STATE OF KNOWLEDGE
ENERGY ACCESS IN ZIMBABWE

EPPSA TEAM

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KEY MESSAGES

1	ENERGY ACCESS	• Electricity access has slowly increased in rural areas but has remained constant in urban areas since the mid-1990s. • The share of the population with access to clean fuels for cooking has declined since the mid-1990s. • Improving energy access in Zimbabwe over recent decades has been hindered by economic and political instability.
2	ENERGY SUPPLY	• Electricity supply comes from coal (45.7%), hydropower (24.6%), and imported sources (29.7%). • There is significant potential for solar power in Zimbabwe, but only small-scale solar projects are currently operational. • Biomass accounts for 75% of household energy.
3	ENERGY DEMAND	• Three sectors dominate energy consumption: mining and industries (45%), domestic (27%) and commercial (21%). • Household energy demand is expected to increase in urban areas due to migration from rural areas. • Energy needs of public institutions including health care facilities and schools is unmet.
4	ENERGY POLICY	• The National Energy Policy (2012) identified broad goals to increase access to modern energy. • The National Renewable Energy Policy (2019) and the National Biofuels Policy (2020) provide long-term targets focused on renewable energy and sustainable biofuels. • Linkages are weak between Zimbabwe's energy policies and health, climate, forestry, and gender sector policies.
5	ENERGY GOVERNANCE AND STAKEHOLDERS	• The Government of Zimbabwe officially unbundled Zimbabwe Electric Supply Authority (ZESA) from a centrally managed state utility into several smaller utilities in 2019. • The Rural Electrification Authority, a government funded group, is responsible for expanding the national grid to rural areas.
6	ENERGY, CLIMATE, ENVIRONMENT LINKAGES	• The National Climate Policy (2017) outlines activities to mitigate the climate impact of energy generation and use. • Despite climate mitigation efforts, the energy sector is Zimbabwe's largest contributor of greenhouse gases. • Energy dependent production systems including tobacco curing and sugar cane processing contribute to forest degradation in Zimbabwe.
7	ENERGY DATA AND RESEARCH	• There are a range of data sources available on energy in Zimbabwe–household surveys, spatial data sets, and more. • The number of publications on energy in Zimbabwe has historically been very low but has increased in the past few years. Publications since 2019 account for 77% of all publications since 1987.

ZIMBABWE OVERVIEW

The Republic of Zimbabwe (Zimbabwe) is a landlocked country in Southern Africa. Its immediate neighbors are Zambia to the North, Mozambique to the East, Botswana, and Namibia to the West, and South Africa to the South. In 2021, the total population of Zimbabwe was 16 million people, of whom 53% have access to electricity (United Nations, 2022). Only 30% have access to clean fuels and cooking technologies (ESMAP 2022), and the share might increase as the population of the country is projected to be approximately 26 million by 2050 (United Nations, 2022).

In its 2012 National Energy Policy (MEPD 2012) and more recent policies on renewable energy (MEPD 2019) and biofuels (MEPD 2020), Zimbabwe has committed to ensuring that the country's energy sector drives economic growth and reduces poverty, particularly through improving access to reliable energy for its rural population, and to secure long-term energy needs in a sustainable manner through investment in renewable off-grid energy options. However, economic growth in the country has been hampered by high inflation, unstable exchange rates, and high debt levels, further worsened by the COVID-19 pandemic (The World Bank 2022a).

ENERGY TERMS

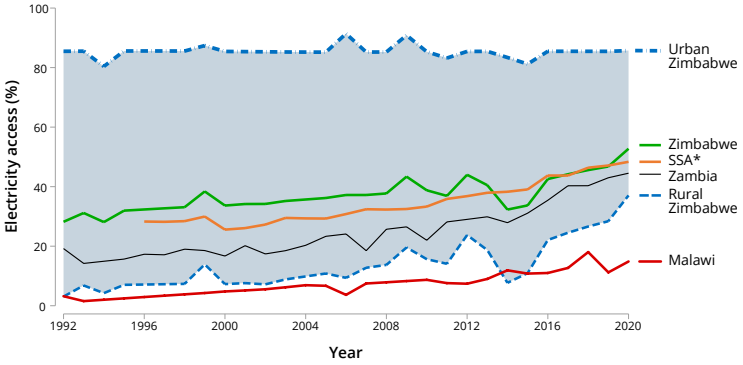
WATT	A **watt** is a unit for power that is equal to 1 Joule per second (energy in an amount of time) (1 megawatt (MW) = 1 million watts)
WATT-HOUR	A **watt-hour** is a unit of energy equal to one watt of output per hour (power in an amount of time). **Kilowatt-hours** (equal to 1,000 watt-hours) are a standard unit used to describe electrical power consumption and/or production.
TONNE OF ENERGY EQUIVALENT	A **tonne of energy equivalent** (toe) is a unit of energy used to describe the amount of energy released by burning one tonne (1000 Kilograms) of crude oil (**1 ktoe** = 1,000 toes)
TRANSMISSION CAPACITY	The **transmission capacity** of an electrical gridline is the amount of power (in watts) that can be sent over the transmission line.
INSTALLED CAPACITY	The **installed capacity** of a power plant refers to how much power a station can produce.
INDEPENDENT POWER PRODUCER	An **independent power producer (IPP)** is a non-public entity, which owns the facilities and infrastructure needed to generate electrical power for sale to public utilities and/or directly to users.

Hydroelectric power generated at the western end of the Zambezi River at Victoria Falls is a significant electricity source to Zimbabwe and neighboring Zambia

ENERGY ACCESS

The share of households with access to electricity in Zimbabwe increased from 28% in 1992 to 52% in 2020 (The World Bank 2022a). However, access to electricity is uneven. The share of urban households with access to electricity has remained relatively stable at around 85% or approximately 4 million households in 2020 (**Figure 1**). The share of the rural population with access to electricity has increased four-fold over the same period from 3% to 37% or 3.7 million rural households in 2020 (**Figure 1**) (The World Bank 2022a). The Rural Electrification Agency (REA) was established to increase access in rural areas (ESMAP 2015). However, access to electricity, often measured by grid connectivity is a tenuous measure since many areas in the country are affected by heavy load shedding, with power outages lasting up to 12 hours a day (Marawanyika 2021; Reid & Simatele 2021). **Figure 2** shows the electricity gridlines in Zimbabwe and nightlight imagery highlighting five urban centers.

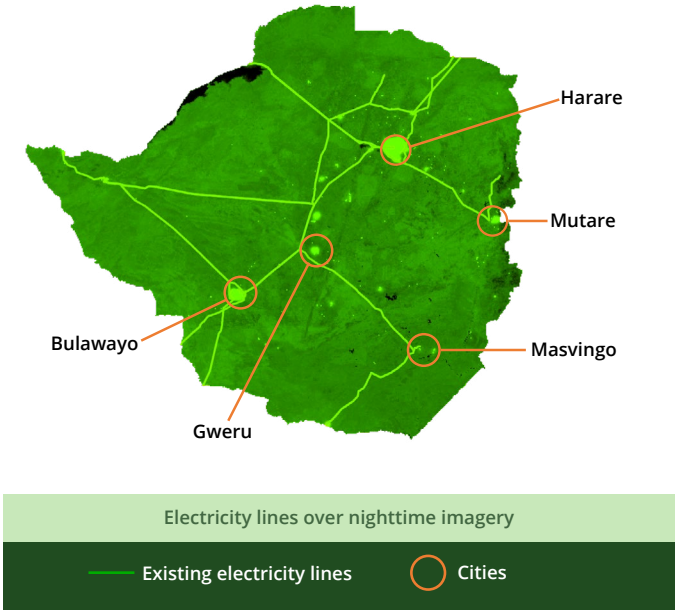
Figure 1: Trends in electricity access (Data: Development Indicators, 1992–2020)



*Sub-Saharan Africa

In 2019, the government of Zimbabwe launched the National Renewable Energy Policy that aimed at increasing the share of renewable energy sources along with implementing clean energy technologies for cooking, heating, and lighting (MEPD 2019). The share of the population with access to clean cooking fuels and technologies has increased only slightly over the past 20 years remaining at around 30% since 1999 (The World Bank, 2022b). The country has also seen a decline in the share of the population primarily utilizing clean cooking technologies from 1999 to 2015. The primary cooking fuel is electricity in urban areas (66.3%) and fuelwood in rural areas (92.6%) (ZNSA & ICF 2016). Because solid fuels are still a major energy source for household cooking in Zimbabwe, indoor air pollution is a major health concern mainly for women and children, since women are primary cooks and care providers to children (WHO 2022a). Air pollution has remained the third highest risk factor for disease burden in Zimbabwe since 2009 (IHME 2022).

Figure 2: Nighttime lights and major cities in Zimbabwe (Data: Transmission lines, OpenStreetMap 2017; NASA Nighttime lights, Small & CIESIN 2020)



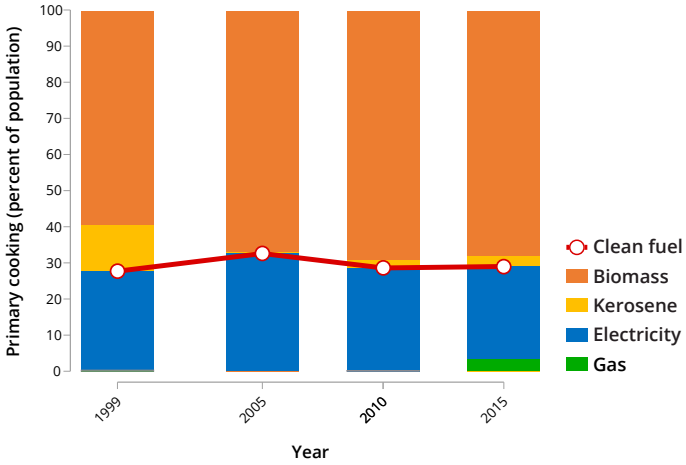
Although Zimbabwe is endowed with many renewable energy resources, the country has not met its potential to utilize the resources to improve energy access (Se4all 2022). Zimbabwe's progress toward universal household energy access has been hindered by the political and economic instability of the past two decades (Makonese et al. 2011; Zuzhang 2014). The combination of an already suffering economy and political sanctions led to a period of inflation and hyperinflation in the mid- to late 2000s (Hanke and Kwok 2009). In 2009, the Zimbabwe Dollar was taken out of circulation, and foreign exports declined significantly hindering its ability to import electricity from neighboring countries. This coincided with deteriorating supply chains of coal for power plants, leading to extended periods of low electricity generation (Kararach and Otieno 2016) and intensive load shedding, with power cuts lasting up to 12 hours per day (Marawanyika 2021).

After a period of economic stabilization between 2008 and 2013, the country's economy was in decline and returned to >500% hyperinflation in March 2020 (Ndlovu & Goko 2020). High levels of load shedding returned because of an inability to import electricity, which continued until fuel was once again allowed to be sold in US dollars (Nyavaya 2022). Huge debt levels and reduced foreign investments have hindered supporting existing energy infrastructures (The World Bank 2022a; Banya 2019). Further, other environmental shocks, such as recurrent drought and Cyclone Idai in 2019, have also affected reduced production from the existing plants resulting in severe outages (Banya 2019).

ENERGY SUPPLY

Energy supply in Zimbabwe comes from several sources including coal-fired power plants, hydroelectric power plants, and a small share of other renewable sources such as solar (Mutasa 2021). Other energy sources include petroleum-based fuels (e.g., liquified petroleum gas and diesel), which are imported but not produced or refined within the country, and biomass (predominately firewood), which is the main source of household energy used among urban and especially rural households. **Figure 3** shows the sources of energy supply in Zimbabwe from 1990 to 2020. While most investment and development programs aim to increase energy supply through increased electricity generation, Zimbabwe still relies heavily on biomass to meet its energy needs (IEA 2022).

Figure 3: Total energy supply by type (ktoe) (Data: International Energy Agency, 1990–2020)



Biomass Energy

Zimbabwe continues to rely on biomass as the primary source of energy, supplying approximately 66% of total energy consumption in the country. Ninety-eight percent of biomass energy is firewood harvested from forests and woodlands. Other biomass sources include animal waste, agricultural residues, and to a very limited extent charcoal. Nationally, 68.2% of households rely on biomass as the primary source of energy for heating and cooking (ZIMSTAT & ICF 2016). Further, reliance on biomass is far more prevalent in rural (94%) areas compared to urban (20%) areas (Chipango 2019).

Electricity generation

Zimbabwe currently has an installed capacity of approximately 2,400 megawatts (MW) (IRENA 2020). In 2021, 70% of the country's electricity was generated from hydropower, and 29% from coal (Mutasa 2021). The country's electricity supply is primarily managed by government-owned institutions, the Zimbabwe Power Company (ZPC) and the Zimbabwe Electricity Transmission and Distribution. Company (ZEDTC) (ZERA, 2021). Currently, Zimbabwe produces approximately 1,000MW of electricity which does not meet the country's half of peak demand (Emi, 2020; Makonese, 2016). Zimbabwe has other renewable energy sources, such as solar, wind, and biomass, but their potential is not developed (IRENA, 2020).

Coal power

Among the power stations managed by South African Power Pool (SAPP) and operated under Zimbabwe Electricity Supply Authority (ZESA), coal-powered plants supply 50.58% of Zimbabwe's energy supply (SAPP 2019). Zimbabwe has four coal-powered plants with a total capacity of 1,160: Munyati Power Station (100MW), Hwange Power Station (920MW), Bulawayo Power Station (90MW), and Harare Power Station (50MW). In 2018, ZPC started an expansion project for the Hwange Power Station, the largest coal-powered station, to increase its capacity to 1,520MW. Further, plans for the construction of two new coal-powered plants, Sengwa and Lusulu have been stalled due to a lack of investment in the sector (Banya & Reid 2022). The electricity generation from coal-powered plants is affected by aging infrastructure, older technologies, and economic constraints (Banya 2019; ZERA 2022a).

Hydropower

Among the power stations managed by SAPP and operated under ZESA, hydropower supply 44.4% of the total electricity generation in country(SAPP 2019). Zimbabwe shares the Kariba Power Station on the Zambezi River with Zambia. In Zimbabwe, the South Power Station is operated by the Zimbabwe Power Company (ZPC) (ZPC, 2022; The World Bank, 2015). The current capacity of the Kariba South Power Station is 1,050MW making it the biggest power plant in Zimbabwe (ZPC, 2022). However, the station frequently fails to generate electricity at its installed capacity level. In recent years, a severe drought greatly reduced the water level in the Zambezi River and impacted the production of the hydropower plant (Emi, 2020). To meet the energy shortfall, Zimbabwe imports electricity from its neighboring countries, such as Mozambique and S. Africa (Chipango 2021).

Solar Power

Given the challenge of meeting demand with existing electricity infrastructure, solar energy is gaining traction as a potential energy source for electricity generation. Zimbabwe has significant solar photovoltaic potential (Jingura and Matengaifa 2009). The annual daily average solar radiation is 20 megajoules per square meter with the potential to produce up to 10,000 GWh of annual energy supply (UNICEF 2015). Further, a total area of 250,000 km2 in Zimbabwe has great potential for installing concentrated solar power plants and with only 10% of the proposed locations utilized, it could generate approximately 30 times Zimbabwe's current energy demand (Ziuku et al. 2014). However, the potential to increase energy access through solar power is underutilized in Zimbabwe mainly because of high upfront costs and unstable government and political situations in the country to implement policy changes (Njenda et al. 2021). Currently, there are no large-scale solar projects in Zimbabwe. Independent power producers (IPPs) have begun to develop small-scale solar projects. In 2022, there are 30 licensed and operational IPPs, among which 17 are solar, 9 are mini hydro/hydro and 4 are other, such as coal or bagasse, projects (ZERA, 2022b).

Biofuels (ethanol and biodiesel)

Zimbabwe has produced and used biofuels for over 40 years. Biofuels have been used to reduce dependence on fuel imports, increase energy security and stabilize fuel prices. Despite the widespread use of bioethanol blended with petroleum, the production of bioethanol during the 1980s was affected by severe drought. In 2005, Zimbabwe launched the National Biodiesel Feedstock Production Programme to explore the use of Jatropha or biodiesel production, but its progress was impeded by the country's economic downturn (MEPD 2020). In 2013, Zimbabwe introduced the Mandatory Blending of Anhydrous Ethanol with Unleaded Petrol that ensures unleaded petroleum is blended with a minimum of 10% of the ethanol from a licensed producer increasing the use of bioethanol (ZERA, 2013). Zimbabwe also uses biogas as an alternative energy source. The country had 711 biogas plants in 2017 with a majority at the household level mainly used for cooking and remaining in municipal and institutional scales used for lighting and space heating (Kaifa & Parawira, 2019). In 2020, Zimbabwe added 80 biogas digester plants in rural areas (REA 2022).

Bulawayo Power Station is a coal-fired thermal plant in Bulawayo, Zimbabwe

Imports and Exports

Electricity

Zimbabwe is a member of the Southern Africa Power Pool (SAPP), a body of twelve Southern African Development Community (SADC) countries. Membership in SAPP allows a country to receive imported electricity from member countries. However, due to currency shortages, Zimbabwe has been unable to exercise this right consistently or reliably (Madya 2019). In 2019, the South African utility, Eskom, cut supply to Zimbabwe due to a lack of payment of outstanding debt. Later a debt-settlement deal was worked out between the two countries and power was restored (Madya 2019). In 2020, electricity was the third most imported product in Zimbabwe, with the country spending $152M in imports (OEC 2020). Zimbabwe exported $13.7M exported in electricity in 2020 to countries such as Eswatini, Namibia, Botswana, and Mozambique (OEC 2020).

Petroleum-based fuels

Zimbabwe has no domestic oil resources and refining capabilities so it fully relies on imported oil. Zimbabwe imports refined petroleum from Mozambique, Singapore, South Africa, the United Kingdom, and Zambia (WITS 2020). The net import of diesel, petrol, and jet fuels increased since 2009 varies from year to year, but on the whole increased with a net import of approximately 849, 513, and 48 million liters in 2021, respectively. The import of paraffin has been decreasing since 2016 with a net import of approximately 684,423 liters in 2021. The import of LPG has steadily increased since 2015 with approximately 56 million kgs of import in 2021 (ZERA, 2022c). There were decreases in fuel imports in some years, such as 2016, 2017, and 2020 because of the limited availability of foreign currency and the nationwide lockdown during the Covid-19 pandemic in 2020.

ENERGY DEMAND

In Zimbabwe, the main sources of energy consumption are biomass, coal, oil, and electricity. In 2019, the residential sector was the biggest consumer of energy, accounting for 75.2% of total energy consumption mainly used for cooking, heating lighting, and charging electronic items. Transportation, which uses mostly oil-derived fuels, was the second largest energy-consuming sector at 9.1%, followed by industry at 7.3% and agriculture/forestry at 5.7% and with other sectors combined at 2.7% (IEA 2022).

The residential sector in Zimbabwe depends mostly on biomass to meet its energy demand, but electricity consumption in the residential sector has been increasing and accounts for one-third of the total electricity consumption (IEA 2022). In contrast, due to the country's slow economic growth since 2000, the energy demand in the industrial sector has been decreasing. Consequently, electricity consumption is also decreasing but the industrial sector still is the biggest consumer of electricity accounting for 43.5% of total consumption (IEA 2022). The remaining electricity consumption is utilized in commercial and public services (16.5%) and agriculture/forestry and other sectors (6.5%) (IEA 2022).

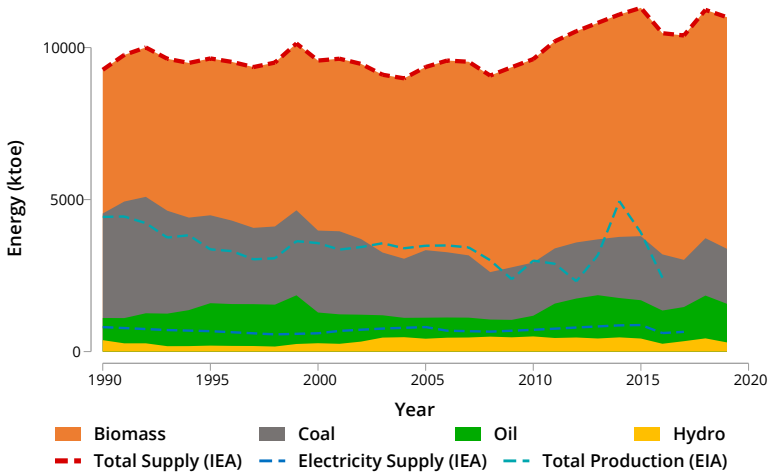
Household demand

Household energy demand in Zimbabwe is mainly driven by use for cooking and lighting. In 2020, 53% of the country's population had access to electricity, but a significant disparity in electricity access exists between rural and urban households as only 37% of the rural population and 85% of the urban population had access to electricity (The World Bank 2022b). In rural Zimbabwe, fuelwood is a major energy source (Maramura et al. 2020), but unsustainable deforestation and land clearing for cropland have affected the fuelwood supply to meet household energy demand (Marambanyika 2020). Urban households mostly use electricity to meet household energy demands (Maramura et al. 2020) but are affected by power outages and erratic power supply in the country (Banya 2019). Household energy demand is increasing in Zimbabwe due to population growth (Shafiullah et al. 2021).

Household cooking

In Zimbabwe, households rely heavily on biomass for cooking (**Figure 4**) (ZNSA & ICF 2016). The 2019 MICS report indicates that 69.3 % of the total population relies on fuelwood for cooking. The dependence on fuelwood for cooking is significantly higher in rural areas (94%) because of poor energy infrastructures and markets (ZIMSTAT & UNICEF 2019). Compared to rural households, urban households have better access to cleaner fuels for cooking, such as electricity, LPG, natural gas, and biogas (ZNSA 2012). Most urban households use electricity for cooking because of greater electricity access in urban areas (ZIMSTAT & UNICEF 2019). In 2006, 87.9% of urban households reported electricity as the primary source of energy used for cooking in their homes (CSO & MII 2007). By 2015, the number was down to 66.3% (ZNS & ICF 2016). In tandem with this decreased reliance on electricity in urban areas has been a rise in the reliance on biomass, primarily fuelwood (Chipango 2019). In urban areas, 15.4% of the population uses fuelwood for cooking (ZNS & ICF 2016) as a majority of the urban communities live in "high-density" areas with poor electricity access due to limited energy infrastructures and services (ZNSA 2012). **Figure 4** demonstrates the sources of primary cooking fuel in Zimbabwe.

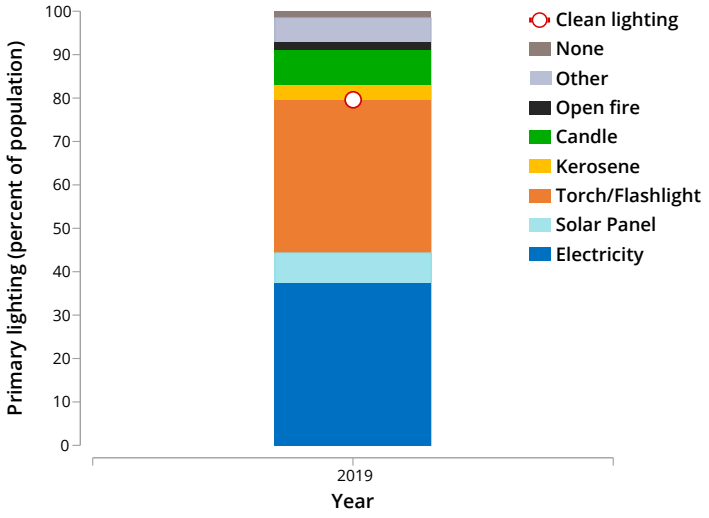
Figure 4: Primary cooking fuel over time (Data: Demographic and Health Survey (1999–2015)



Household lighting

In Zimbabwe, only 33.9% of the total population relies on electricity for lighting. Other common sources of lighting include gasoline/kerosene/paraffin lamps, fuelwood, biogas lamp, oil lamp, solar lanterns, and rechargeable or other battery-operated torches/lanterns. **Figure 5** shows the distribution of different sources of lighting in Zimbabwe. In urban areas, 86.2% of the urban population relies on electricity, and in rural areas, the main source of lighting is battery-operated flashlights/lanterns, kerosene, and fuelwood (ZIMSTAT & UNICEF 2019). Compared to data collected in terms of primary cooking fuel, data on lighting sources have not been collected in previous DHS and MICS surveys, except for the most recent 2019 survey (ZIMSTAT & UNICEF 2019).

Figure 5: Primary lighting fuel (Data: Multiple Indicator Cluster Survey 2019)



Institutional Demand

Besides household energy demand, public and private institutions, such as government buildings, industries, also contribute to the country's total energy demand. Among various institutions, healthcare facilities and schools are the two main institutions dependent on energy to provide their services that contribute to the health and overall development of the country, so energy demand of the two institutions will be reported here.

Health care facilities

A sufficient, reliable power supply is essential for effective healthcare delivery. Electricity enables health facilities to have lighting, power for operating and sterilizing medical equipment, and the ability to store temperature-sensitive medicines and vaccines, among many other basic functions (Ouedraogo and Schimanski, 2018). The 2017 Zimbabwe health facility information and communication technology (ICT) census found that approximately 85% of health facilities had access to electricity (ZimStat, & POTRAZ 2017b). However, significant disparities remain both subnationally and across health facility tiers. Nearly all facilities in urban areas and hospitals have access to electricity, compared to 83% of both rural facilities and non-hospitals (ZimStat, & POTRAZ 2017b). While all health facilities in Bulawayo are electrified, only three-fourths of those in Masvingo province have power (ZimStat, & POTRAZ 2017b).

The national grid is the primary energy source used by the vast majority of facilities in the country (~83%), and approximately 15% of facilities rely on solar as their main source (ZimStat, & POTRAZ 2017b). The remaining facilities use mini-grids (1%) and fuel-powered generators (1%) as their primary energy source. Decentralized electricity sources such as solar, generators, and mini-grids are disproportionately used by facilities in rural areas, which are less likely to be connected to the national grid; 20% of rural facilities rely primarily on decentralized energy sources, compared to less than 2% of urban facilities (ZimStat, & POTRAZ 2017b). Although the majority of health facilities in Zimbabwe are electrified, the unreliable power supply is still a major problem due to the fact that most facilities rely upon the national grid, which is notoriously prone to frequent outages. To address this problem, in recent years efforts have been made to provide health facilities with solar energy systems that can provide more reliable power. In 2017 and 2018, with support from the UNDP, the Ministry of Health installed solar photovoltaic (PV) energy systems in 405 facilities that were worst affected by load shedding to serve as both primary and backup energy sources (UNDP 2020).

Schools

Electricity access also plays an important role in schools by improving the educational services offered, improving administrative processes, and extending the possibility for new services such as evening classes or computer courses (Lenz et al., 2017). A situational analysis of fifteen secondary schools across Zimbabwe indicated that most schools were off-grid, using generators to power a few necessary appliances such as typewriters and photocopying machines. The schools that were connected to the grid dealt with load shedding by using generators as a backup source, which is expensive since these schools pay for both on- and off-grid energy (UNICEF 2015).

Industrial demand

The majority of industrial demand relies on coal and electricity. Mining and extractive industries account for 40% of the electricity demand in the country (ESMAP 2019). The mining sector has been affected by power outages and reduced electricity output in the country. The effect has been greater in low-capacity mines and increased the cost of mining high-valued mines, such as gold and diamond (Kaseke & Hosking 2012). In urban areas, production and other industries mainly use electricity (Mhaka et al. 2020). Zimbabwe's energy policies address the possibility of using solar energy for pre-heating water and developing other, more-efficient energy options for industrial processes, but no initiatives have been taken yet utilizing solar energy in the industrial sector (MEPD 2012; 2019).

ENERGY POLICY

In 2012, the government of Zimbabwe passed National Energy Policy (NEP), and two new sub-policies have been recently added: The National Renewable Energy Policy (2019), and the National Biofuels Policy (2020). Much of the NEP established the status of the energy subsectors, which include electricity, fossil fuel, and renewable energy (MEPD 2012). The main objective of the National Energy Policy was to guarantee access to various forms of modern energy for people's "light, heat, static, and motive power" needs to improve their quality of life (MEPD 2012). However, there were no long-term targets in place to reach this objective, which catalyzed the development of the National Renewable Energy Policy (NREP).

The NREP expanded on the NEP's original framework, aiming to address the problems associated with switching to renewable energies (MEPD 2019). The two goals of the NREP are to install renewable energy sources (excluding large hydro) to reach: 1,100 MW of installed capacity by 2025 or 16.5% of total energy generation from renewable sources, whichever is higher; and 2,100 MW by 2030 or 26.5% of total energy generation from renewables, again, whichever is higher (MEPD 2019). The NREP will be in effect until 2030, with reviews scheduled for the end of 2020 and 2026, and a new framework will be created after 2030 (MEPD 2019).

Figure 6 illustrates how the National Energy Policy is associated with other policy sectors such as climate, forests, gender, and health. The NEP and its extension, NREP, underscore the need to address these links in policy frameworks. Additionally, the National Biofuels Policy (NBP) that was developed as a guide for the biofuels sector in Zimbabwe (MEPD 2020) addresses three aspects of sustainability (economic, environmental, and social) to ensure that the production, processing, distribution, and marketing of biofuels in Zimbabwe are sustainable and equitable (MEPD 2020). Sustainable and efficient sources of the domestic biofuel sector can prove critical for a country like Zimbabwe where energy demand is rising, and other parts of the energy sector are failing to reach this demand. According to the National Biofuels Policy, the current (2020) national need for petrol and diesel are 3,300,000 and 4,300,000 liters per day, respectively (MEPD 2020). This policy sees the widespread adoption of domestic biofuel as a way of approaching many problems, including reducing Zimbabwe's dependence on imported petroleum products, addressing the fuel shortage and stabilizing fuel prices, and creating jobs to reduce poverty (MEPD 2020).

Further, national policies on other sectors also highlight the need to integrate energy as an important policy lever for sustainable development. For example, the Ministry of Environment, Climate, Tourism, and Hospitality Industry released the National Climate Policy in 2017 that details guidelines to mitigate the climate impact from the energy sector, which is the largest contributor to Zimbabwe's greenhouse gas emissions at 60.7% (MECW, 2017a). The mitigation guidelines for the energy sector promote renewable energy and the adoption of energy-efficient technologies and practices, promote, and adopt green, "gender-sensitive" technologies, and promote cleaner fossil fuel technologies and access to clean and affordable energy (MECW 2017a).

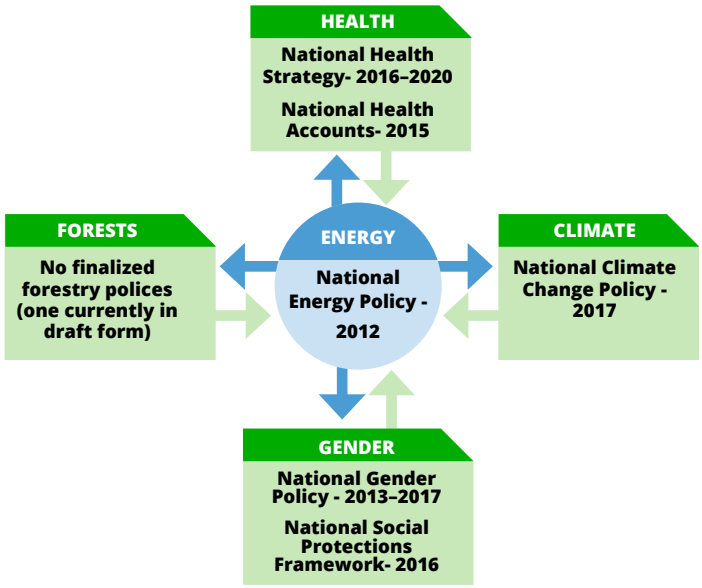
ENERGY SECTOR GOVERNANCE AND STAKEHOLDERS

The government of Zimbabwe developed the National Development Strategy (2021–2025) in 2020 to meet the SDG goals that include improving energy access, specifically electricity, increasing fuel supply, and promoting clean and renewable energy sources in the country. To achieve these goals, the government works with many stakeholders such as non-government organizations, private businesses, and international partner organizations (ILO 2020).

Government

The Government of Zimbabwe oversees the development of a majority of energy infrastructure in the country. There is one main government utility company, the Zimbabwe Electricity Supply Company (ZESA) that manages the production and distribution of electricity through two subsidiaries: Zimbabwe Power Company (ZPC) and the Zimbabwe Transmission and Distribution Company (ZEDTC). In 2011, the Zimbabwe Energy Regulatory Act (ZERA) was established to regulate energy production, transmission, and distribution in Zimbabwe (MEPD 2019).

Figure 6: Policy linkages between the National Energy Policy and Forestry, Climate, Health, and Gender policies



Government Agencies

The national energy sector development is managed by the Ministry of Energy and Power Development (MEPD) and is also in charge of the holding company ZESA. The MEPD also works with other ministries in the country. For instance, the MEPD works with the Ministry of Finance and Economic Development to manage the fund of renewable energy projects through Rural Electrification Fund and develop financial incentives (MEPD 2019). The Ministry of Lands, Agriculture, Fisheries, Water, Climate and

Rural Development also works with the MEPD in identifying land parcels for rural electrification projects and work with the Ministry of Environment, Water and Climate for approval of the projects (MEPD 2019).

Public Utility Companies

ZESA is the holding company for the national generation company, Zimbabwe Power Company (ZPC), and the transmission and distribution utility, Zimbabwe Electricity Transmission and Distribution Company (ZETDC), under the Ministry of Energy and Power Development. ZESA has five major power plants (see Section on energy supply). Currently, the thermal supply is poor, and the energy market is heavily influenced by economic and political situations in the country. The ZESA also manages the Rural Electrification Agency (REA) which was formed under the Rural Electrification Fund Act in 2002 (REF 2022). The REA manages the planning and implementation of rural electrification projects to address the need for equitable electricity access in rural areas (ESMAP 2015). The ZEDTC operates and maintains grid infrastructure and the REA is responsible for grid expansions in rural areas. As of 2021, the REA has expanded access to grid electricity in 9,579 entities of varying sectors that range from primary and secondary schools to health centers, business centers, small-scale farms, villages, and others, since its formation in 2002 (REF 2022). However, financial constraints have hindered the agency from meeting the goal of 50% electrification of major sectors in all provinces (ESMAP 2015). In addition to grid electricity, the REA also focused on increasing the energy supply in rural areas through solar and biogas sources (ESMAP 2015).

Non-governmental actors

Bilateral and multilateral aid organizations

Many multilateral aid organizations provide funding and implement projects in Zimbabwe for sustainable energy policies and improve energy access. In supporting the goal to meet the Sustainable Development Goal (SDG) 7, many international donors provide financial aid, resources, and guidance to improve energy accessibility in the country. For instance, the United Nations SDG fund provided 45 million US dollars for funding a four-year program that aims to facilitate investments in renewable energy sources to help Zimbabwe achieve SDG goals. In addition, the donors also provide data and insights to scale-up energy projects (UNESCO 2022).

Zimfund is another fund provided by seven donor countries to Zimbabwe that manages the Emergency Power Infrastructure Rehabilitation Project aims to increase accessibility and improve the reliability of electricity in the Midlands and Manicaland provinces. In completion of Phase I, the project has helped improve the power supply in many critical facilities such as schools and rural healthcare facilities (Mlotshwa 2022). Other projects in the country include the Sustainable Energy for Rural Communities (SE4RC) and the National Domestic Biogas Programme (SNV 2022). Both projects are funded by SNV, a non-profit international organization, working to establish micro energy grids and biogas plants, respectively.

The World Bank established the Zimbabwe Reconstruction fund (ZIMREF) in 2014. It is a multi-donor trust fund focused on the reconstruction and development of the country supporting the private and government sector, and energy-related components of the fund are focused on developing energy infrastructures and supporting the government of Zimbabwe to integrate climate change issues in projects addressing water-energy nexus (The World Bank 2019). Another trust fund, the Energy and Environment Partnership Trust Fund (EEP Africa) managed by the Nordic Development Fund and funded by 15 countries. Currently, it has implemented multiple projects such as solar pumps for irrigation, solar egg incubators, electric vehicles, and electrification through solar home systems (EEP Africa 2022).

Non-governmental organizations and private sector firms

There are many smaller, in-country non-governmental organizations (NGOs) and private sector firms working in the development of the energy sector in Zimbabwe. Several NGOs work in the country to improve access to and use of clean cooking technologies for households. Practical Action has invested in mini-hydro grids in the Eastern Highlands region (Practical Action 2022). The Renewable Energy Association of Zimbabwe is another NGO that aims to increase the adoption of renewable and sustainable energy sources (REA 2022). Power for All is another NGO that is working in many African countries including Zimbabwe to improve access to decentralized renewable energy sources in rural areas and end energy poverty (Power for All 2022). There are many other NGOs that are focused on other development sectors that are associated with energy access (Pindula 2020).

The private sector in Zimbabwe has three large ventures operating: Green Fuel, C-Quest Capital (CQC), Global Solar Private Ltd. Green Fuel is an ethanol fuel company, which aims to train 36,500 Zimbabweans in a variety of energy and ethanol-related trades by 2025 (Green Fuel 2019). C-Quest Capital is working on a pilot project of improved cookstoves in Kambarami Village near Harare (CQC 2022). Global Solar Private Ltd. is engaged in ensuring affordable clean energy accessible to help improve people's quality of life and reduce poverty by providing access to various solar energy and lighting technologies (Global Solar 2022). There are many other private companies that have been funded to run various energy projects in Zimbabwe (Renewables Now 2022).

ENERGY, CLIMATE, ENVIRONMENT LINKAGES

The Government of Zimbabwe developed the National Climate Policy in 2017 to manage economic, environmental, and social risks from climate change with a vision to achieve - "A climate resilient and low carbon Zimbabwe". The policy was developed in response to increasing exposure to climate change vulnerabilities, such as droughts and floods, which directly impacted the country's socioeconomic development (MEWC 2017b). In addition to addressing climate change risks, the policy also integrates issues related to climate change with other sectors such as energy, gender, forests, and health. Particularly related to the energy sector, the policy objectives are to improve the adoption of

renewable and energy-efficient technologies and monitor GHG emissions from the energy sector (MEWC 2017b).

Climate change impacts on the energy sector have significantly affected the country's energy supply. Reduced output and erratic power supply are major impacts of severe and recurrent droughts in the country (Banya 2019). Regular power outages and increased load-shedding hours resulted in increased use of fuelwood and other biomass sources for cooking and meeting household energy demands (Chipango 2019). Consequently, the rise in fuelwood collection increased deforestation and forest degradation (Marambanyika 2020). The government of Zimbabwe acknowledges these challenges and addresses them in its national policy plans.

Electricity

Impact

The energy sector in Zimbabwe is the country's largest contributor of greenhouse gases emitting 60.7% of the country's GHG emissions, followed by agriculture at 20.7%, industrial processes at 16.6%, and waste at 1.9% (MEWC 2012). Within the energy sector, over 46.4% of electricity generated comes from coal burning (MEWC 2012). Such high reliance on fossil fuels results in emissions of carbon dioxide and methane contributing to anthropogenic climate change. Further, the country also generates electricity from the Kariba South Power Station which has different social and environmental impacts. For example, the dam construction of the Kariba station is associated with water pollution, decreasing fish populations, and wildlife displacement (Makumbe et al. 2022). The water quality and quantity affected by dam construction also affect the livelihood of communities living downstream (Marowa & Matanzima 2022).

Vulnerability

Energy production from hydropower in Zimbabwe is highly susceptible to changes in rainfall. Recurrent droughts have decreased the water supply to the hydropower station. A recent severe drought greatly reduced the water level in the Zambezi River and impacted the production of the hydropower plant (Emi, 2020). The impact of reduced electricity output there also affects industrial productivity. Mining, commercial, and service industries depend on electricity and frequent power outages in the country have slowed the economic growth of these industries (Mhaka et al. 2020). Since the industrial sector is the largest consumer of energy in Zimbabwe, vulnerabilities in the electricity supply underscore the need to expand energy sources for greater resilience.

Biomass

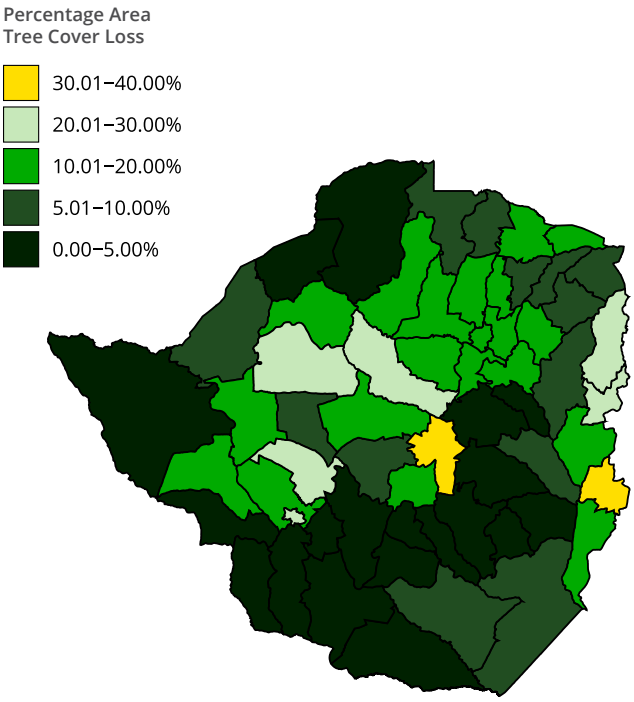
Impact

Biomass, primarily firewood harvested from forests and woodlands, is the primary source of energy in Zimbabwe. Greenhouse gas emissions, such as methane and carbon dioxide, from biomass use are a major climate change concern. Biomass burning also releases other pollutants, such as particulate matter and black and organic carbon, that cause ambient and indoor air pollution affecting both public health and the environment. Further, fuelwood collection, usually in an unsustainable manner, at the household level could result in deforestation and forest degradation on a local level. However, there are several energy-dependent processes that contribute to forest and woodland degradation and deforestation in Zimbabwe. For example, tobacco curing and clearing land for cropland result in a large-scale reduction of carbon stocks (Jingura et al. 2013; Manyanhaire and Kurangwa, 2014; Chipango, 2018). In 2011, it was estimated that more than 46,000 hectares of woodland were destroyed to cure a portion of the 127 million kilograms of tobacco produced that year (MECW 2012). **Figure 7** shows the annual tree cover loss from 2000 to 2019 at the district level in Zimbabwe (Potapov et al. 2022). Estimates have indicated that biomass used for energy purposes may continue to increase as the population increases but the energy supply could remain limited (Jingura et al. 2013).

Vulnerability

Zimbabwe's population continues to grow which increases the demand for energy and food production. Since a majority of rural communities do not have access to electricity and heavily rely on biomass, clearing forested landscapes is expected to continue in the future for increased food production and fuelwood collection. Further, power dynamics between state actors and the general public also play important role in fuelwood access indicating fuelwood scarcity is affected by the political situation in the country (Chipango 2019). Despite grid connection, many urban households in Zimbabwe continue to use biomass because of regular power outages and unstable supply (Chipango 2019). Increasing dependence on biomass for energy could increase the vulnerability of the forest resources and subsequently, future biomass supply.

Figure 7: Tree loss by district from 2000-2021 as a percentage of tree cover area in 2000. (Data: Potapov et al. 2022)



Hence, sustainable management of forested landscapes is important until alternative and renewable energy sources are available (Mujuru & Oeba 2019).

ENERGY DATA AND RESEARCH

Population data are used to evaluate energy consumption in Zimbabwe. Since 1982, the Zimbabwean census has been conducted every ten years; the most recent census was completed in 2012 (ZIMSTAT & ICF 2012). To estimate population between census counts, there are a number of gridded population data products that use demographic projections and dasymetric mapping to disaggregate population estimates to sub-administrative unit levels at 1- or 5-year intervals. Some of these products are WorldPop, Landscan, Global Human Settlement Layer - Population, Global Rural Urban Mapping Project, and Gridded Population of the World Version 4.

Census data and population grids are important to understand population change and energy demand over time. In addition, nationally representative studies of household behaviors and economics provide valuable insights to understand household fuel choices and energy consumption. The Demographic and Health Surveys (DHS) are nationally representative surveys administrated at the household level in low- and middle-income countries, with an emphasis on maternal and child health indicators along with a module on household characteristics, which includes questions about fuel choices and electricity access. DHS surveys for Zimbabwe are publicly available for 1994, 1999, 2005, 2010, and 2015. The Multiple Indicator Cluster Survey (MICS), administered by UNICEF, also includes questions about fuelwood collection, cooking practices, stove type, household fuel choice, household labor, and assets, which provide valuable information on household fuel use and access. MICS for Zimbabwe are available for the years 2009 and 2014.

While energy demand data is important, data on energy infrastructure is also important to understand a country's energy infrastructure. In Zimbabwe, there are very few publicly available datasets that inform about its energy infrastructure. Currently, there are only two available data sets -a vector file of the main electricity transmission network based on OpenStreetMap and a vector file of the location of the power plants.

Below is the complete list of data sources on Zimbabwe's population, energy use, and energy supply:

POPULATION

- Global Human Settlement Layer. JRC.
- Global Rural-Urban Mapping Project (GRUMP), v1. CIESIN. 2020.
- Gridded Population of the World, v4. CIESIN. 2020.
- Oak Ridge National Laboratory. "Landscan." 2020.

HOUSEHOLD SURVEYS

- MICS. UNICEF.
- DHS. USAID.

ENERGY SUPPLY & SPATIAL DATA

- Zimbabwe ETN. ENERGYDATA.INFO
- Zimbabwe Power Plants. ENERGYDATA.INFO

Maize in a rural village near Mutewa, Zimbabwe

In recent years, there has been a rapid growth in research on energy access in sub-Saharan Africa (Figures 8 & 9), Between 1987 and 2019, 35 peer-reviewed publications on various dimensions of energy have been published about Zimbabwe. Such a significant increase in the number of peer-reviewed publications coincides with the announcement of SDG7 in 2015, and the introduction of several global initiatives focused on energy access, such as Sustainable Energy for All, the World Bank's ESMAP program, and the Clean Cooking Alliance.

Figure 8: Count of peer-reviewed publications on energy in Zimbabwe over time (Data: Jeuland et al. 2021))

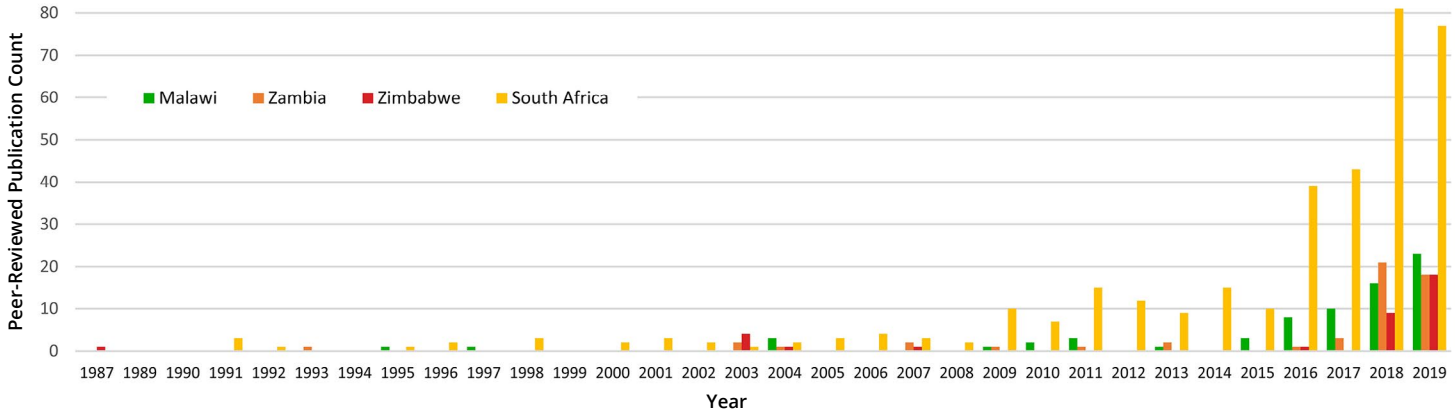
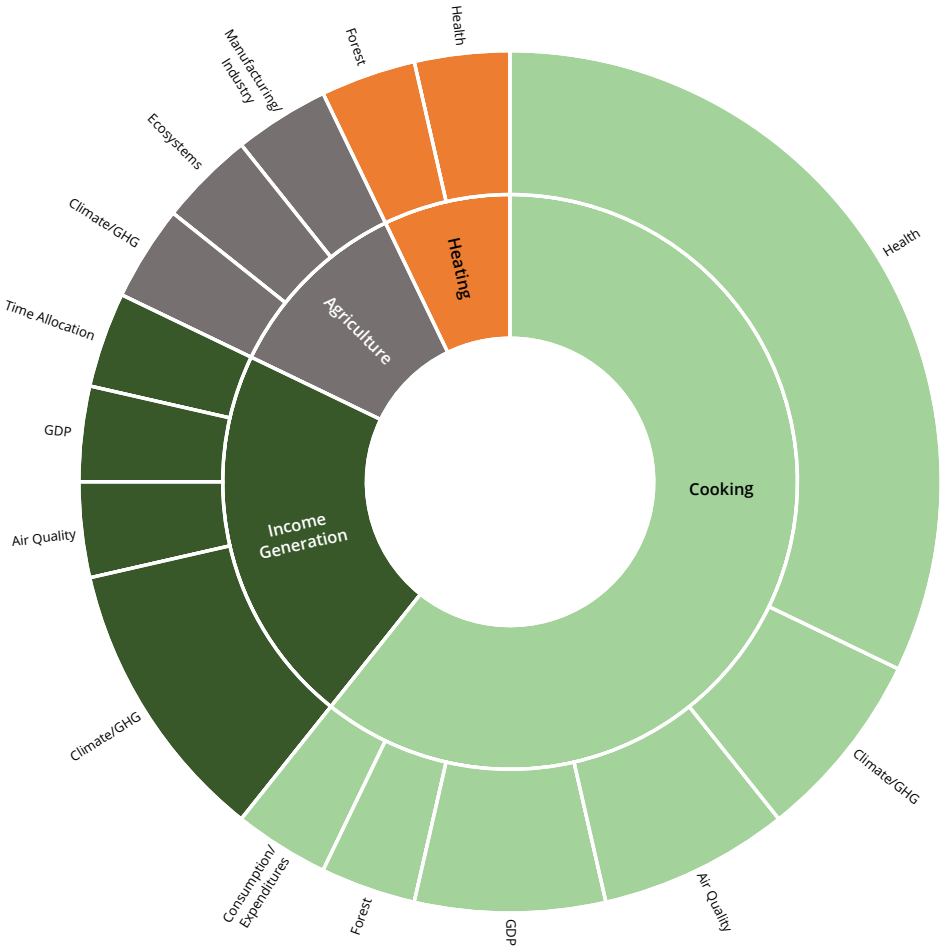


Figure 9: Energy topics and the impacts of quantitative peer-reviewed publications based in Zimbabwe from 1987–2019 (Data: Jeuland et al. 2021)



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