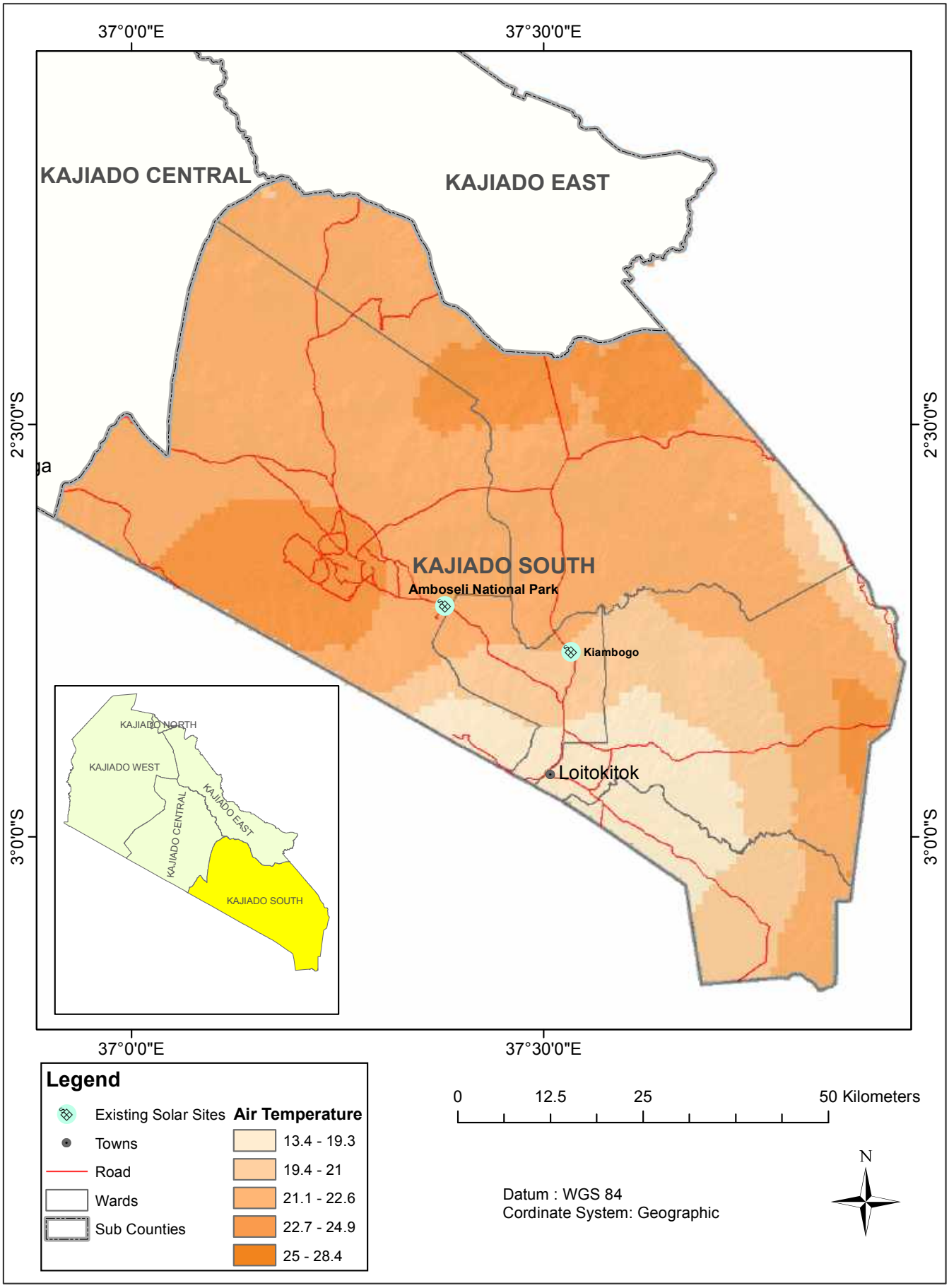


Figure 1.20: Existing Solar Energy Sites in Kajiado South.

3.3 Potential solar sites in Kajiado County

In Singiraine village, Hivos East Africa and Bithub are in the process of piloting a new smart grid solar technology. The micro-grid will be backed by blockchain technology which keeps all the data on power distribution and purchase.

The technology will allow residents with solar panels to generate and sell their surplus energy to their neighbours.

The seller can then check the amount of electricity he sold or the amount of money he has made in a month by dialling a short code on his phone. Power consumers on the mini-grid can also monitor their power consumption.

Other potential sites include:

Kajiado North – Kerarapon drive 16, Bulbul, Oloika; Oloolua; Kibiko; Nkaimurunya; Kamula; Kahuho; Exciting area; Rongai

Kajiado West – Nkiushin; Najile; Enkorika; Oloshooboir; Kibiko; Kimuka; Loodo Ariak; Naserian; Oloyiankalani; Kilonito; Mile 46; Kenya Mable Quarry; Lengobei; Olkiramatian; Entosopia area; Oloika

Kajiado East – Emali (Entumata); Nkama; Sultan Hamud Community area; Enkigiriri; Kaputie plains; Olorena; Kitengela reserve

Kajiado South – Rombo; Oringila; Entarera; Illasit; Lemongo; Duka Moja; Oltiasika; Impirikani

Kajiado Central – Eluanata; Enkokidongoi; Olchurrai; Lorngosua; Olepolos; Nalepo; Olobelibel: Malilima; Orine; Enkorika; Orgos; Enduata; Nginye; Nkinye; Oloserien; Olkiloriti; Orkeju; Kumpa;

936 solar panels with a maximum power output of 380kWp at PJ Daves flower farm in Isinya, Kajiado County.

Photo credit @ Kevin Mungai

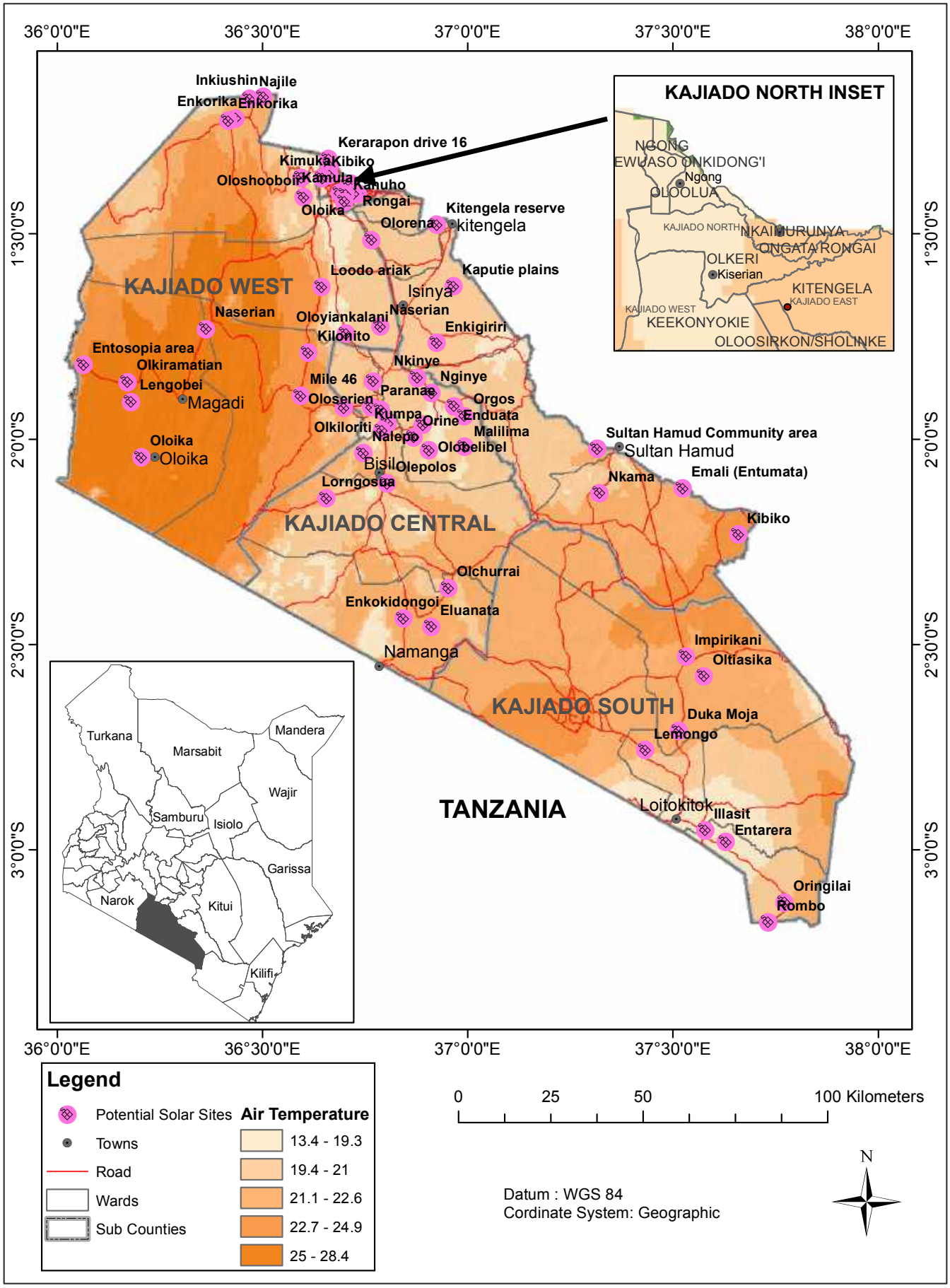


Figure 1.21: Potential Solar Energy Sites in Kajiado County.

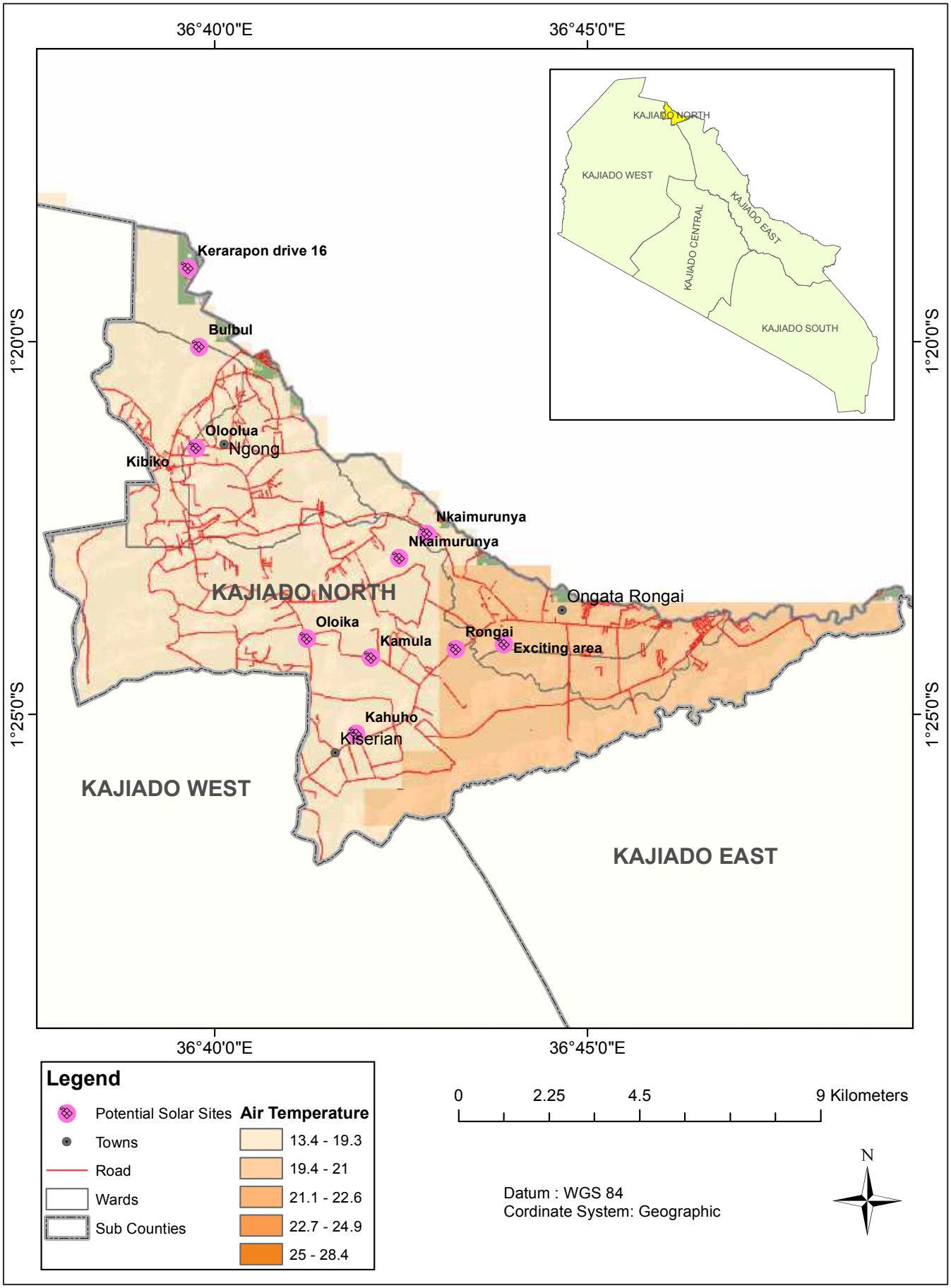


Figure 1.22: Potential Solar Energy Sites in Kajiado North.

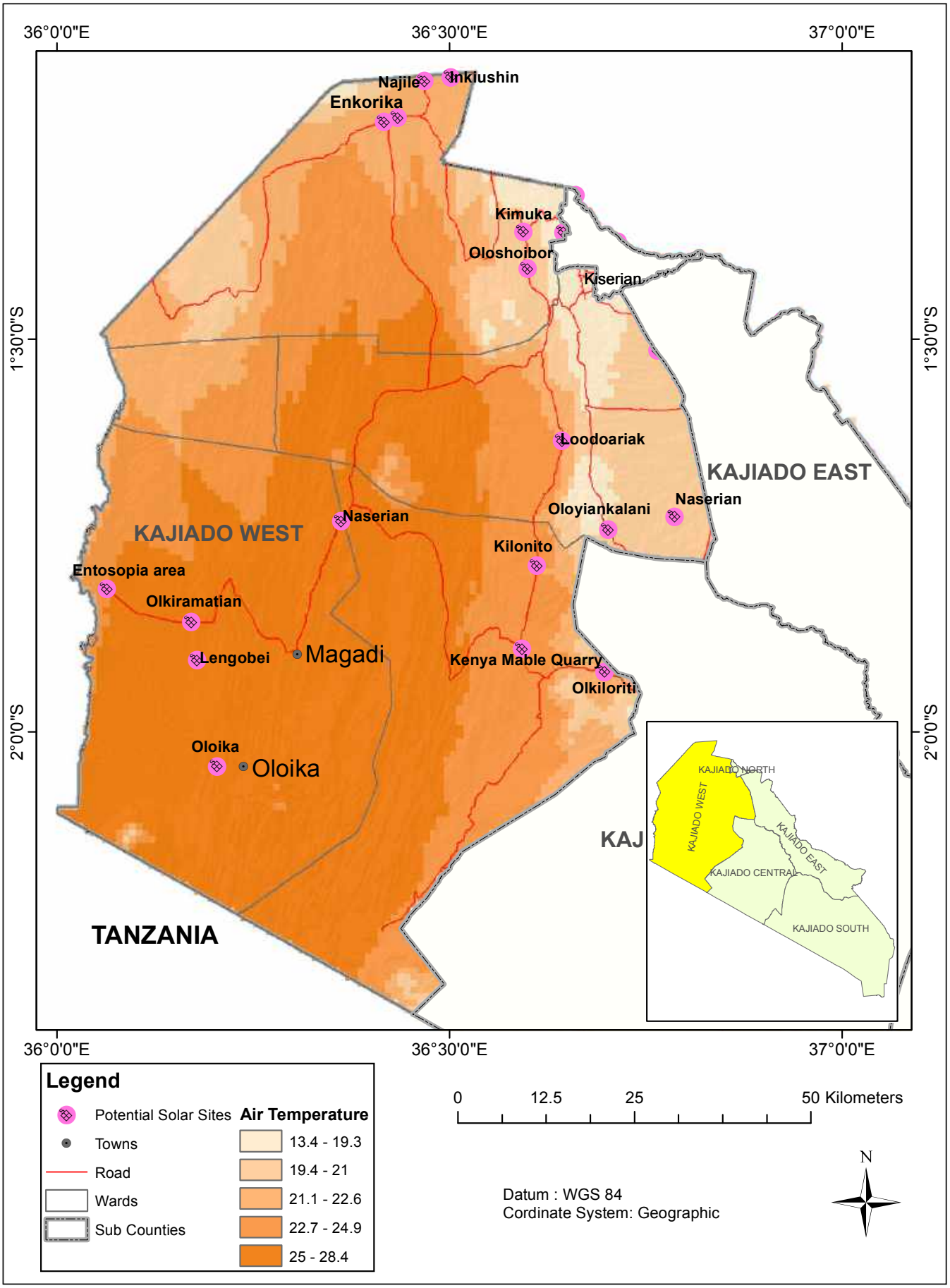


Figure 1.23: Potential Solar Energy Sites in Kajiado West.

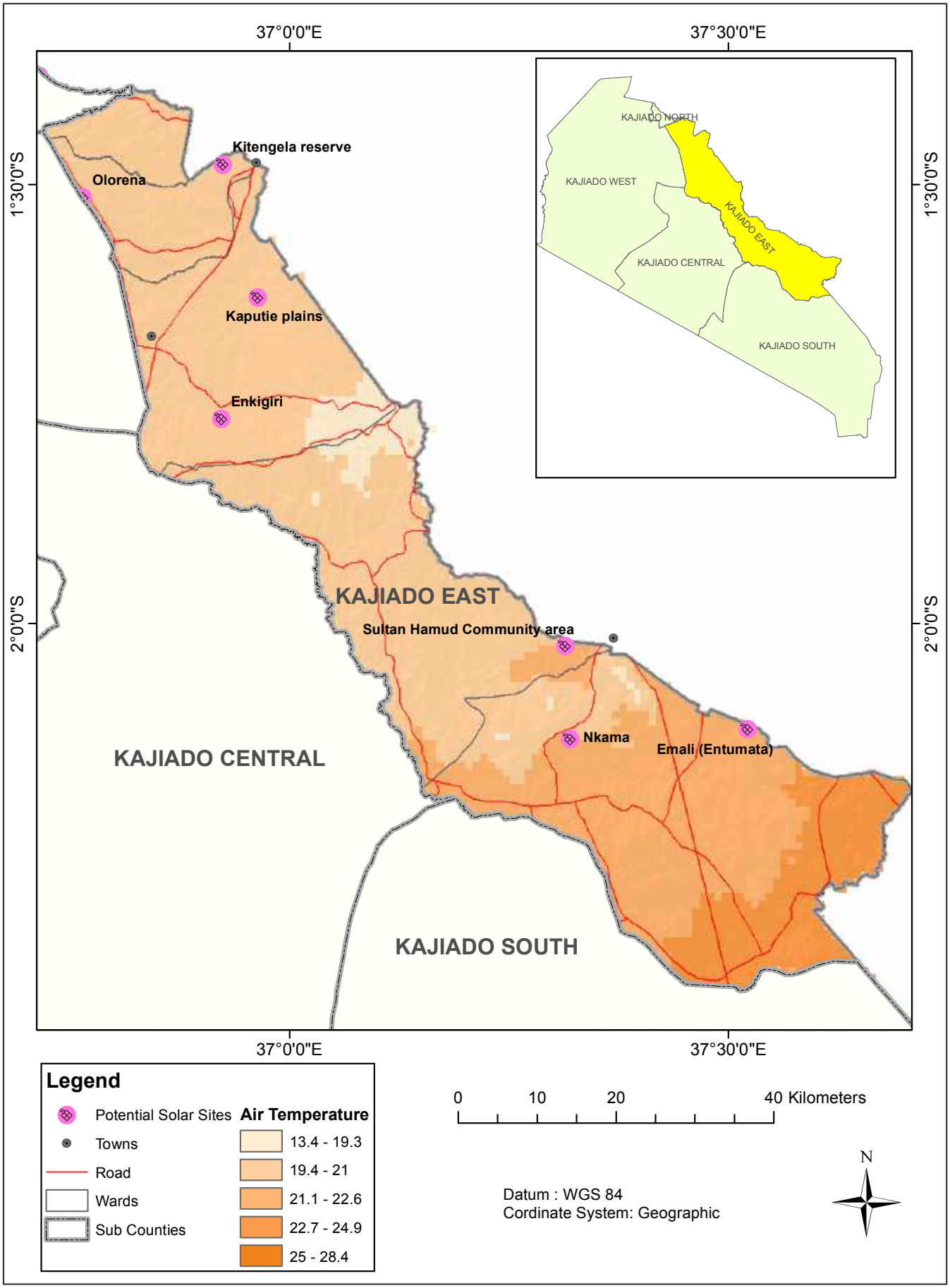


Figure 1.24: Potential Solar Energy Sites in Kajiado East.

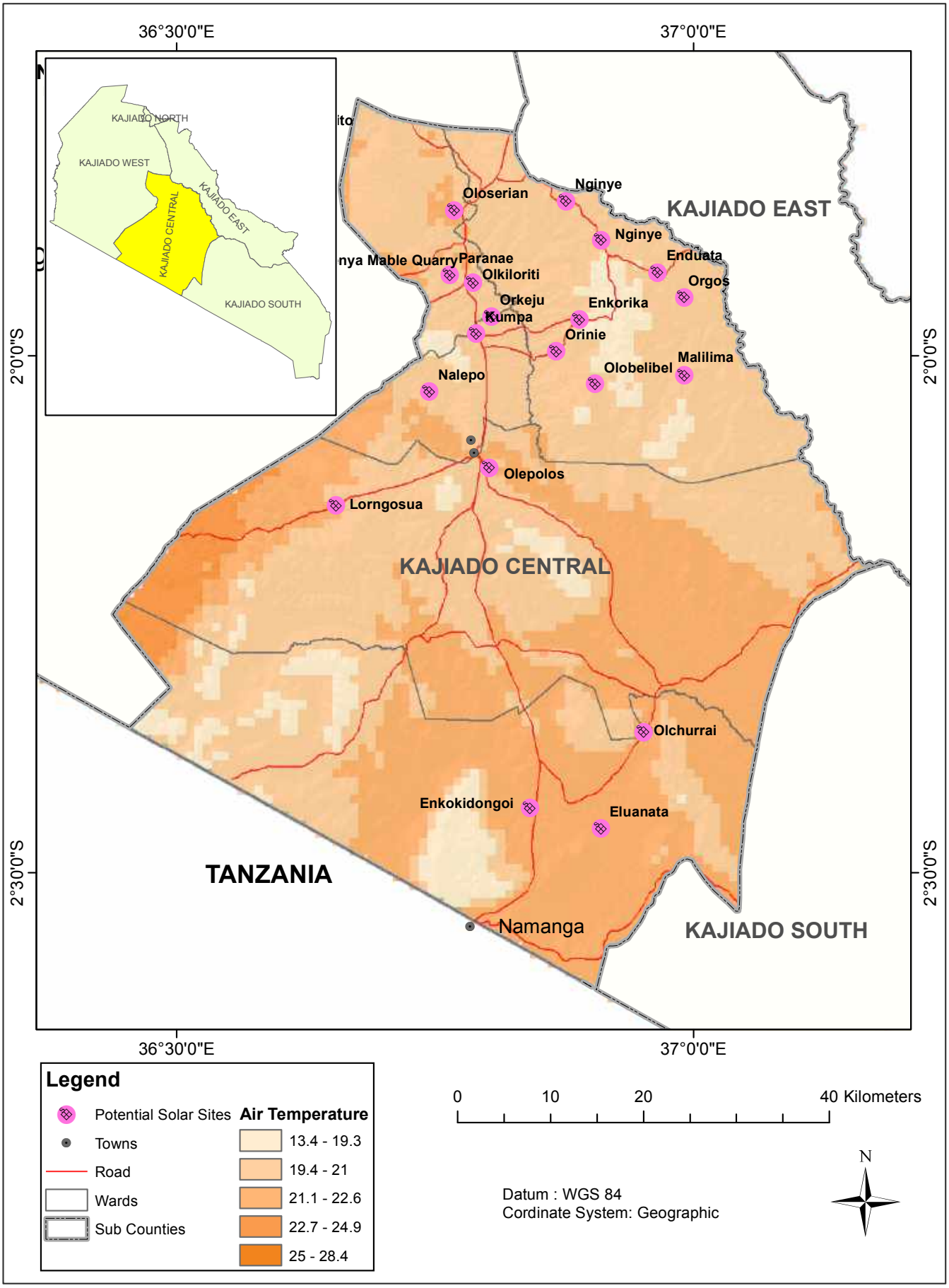


Figure 1.25: Potential Solar Energy Sites in Kajiado Central.

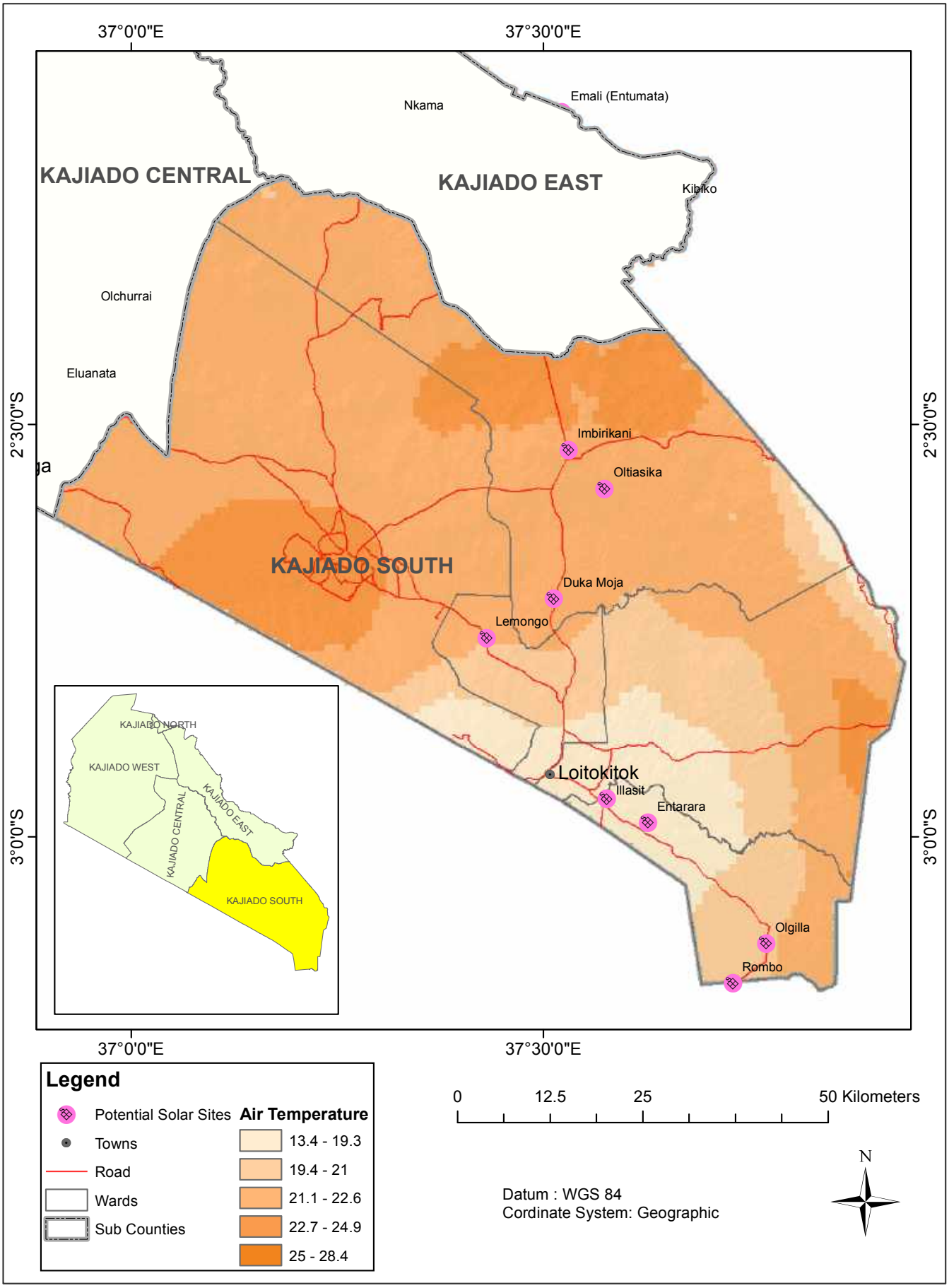


Figure 1.26: Potential Solar Energy Sites in Kajiado South.

Chapter

04 Wind Energy

According to the Kenya National Bureau of Statistics (KNBS) Economic Survey 2020, Wind generation increased more than fourfold from 375.6 GWh in 2018 to 1,562.7 GWh in 2019, following full operationalization of Turkana Wind Power Plant.

Consequently, wind was the third largest source of electricity generation in 2019 accounting for 13 percent of total generation. The installed wind capacity in Kenya is now 336.1 MW.

Kenya aims to generate 2,036 MW of wind power, or 9 percent of the country's total capacity, by 2030. It is expected that about 25 percent of the country is compatible with current wind technology.

> *Ngong Hill windfarm produce a power capacity of 25.5MW with annual net output of 12GWh.*

4.1 Existing Wind Energy Sites

Kajiado County has abundant wind resources available for energy development. The best wind resources are largely located in the Northern region of Ngong Hills. Ngong Hill windfarm produce a power capacity of 25.5MW with annual net output of 12GWh which is operated by KenGen and to the Western; Kipeto windfarm with installed capacity of 100MW.

Kipeto windfarm is projected to cover 17km (220KV) transmission line to evacuate the power to Isinya substation, providing power to the equivalent of approximately 40,000 homes in the region a significant contribution to Kenya's Vision 2030 and Big Four Agenda.

Photo credit @ Kevin Mungai

Wind turbines at Ngong Hills Wind Farm.

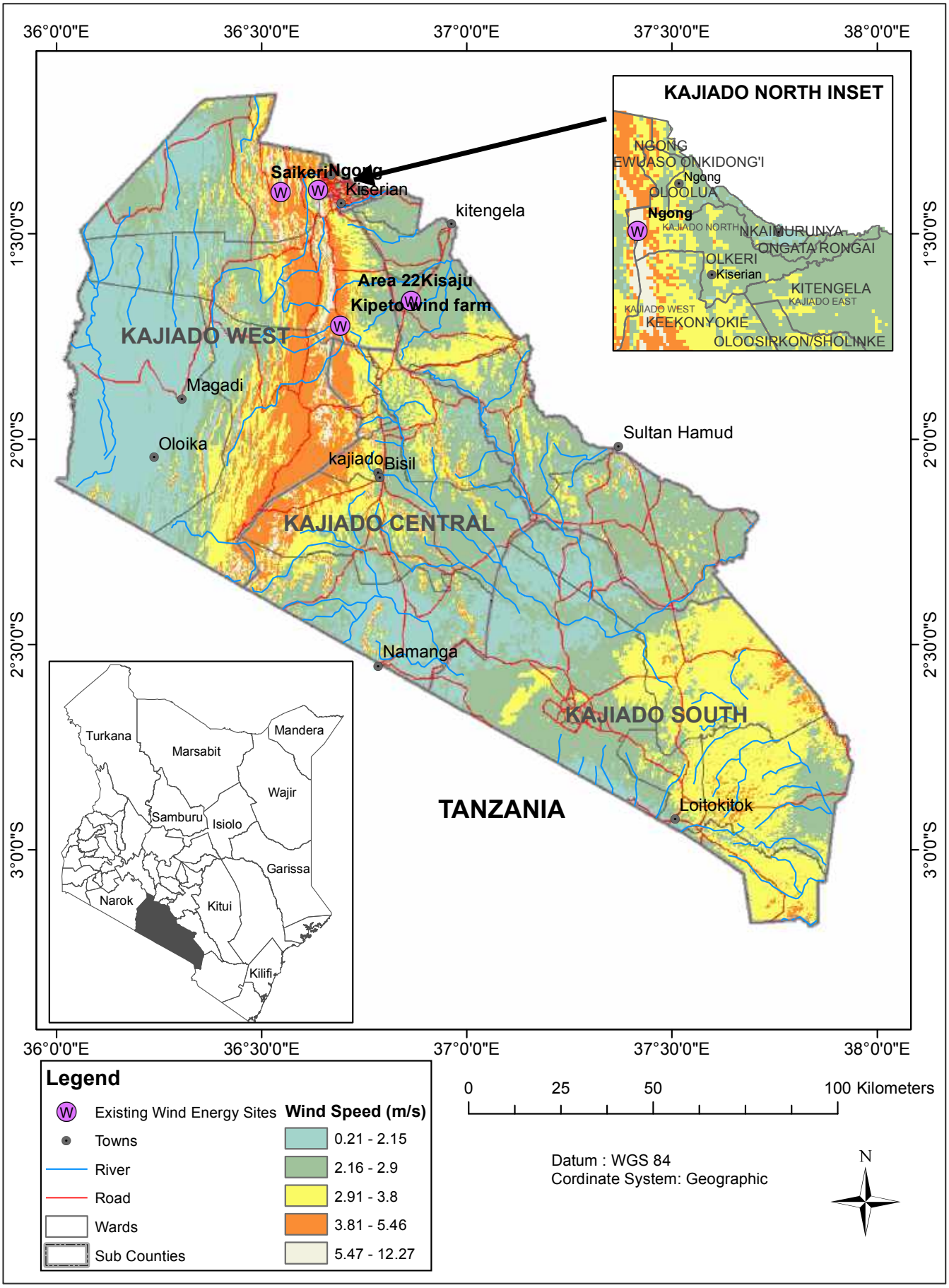


Figure 1.27: Existing Wind Energy Sites in Kajiado (m/s).

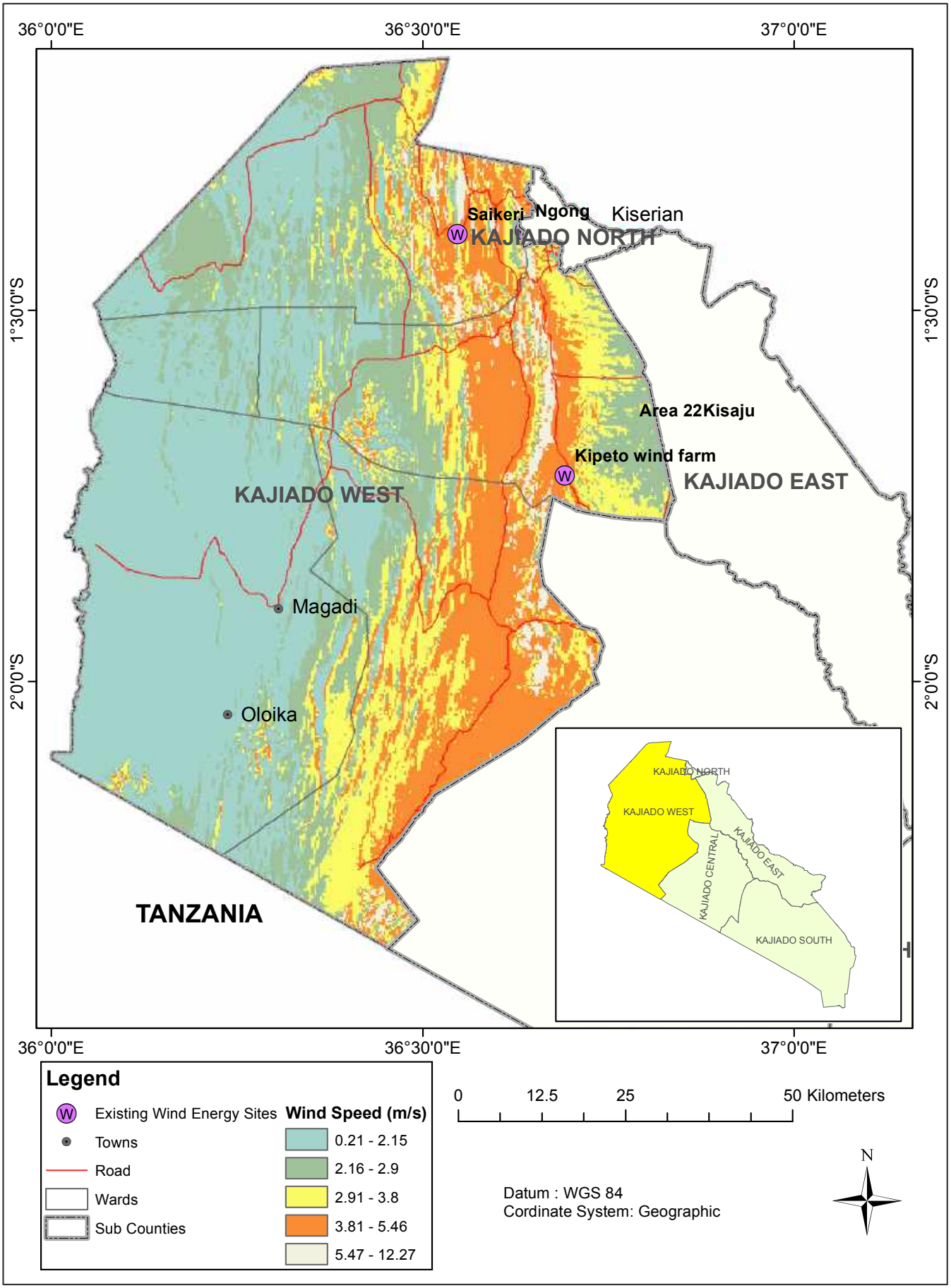


Figure 1.28: Existing Wind Renewable energy Sites in Kajiado West (m/s).

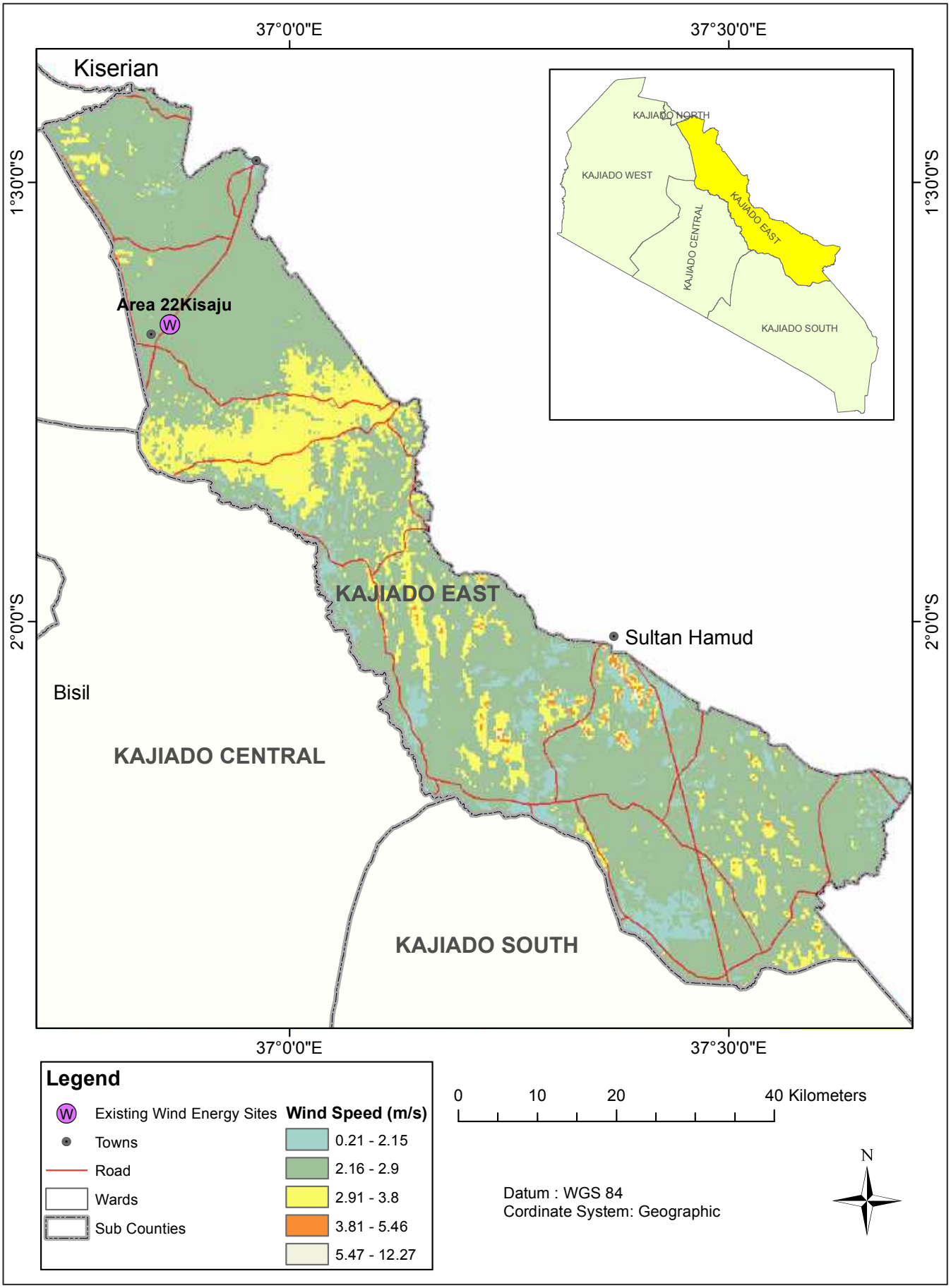


Figure 1.29: Existing Renewable Energy Sites in Kajiado East (m/s).

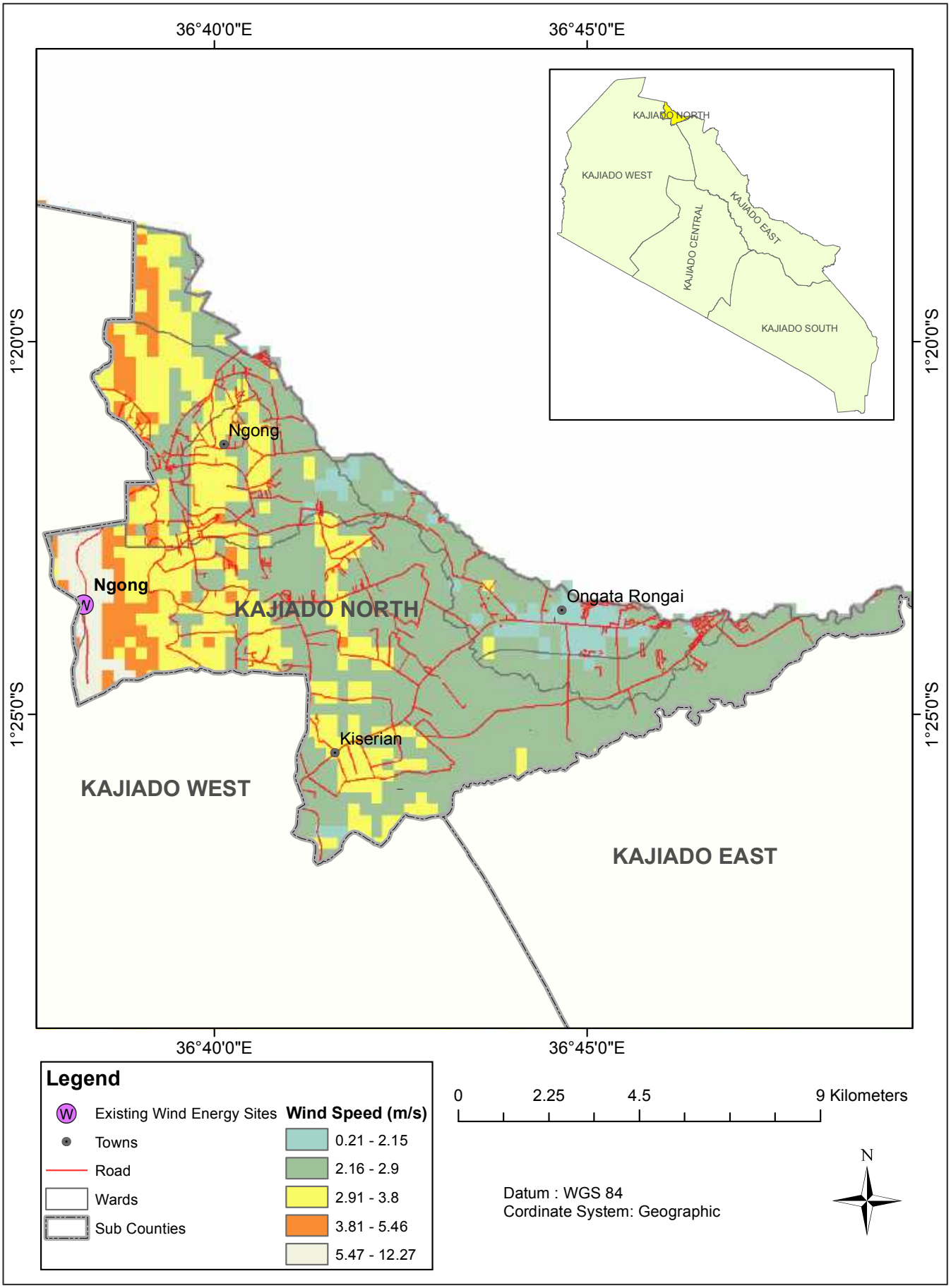


Figure 1.30: Existing Wind Renewable energy Sites in Kajiado North (m/s).

4.2 Potential Wind Energy Sites

Some parts of Kajiado County experience high wind speed and air density. Notably, most wind turbines technologies cut in speeds is 4m/s, as such areas identified with such characteristics form our potential sites for wind power.

These areas include the last two sections of the map scaling of 3.81–5.46 m/s and 5.47 – 12.27 m/s. Notable areas include Oldoinyo-Orok, Mailwa, Oloodero, Milimani Bisil, Enkaroni, Enkorika, Oloorkisalie, Oldonyonyokie, Shompole, Pakase, Dubai, Esilanke Hills, Chyulu hills, Kisamis Hills, Kitengela Reserve, Maroroi, Olgumi, Corner Baridi, Oloolua, Torosei and Oloyiankalani. Wind power technologies such as wind turbines can do better in these areas.

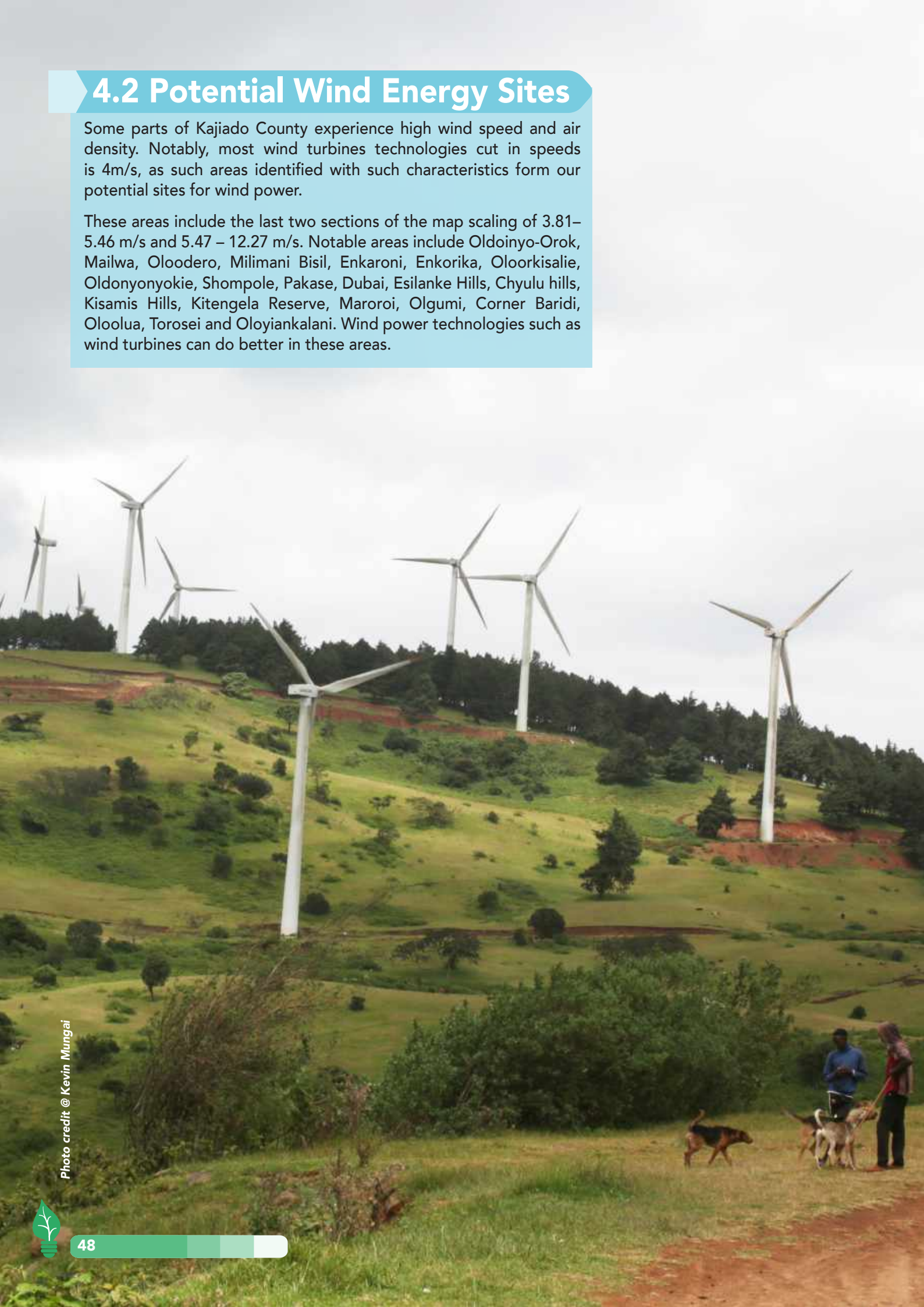


Photo credit @ Kevin Mungai

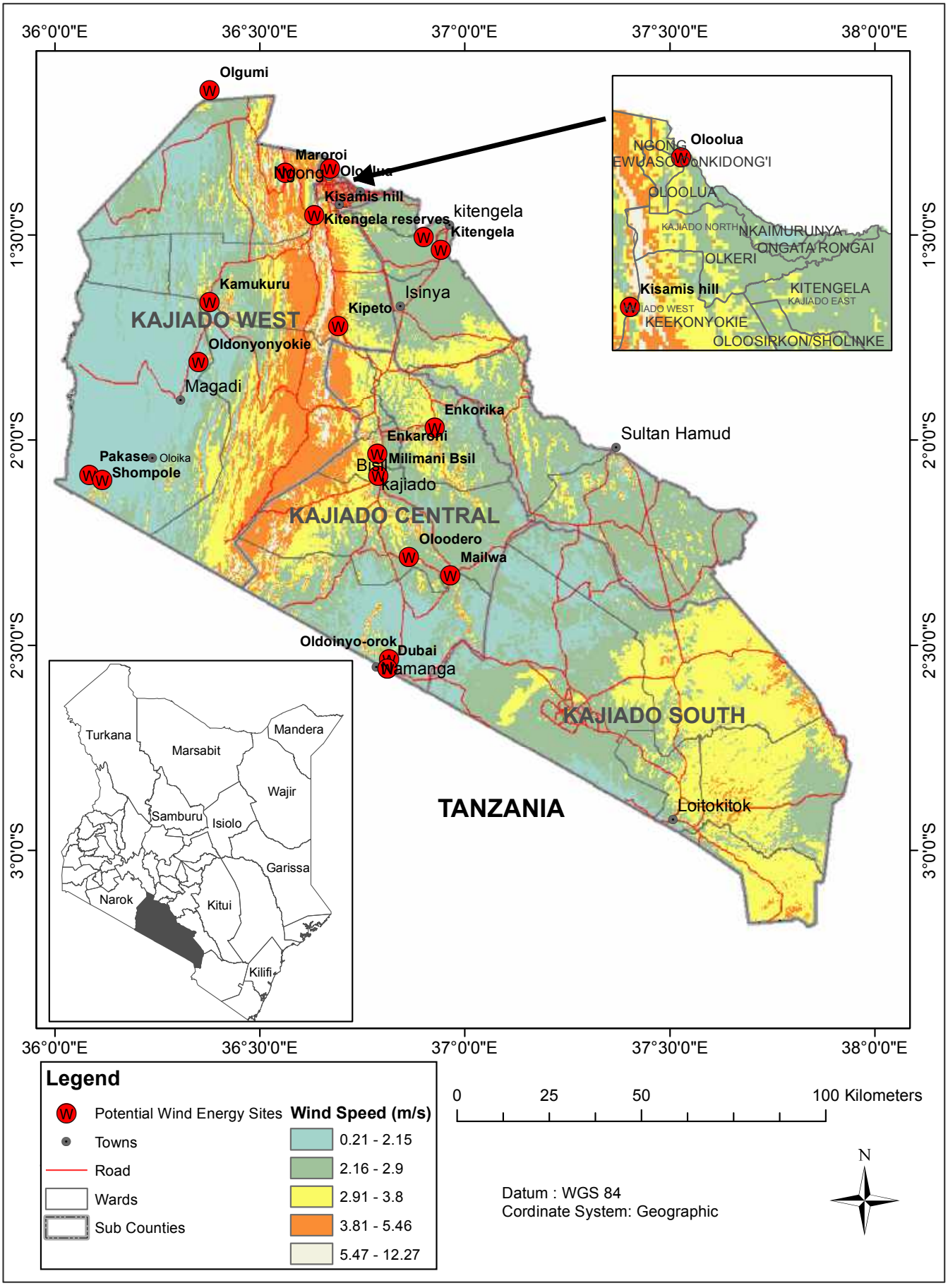


Figure 1.31: Potential Wind Renewable Energy Sites (m/s).

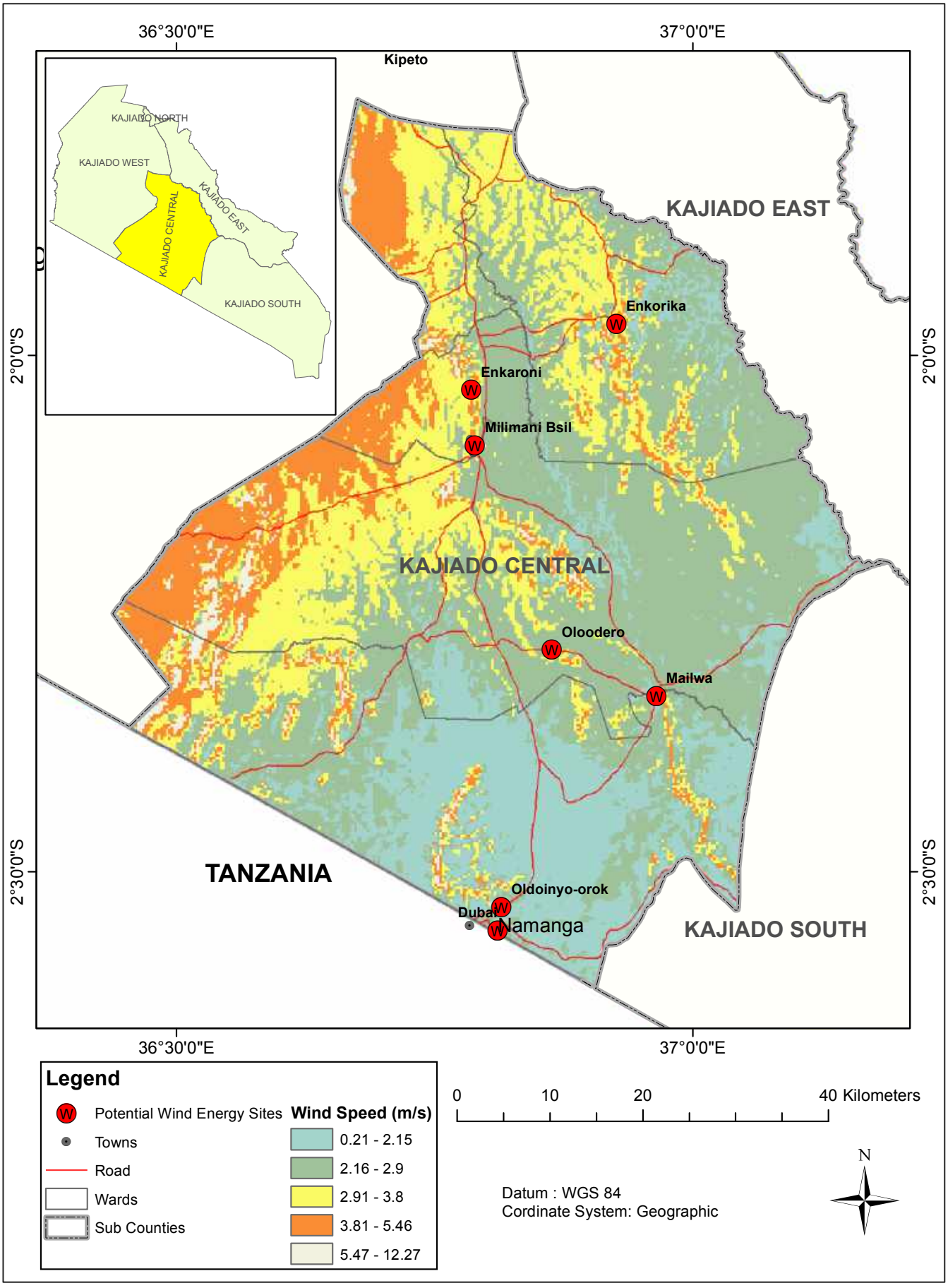


Figure 1.32: Potential Wind Renewable Energy Sites in Kajiado central.

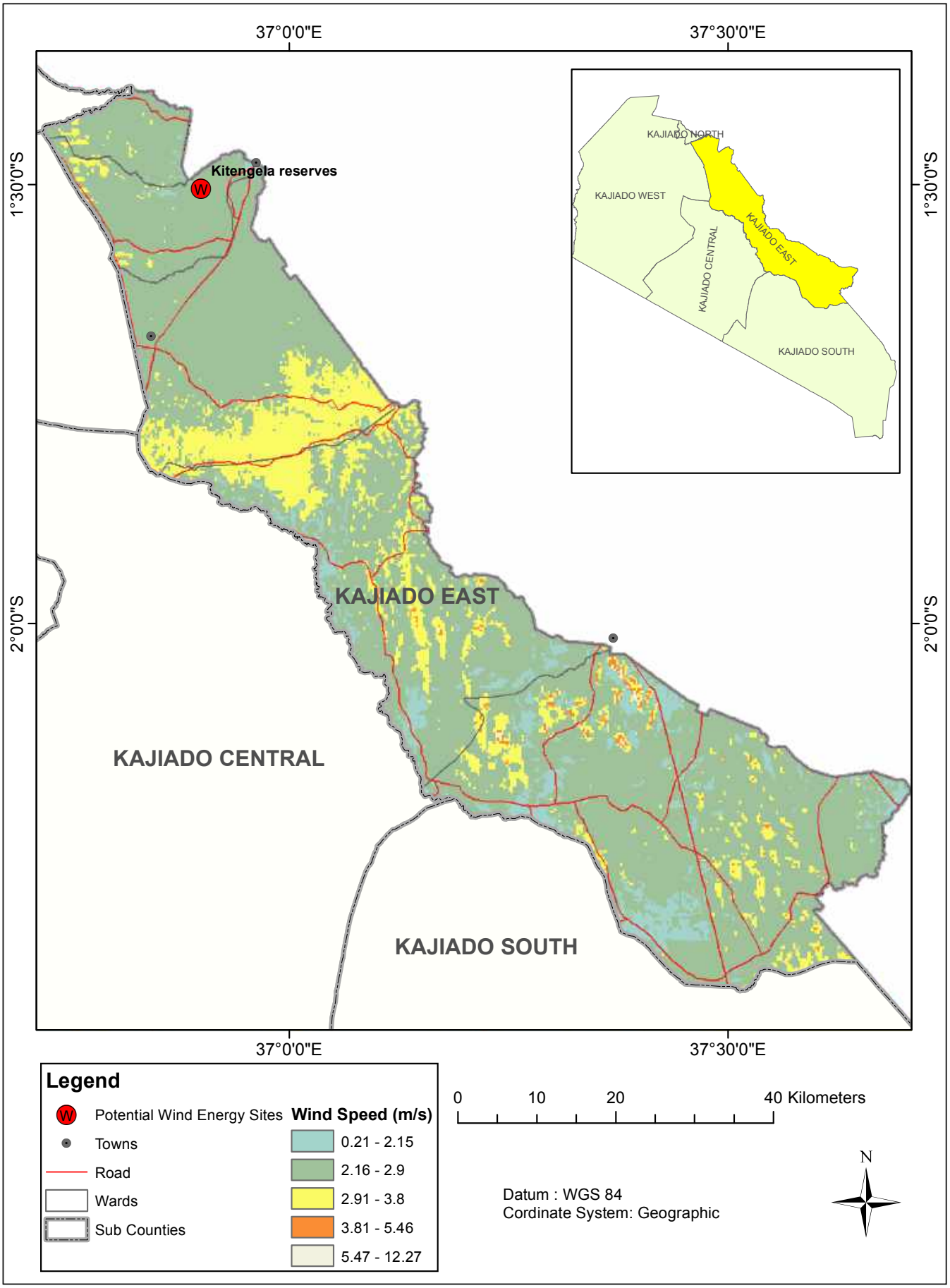


Figure 1.33: Potential Wind Renewable Energy Sites in Kajiado East.

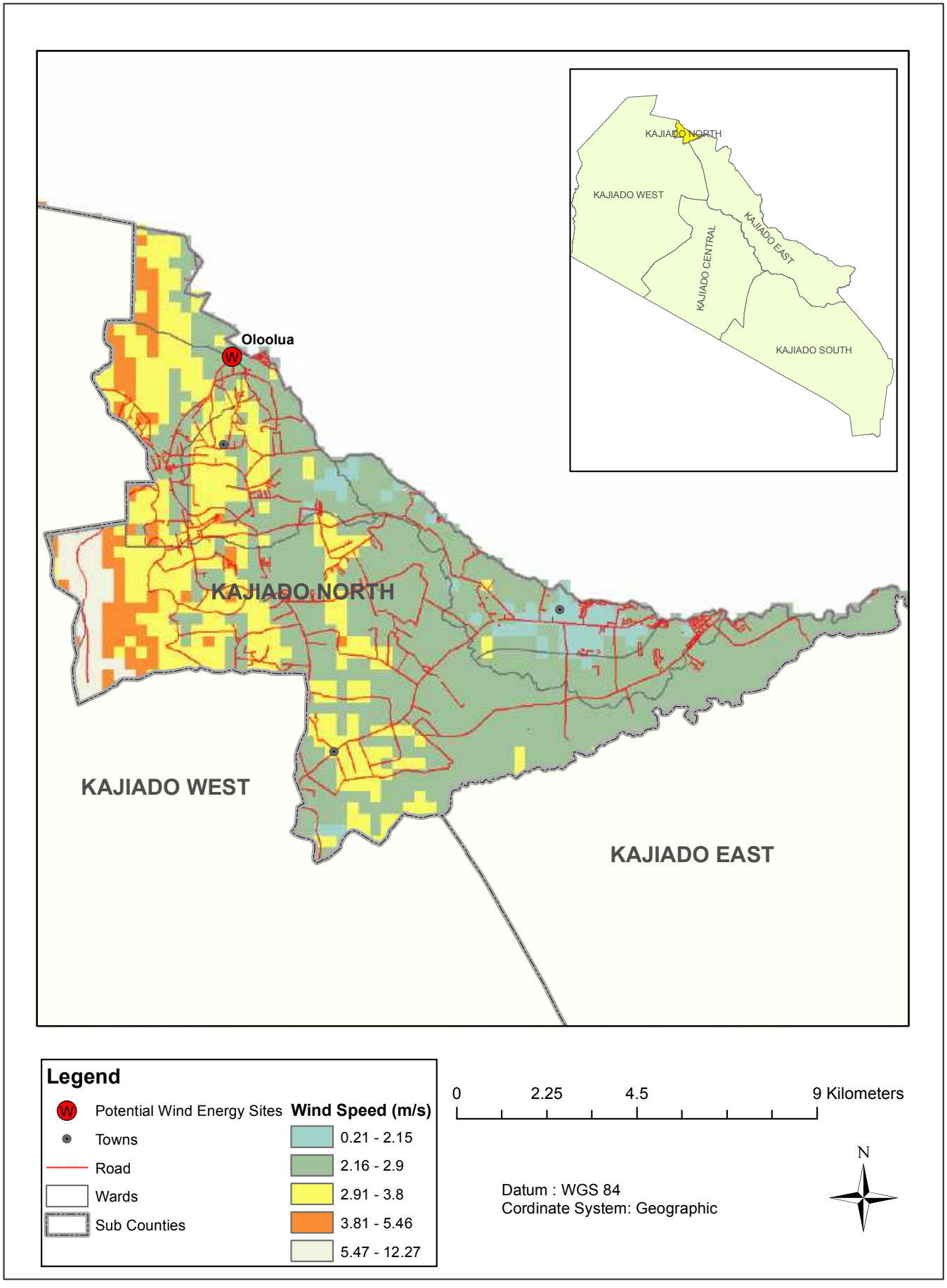


Figure 1.34: Potential Wind Renewable Energy Sites in Kajiado North.

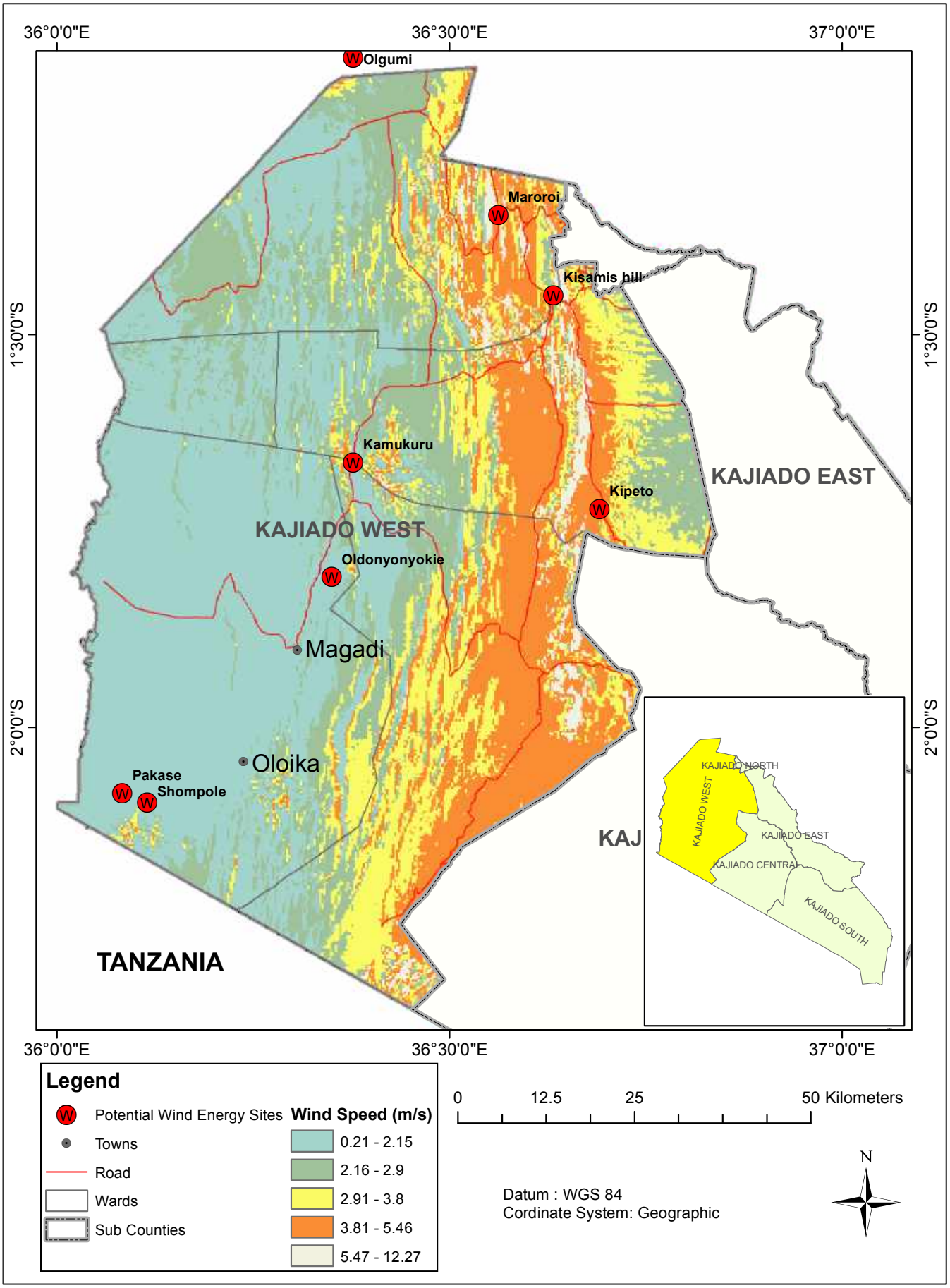


Figure 1.35: Potential Wind Renewable Energy Sites in Kajiado West.

Chapter

05 Geothermal Energy

105 MW Olkaria 2 @ KenGen

According to Renewable Capacity Statistics 2020 prepared by the International Renewable Energy Agency (IRENA), Kenya is now the seventh biggest producer of geothermal power globally. In doing so, the country has overtaken Italy, which is the land of birth of geothermal technology.

Kenya leads Africa in the production of geothermal energy and is also on track to join the club of 4 countries with an installed 1000MW capacity or greater. Exploration reveals that geothermal potential exceeds 10,000 MW in the Country. Geothermal energy is heat derived within the sub-surface of the earth.

Data from the Kenya National Bureau of Statistics (KNBS) Economic Survey 2020, shows that Geothermal remains the major source of electricity in Kenya accounting for 45 percent of total generation. Geothermal generation increased from 5,127.8 GWh in 2018 to 5,234.7 GWh in 2019.

The addition of the Olkaria V geothermal power plant to the national grid in 2019 expanded the country's geothermal capacity by 25.0 percent to 828.4 MW.

Investment in Geothermal energy requires comprehensive feasibility studies to establish it respective capacities.

A Geothermal project can be divided into the following phases:

- Project definition and reconnaissance evaluation
- Detailed exploration
- Exploratory drilling and delineation
- Resource analysis and assessment of development potential
- Field development
- Steam production and resource management

Usually after completion of exploratory and appraisal drilling is when geothermal power production can be found to be commercially viable.

Kajiado has three distinct potential geothermal resource regions:

- The Mt. Suswa, in the Northern part of the county
- Lake Magadi Springs in the western part of the county
- The Kisaju Area 22 in the eastern part of the county

5.1 The Mt. Suswa Geothermal Site

The Ministry of Energy awarded Geothermal Development Company (GDC) Ltd a geothermal prospecting license covering a concession area surrounding Mount Suswa and its environs for Suswa Geothermal Development Project.

The license allows GDC to explore for geothermal energy, produce and convert steam to electricity and build a geothermal power plant.

Geographically, the prospecting area centres on Mount Suswa and its calderas, which lies within Kajiado and Narok Counties. Mount Suswa comprises a 12 km diameter double caldera system, a vast network of obsidian caves and habitat to a variety of wild animals and plants.

The geothermal potential of Suswa is associated with the shallow hot magma that exists under the inner caldera. The magma may be within a depth of 3-5km. Fumaroles (steam vents), steaming and hot grounds, steam jets, and altered grounds are the evidence of geothermal activity at Suswa.

Detailed surface studies undertaken by KenGen indicate reservoir temperatures of over 250°C, which is comparable to that at Olkaria large potential. Hydrological recharge for the Suswa geothermal reservoir is from the rift flanks of Mau and Aberdares ranges. The recharge occurs through detachments and rift faults.

5.2 Lake Magadi Springs

On 23rd October 2017, Zhejiang Kaishan Compressor Company Ltd, received a geothermal resource license from the Ministry of Energy. The license gave Kaishan the rights and concession to explore and develop the Magadi Geothermal Project. The concession area is 3543km2, mainly within Kajiado county.

Kaishan has planned phase one development target at 300MW or at a maximum capacity based on economic feasibility.

The Lake Magadi region experiences rift tectonism accompanied by intense volcanism. This is characterized by hydrothermal activity and is envisaged to host extensive geothermal systems. This has in turn produced several active hot springs with unknown geothermal energy development potential.

5.3 The Kisaju Area 22

The Kisaju Area 22 has low to moderate temperature geothermal systems with surface expressions as gas springs. A borehole drilled by a resident in the area ended up producing a flammable gas. The borehole had only been drilled to a depth of 200m when a high level of gas emission was noted leading to closing of the bore hole and site for further investigations. This instance shows potential of geothermal energy. Further studies need to be done to conclude on the commercial viability of the same.

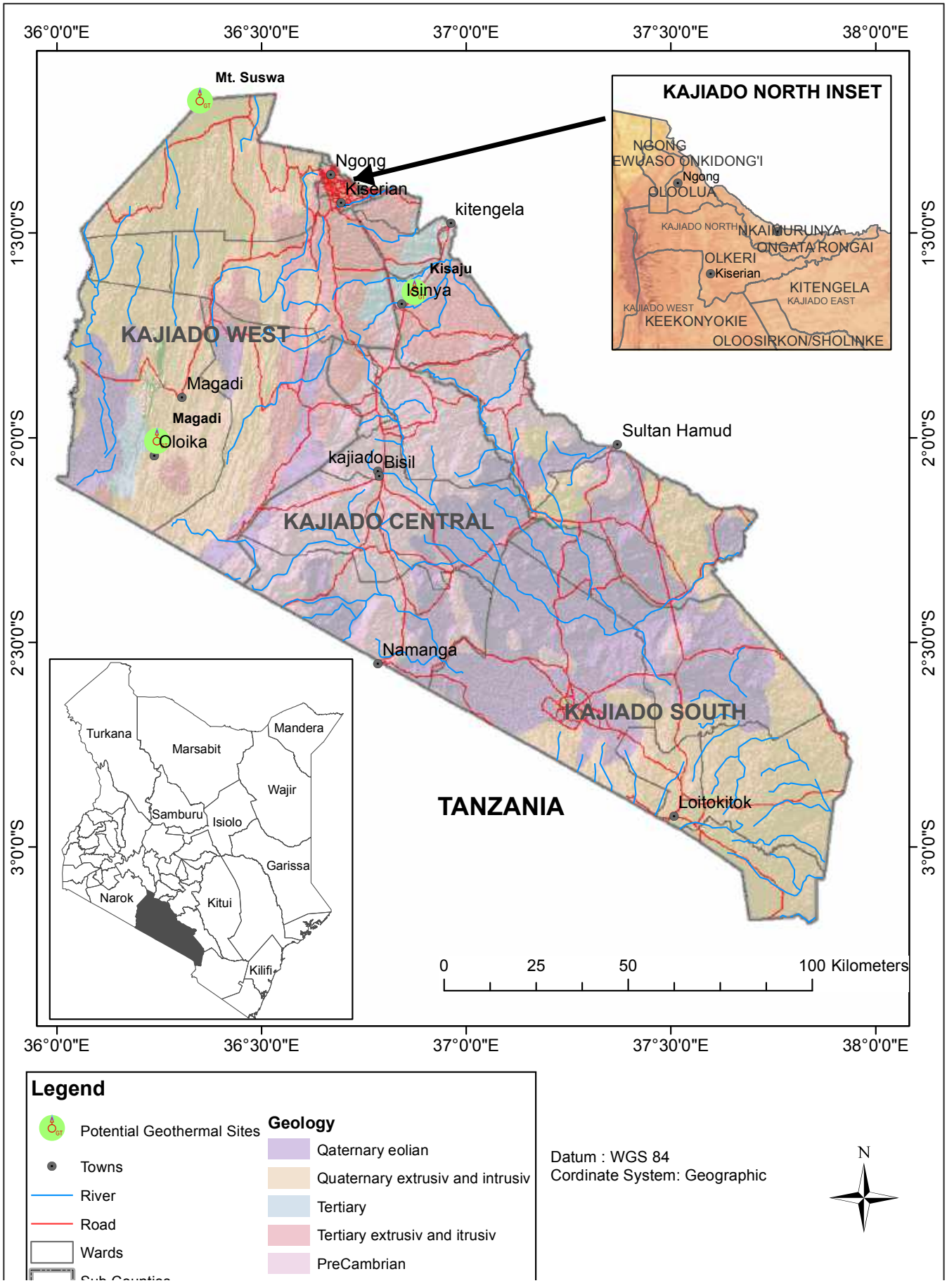


Figure 1.36: Potential Geothermal Energy Sites in Kajiado County.

Chapter

06 Hydro Power

Data from the Kenya National Bureau of Statistics (KNBS) Economic Survey 2020, shows that hydro generation registered a drop of 19.6 percent to 3,205.3 GWh in 2019 making it the second largest source of electricity generation in 2019 accounting for 28 percent of total generation. The installed hydro capacity in Kenya is 826.2 MW.

Kajiado County lies in the semi-arid and arid zones hence receiving minimal precipitation annually (400mm/year). Largely the county relies on seasonal rivers, shallow wells springs, dams, water pans and boreholes. With potential damming, an environment viable for hydroelectric power generation from the rivers viable on two fronts; large land tracks are available, the topography favors the damming activity. The construction of dams is to facilitate regular water flow and increase the water speed required to run the turbines will be necessary for all catchment areas.

Hydropower potential is supported by the presence and strength of the flow of rivers during the wet seasons within the County. The mass of water within these rivers is another critical aspect for the site which makes it possible to tap the water into potential hydropower generation. The slope of the area also accelerates the strength and flow of the rivers.

Analysis shows that the highest angle of the slope is greater than 300 translating to significant strength of the flow which can basically support hydropower generation.

High yielding springs are found on the slopes of Mt. Kilimanjaro with an average yield of $20m^3$/hr. to $50m^3$/hr.

The major seasonal Potential hydro sites identified are Entasopia River, Pakase River, Kimana River, Saikeri River, Kiserian dam, and Shompole Dam.

Hydropower potential is supported by the presence and strength of the flow of rivers during the wet seasons within the County.

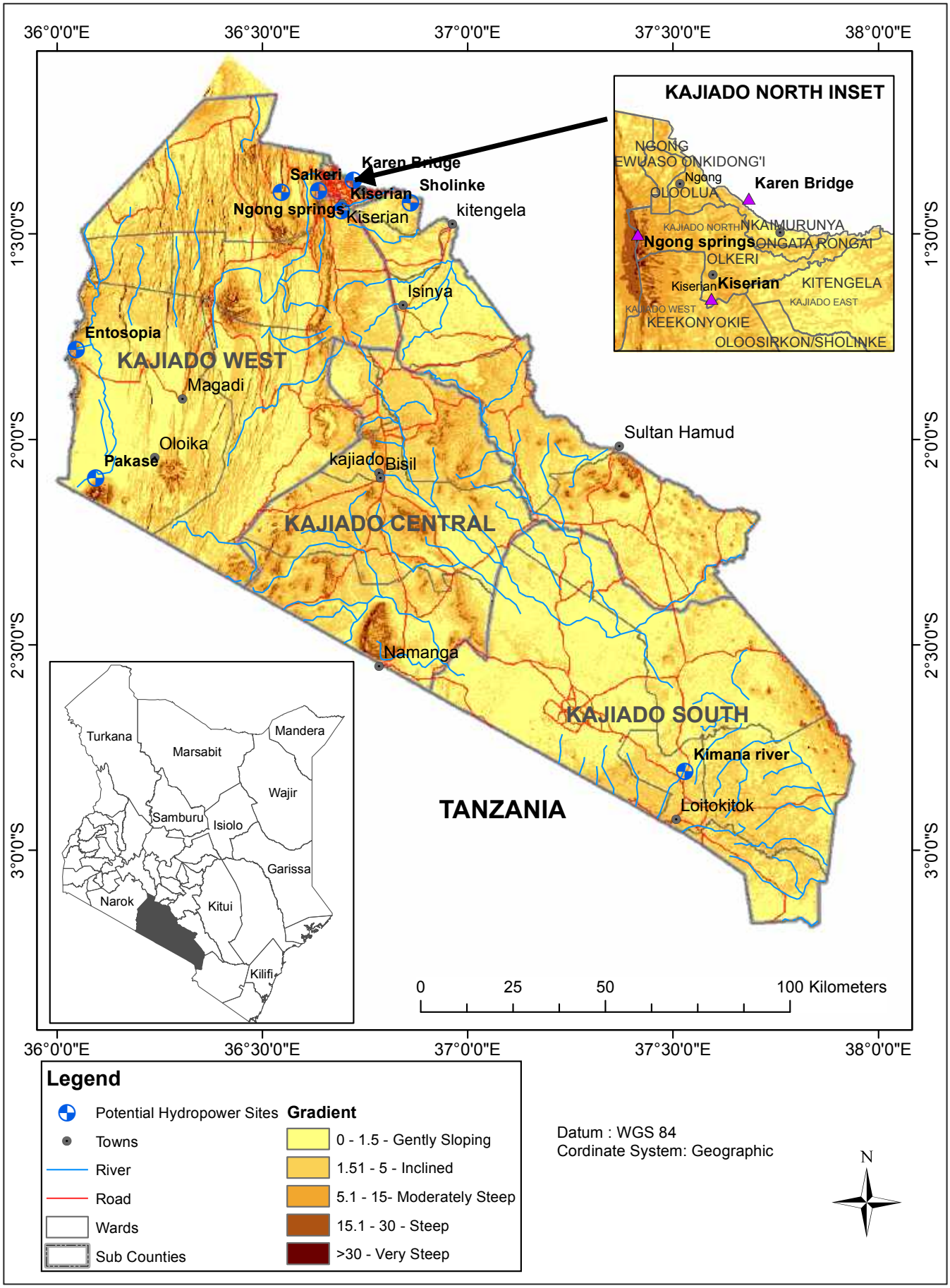


Figure 1.37: Potential Hydropower Sites in Kajiado County.

Chapter

07 Biomass Energy

Photo credit @ Kevin Mungai

A worker at Keekonyoike Slaughter House getting rid of excess waste from the biogas plant.

According to the 2019 Kenya Population and Housing Census (KPHC) Volume IV Report, firewood was the most commonly used type of cooking fuel in Kenya reported by 55.1 percent of the households followed by Liquefied Petroleum Gas (LPG) at 23.9 percent.

Charcoal and paraffin are used by 11.6 and 7.8 of the households in Kenya respectively while 0.5 percent use biogas. Firewood is the most used cooking fuel in rural areas with 84.1 percent of households while charcoal is used by 7.1 percent of rural households.

The type of cooking fuel in use in Kajiado County includes LPG, firewood, paraffin, charcoal, electricity, biogas and solar. LPG and firewood are the most used cooking fuel at 47.2 and 29 percent respectively. In addition, 12.7 percent use paraffin, 9.1 percent use charcoal while 0.7 percent use biogas.

Loitokitok leads in the use of firewood at 66.1 percent followed by Kajiado West at 57.3 percent, Kajiado Central at 51.6 percent and Mashuuru at 50.7 percent.

More than 22,000 biogas plants have been installed in the country of which 20,000 rely on livestock manure and the rest from crop waste – support.

Over 90 percent of these biogas plants are domestic, others are institutional while the rest are in flower farms. Most of the biogas plants in Kajiado County are located within Kitengela, Ngong and Rongai areas. This is attributed to livestock and crop farming which form waste needed in the production of biogas.

"Kajiado County is one of the frontier Counties in the development of green energy"

Photo credit @ ALIN-EA

Cylinders used to store biogas at Keekonyoike Slaughter House in Kitengela.

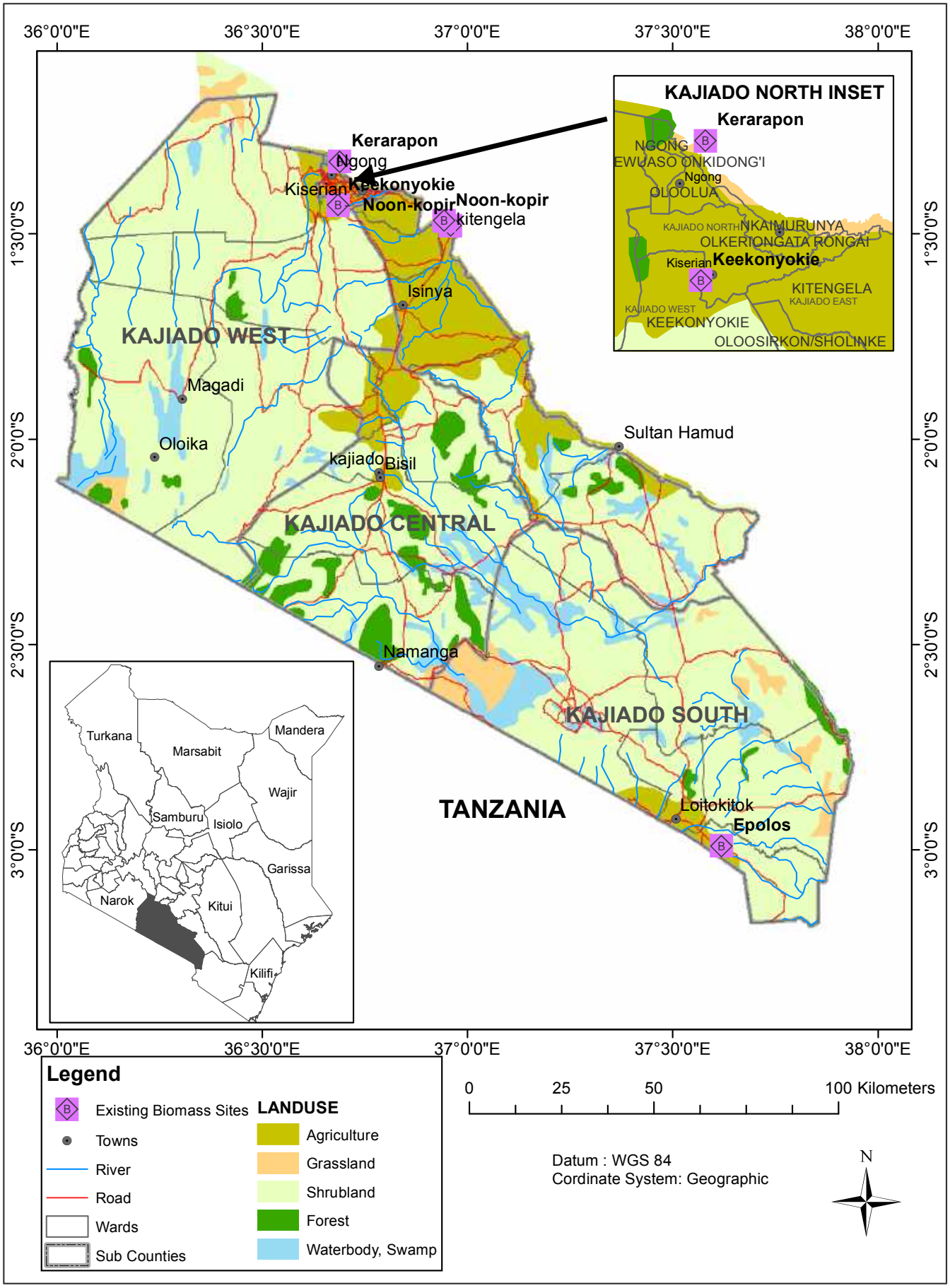


Figure 1.38: Existing Biomass Sites.

7.1 Potential Biomass Energy Sites

In the County, the primary biomass fuels are agricultural production, wood, solid wastes, by-products and municipal waste. Solid waste remains an important renewable energy source in conjunction to pastoralist practice in the County. The County is covered with invasive species such as Prosopis Juliflora (Mathenge) and ipomoea which can serve as a source for biomass in the production of biogas and briquettes. This will help eradicate the poisonous species such ipomoea which have affected at least one million acres of land preventing grass from growing hence resulting to insufficient pasture (Farmbiz 2018). The weed has affected at least 45 percent of pasture land in Kajiado Central region alone.

The key potential areas for biomass energy in the County include re-afforestation and or plantation woodlots, dumping sites, slaughter houses and homesteads with high number of livestock; the major dumping sites which can be used for biomass energy production include: Ngong dumpsite, Kitengela dumpsite and Kajiado dumpsite. All slaughter houses within the County remain potential sites to generate Biomass energy; Town centers emerge as high potential sites to get locally available materials to aid in making of briquettes.

Commercial residential houses, estates, schools , hospitals and restaurants are potential sites for installation of biogas plants. These can be tapped for small scale or large scale consumption such as heating, cooking and pumping water from wells.

The Kajiado County Government has been training women groups within Kajiado County on alternative sources of cooking energy like briquettes. The County Government in collaboration with other stakeholders has also donated briquette machines to some women groups.

Briquettes being dried in preparation for packaging at Ephitech Limited in Kitengela.

Photo credit @ Kevin Mungai

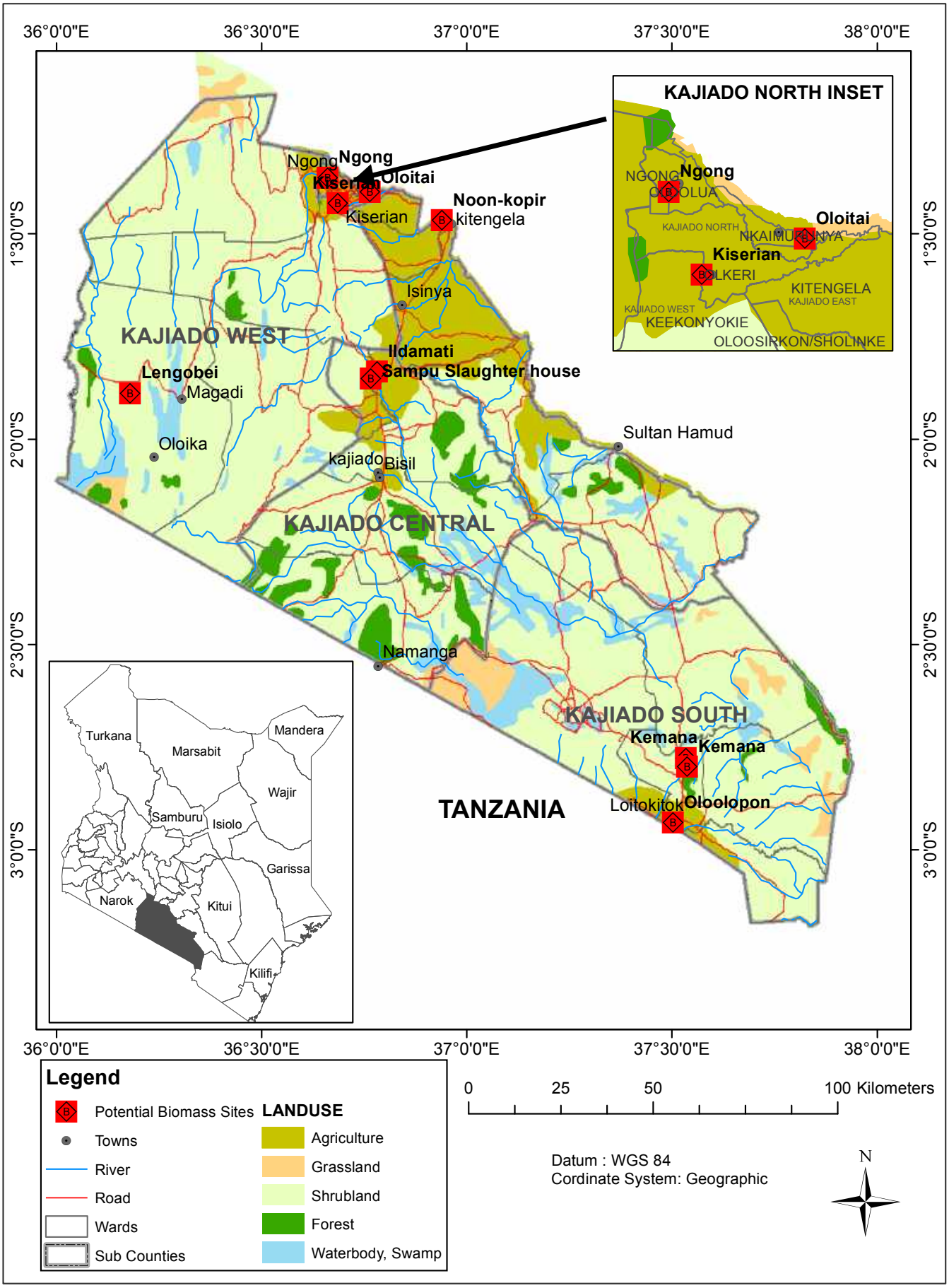


Figure 1.39: Potential Biomass Sites.

Chapter

08 Conclusion

Energy is one of the three macro-economic sectors on which the pillars of vision 2030 is anchored.

Kajiado County has abundant potential for energy production both at small and large scale. Solar, wind and biomass energy, shall require minimal input, whereas geothermal and hydroelectric, energy will require a considerable investment. This can be achieved by syncing both the national and county government strategies, which aim to increase the use of renewable energy by 2030.

Several exploitation methods need to be prompted; small scale production at household levels and public-private partnership for mega projects. This should be enhanced through sound policy, legal and institutional frameworks at both the County and National governments.

This will further the narrative of an Energy-sustainable County, leading to robust integration of renewable energy policies, environmental protection and sustainable living. It will be a major contribution to clean energy, thereby reducing the carbon footprint, which is a major contributor to climate change.

Clean energy brings about increased energy security, where the evolving energy markets and geopolitical uncertainty moves energy security and energy infrastructure resilience to the forefront of many energy strategies. Therefore, it offer plentiful opportunities for increasing renewable energy; as well as heating and cooling demands.

> *An energy efficient nation has to take a step toward the direction of renewable energy, environmental protection and sustainable living.*

Chapter 09 Recommendations

Kajiado county stands to benefit and has a great potential for renewable energy. This is compounded by the vast area it covers and the spatial distribution of the population which limits the coverage of KPLC as the main power distributor.

From a policy and legal perspective, Kajiado county needs to foster an enabling environment by mainstreaming renewable energy on projects/ departments within the county. This targets an increased uptake and safeguarding the development and players in the renewable energy sector. A renewable energy blueprint with a stand-alone budget should guide this process.

Sectional rapid recommendations are highlighted below, but are not limited to the stated ones:

Solar

The County Government should foster growth of commercial scale solar farms as the County is blessed with a huge untapped potential on that regard. Further solar energy should be targeted for public utilities such as schools, hospitals, governments offices, borehole sites, streetlighting etc. Through the aid of the Physical planning department, all development approvals should factor in renewable energy.

Wind

The County Government of Kajiado boasts of hosting two wind farms i.e. Ngong forest wind farm and Kipeto wind farm which directly feed into the main KPLC grid. However, the potential of wind energy is not yet fully exploited. The concerned county government agents with the aid of the identified potential areas could also introduce household level turbine technologies to communities along the wind energy potential path to fully enjoy the gains on this resource.

Geothermal

Geothermal energy in Kenya is mainly managed by Geothermal Development Corporation (GDC). The county should liase and fast-track research and exploitation of the identified sites within their county.

Biomass

Biomass is primarily the lead source of domestic household energy in Kajiado county. A series of coordinated approaches can increase the biomass potential and promote this as a renewable energy resource. They include:

- Increase afforestation activities and woodlot plantations. This can be achieved by various means and can be used to counter the increasing levels of de-vegetation.
- Through research, develop proper landfill sites which can be used to either generate methane of adequate waste for producing thermal energy
- Promotion of biogas technologies both at farm / household level and slaughterhouse /commercial level
- Promotion of emerging technologies such as the briquettes industry. This is elevating their production levels to commercially viable ventures in terms of production. This can be achieved in the minimum by training communities to improve quality and quantities and further mechanizing the processes of production. Further organizing the players into community-based organizations or production units to be able to meet the market requirement.

Hydros

Despite Kajiado county being categorized as arid and semi-arid, it has the benefit of the vast land factor, a gradient favoring rapid water flow and a topography that would favour relatively cheap dam design. Dams need to factor in the seasonably of the wet weathers the county experiences. Proper research and studies need to be carried out to prove the commercial viability of this line of energy production.

> *... all developments should consider renewable energy.*

List of Potential Renewable Energy Sites

R.E TYPE	LAND USE	LOCATION
Biomass	Slaughter House	Kiserian
Biomass	Commercial (market)	Oloika
Hydro	Forest	Mbagathi R
Solar	Agriculture	Rongai
Wind	Enkasiti plains	Kitengela
Wind	Kitengela reserve	Kitengela
Solar	Agriculture	Nkinye
Solar	Commercial	Kumpa
Wind	Rangeland	Enkaroni
Wind	Residential	Milimani Bisil
Solar	Rangeland	Lorngosua
Solar	Rangeland	Nkoile
Solar	Rangeland	Olepolos
Wind	Rangeland	Oloodero
Solar	Rangeland	Olchurrai
Solar	Rangeland	Eluanata
Wind	Rangeland	Ok donyo orok
Wind	Residential	Dubai
Biomass	Agriculture	Kiserian Slaughter House
Solar	Rangeland	Oloyiankalani
Wind	Rangeland	Kisamis hill
Solar	Agriculture	Kimuka
Solar	Residential	Kilonito
Solar	Rangeland	Mile 46
Solar	Rangeland	Kenya Marble Quarry
Geothermal	Rangeland	Magadi
Solar	Rangeland	Oloika
Hydo	Agriculture	Entasopia
Solar	Commercial	Entasopia

Groups of Project Consumers

GROUP NAME	LOCATION
Green Voice for Change	Ngong'
Mazingira Jeshi	Ongata Rongai
Arid area Community Project	Ngong
Naboisho Youth CBO	Ngong
Mazingira CBO	Nkaimurunya
Embulbul Environmental conservation	

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