LEAP-RE

Research and Innovation Action (RIA)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 963530

Start date : 2020-10-01 Duration : 63 Months
http://www.leap-re.eu/

Final report on the social analysis and the related data developed in task 9.3 and to be used in the Geothermal Atla

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LEAP-RE - Contract Number: 963530

Project officer: Bernardo Luis ABELLO GARCIA

Document title	Final report on the social analysis and the related data developed in task 9.3 and to be used in the Geothermal Atlas
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Number of pages	118
Document type	Deliverable
Work Package	WP9
Document number	D9.4
Issued by	UoN
Date of completion	2024-04-10 19:10:15
Dissemination level	Public

Summary

Executive Summary This report addresses two primary objectives of the task: a review of socio-economic context for analysis of African countries, and analysis of Case Studies of renewable energy development across Africa. The Socio-economic analysis was anchored on on existing documents available at national scale from national and international databases. The analysis for the African countries lays emphasis on the on their likelyhood of involvement in geothermal development, while integrating with the geoscientific knowledge acquired. Regarding Cases of renewable energy development across Africa: the focus was on identifying cases of geothermal ? and potentially renewable ? energy developments to provide a collection of good practices implemented by various actors (e.g. multinational companies, state-owned companies, private consortia, etc.) in order to understand drivers for success and barriers (e.g. cultural-based drivers or barriers, drivers for communities? engagement, and regulatory barriers). Recent Economic Development Contexts in Kenya, Djibouti, Ethiopia, and Rwanda Economic growth range between 4.5% to 6.5%: In Kenya, the average real GDP growth over the last decade was 4.5% Djibouti posted average economic growth of 5.3% over the 2016?2021 period. Rwanda the average real GDP growth of 6.5% over the last decade. In 2021, Ethiopia had nominal GDP of USD 120.4 billion. Average real GDP growth of 8.4% and has been highest over the last decade. The structure of the economies tend to similar, with services sector playing an increasing dominant role. Kenya?s economic structure in 2021 shows that services was dominant sector accounting for 61% of overall. Djibouti The structure of the economy is dominated by the service sector - transport, communications, commerce and tourism. These contribute to more than 80% of Djibouti?s gross domestic product (GDP). Rwanda economic structure shows that in 2021, services accounted for 56% of overall GDP. Ethiopia economic structure shows that in 2021, services accounted for 41% of overall GDP. Human development levels are diverse ? for Kenya falling within Medium Human Development category globally, Globally, its Human Development Index (HDI) is 0.601, ranking 146 in 2024. Djibouti falls within the low Human Development category globally, it?s Global Human Development Index (HDI) is 0.515, ranking 171. Rwanda falls within low Human Development category globally; Rwanda?s Global Human Developm...

Approval

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LEAP-RE

Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

Research & Innovation Action

10th April 2024

Final report on the social analysis and the related data developed in task 9.3 and to be used in the Geothermal Atlas

Version N°1

This project has received funding from the European Union’s Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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Document information

Grant Agreement	963530
Project Title	Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy
Project Acronym	LEAP-RE
Project Coordinator	Vincent Chauvet (Vincent.chauvet@lgi-consulting.com) – LGI
Project Duration	1st October 2020 – 31st December 2025 (63 Months)
Related Work Package	9
Related Task(s)	9.3
Lead Organisation	UoN
Contributing Partner(s)	SSSA, UNITO and GEO2D
Due Date	31/03/2024
Submission Date	10/04/2024
Dissemination level	PU

History

Date	Version	Submitted by	Reviewed by	Comments
10/04/2024	1.0	Joseph Onjala		

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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Abbreviations and Acronyms

Acronym	Description
WP	Work Package
AfDB	African Development Bank
ARENE	Energy Regulatory Authority
CREG	Algerian Electricity and Gas Regulation Commission
CSA	climate smart agriculture
CS-EP	Cabinet Secretary for Energy and Petroleum
EBRD	European Bank for Reconstruction and Development
EDCL	Energy Development Corporation Limited
EDD	Electricité de Djibouti
EDM	Electricidade de Moçambique
EEP	Ethiopian Electric Power
EETC	Egyptian Electricity Transmission Company
EEU	Ethiopian Electric Utility
EgyptEra	Egyptian Electric Utility and Consumer Protection Regulatory Agency
EIB	European Investment Bank
EPI	Environmental Performance Index
EPRA	Energy and Petroleum Regulatory Authority

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EPRA	Energy and Petroleum Regulatory Authority
ETIP	Kenya Energy Transition and Investment Plan
EUCL	Energy Utility Corporation Limited
EUCL	Energy Utility Corporation Limited
EWSA	Energy, Water and Sanitation Authority
EWURA	Energy and Water Utilities Regulatory Authority
GAA	Geothermal Atlas for Africa
GCRI	Global Climate Risk Index
GDC	Geothermal Development Company
GDI	Gender Development Index
GDP	gross domestic product
GGGI	Global Green Growth Initiative
GHG	greenhouse gases
GNI	Gross National Income
GoK	Government of Kenya
HDI	Human Development Index
IPPs	Independent Power Producers'
IRENA	International Renewable Energy Agency
KETRACO	Kenya Electricity Transmission Company Ltd
KNLGL	Kenyan National Geothermal Laboratory
KPLC	Kenya Power and Lightning Company Ltd
MOERE	Ministry of Electricity and Renewable Energy
MoU	memorandum of understanding
NREA	New and Renewable Energy Authority
ODDEG	Djiboutian Office for Geothermal Energy Development
PEA	Petroleum and Energy Authority
PEA	Petroleum and Energy Authority
PLC	Kenya Electricity Generating Company
PPA	Power Purchase Agreement
PPPs	Public-Private Partnerships
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
RSP	Rwamagana Solar Power
RURA	Rwanda Utilities Regulatory Authority
SAPP	Southern African Power Pool

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SDGs	Sustainable Development Goals
TANESCO	Tanzania Electric Supply Company Limited
TES	total energy supply
SHAEMS	Algerian Society for Renewable Energies
TGDC	Tanzania Geothermal Development Company
TPES	Total Primary Energy Supply
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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Executive Summary

This report addresses two primary objectives of the task: a review of socio-economic context for analysis of African countries, and analysis of Case Studies of renewable energy development across Africa. The Socio-economic analysis was anchored on on existing documents available at national scale from national and international databases. The analysis for the African countries lays emphasis on the on their likelyhood of involvement in geothermal development, while integrating with the geoscientific knowledge acquired. Regarding Cases of renewable energy development across Africa: the focus was on identifying cases of geothermal – and potentially renewable – energy developments to provide a collection of good practices implemented by various actors (e.g. multinational companies, state-owned companies, private consortia, etc.) in order to understand drivers for success and barriers (e.g. cultural-based drivers or barriers, drivers for communities' engagement, and regulatory barriers).

Recent Economic Development Contexts in Kenya, Djibouti, Ethiopia, and Rwanda

Economic growth range between 4.5% to 6.5%: In Kenya, the average real GDP growth over the last decade was 4.5% Djibouti posted average economic growth of 5.3% over the 2016–2021 period. Rwanda the average real GDP growth of 6.5% over the last decade. In 2021, Ethiopia had nominal GDP of USD 120.4 billion. Average real GDP growth of 8.4% and has been highest over the last decade.

The structure of the economies tend to similar, with services sector playing an increasing dominant role. Kenya's economic structure in 2021 shows that services was dominant sector accounting for 61% of overall. Djibouti The structure of the economy is dominated by the service sector - transport, communications, commerce and tourism. These contribute to more than 80% of Djibouti's gross domestic product (GDP). Rwanda economic structure shows that in 2021, services accounted for 56% of overall GDP. Ethiopia economic structure shows that in 2021, services accounted for 41% of overall GDP. Human development levels are diverse – for Kenya falling within Medium Human Development category globally, Globally, its Human Development Index (HDI) is 0.601, ranking 146 in 2024. Djibouti falls within the low Human Development category globally, it's Global Human Development Index (HDI) is 0.515, ranking 171. Rwanda falls within low Human Development category globally; Rwanda's Global Human Development Index (HDI) is ranked 161 at 0.548. Ethiopia Falling within low Human Development category globally, Ethiopia's Global Human Development Index (HDI) is ranked 176 at 0.492. Equally, life expectancy is diverse.

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The *main sources of modern energy* are petroleum and electricity. Even so, biomass fuel is the most prevalent energy source within rural and informal urban settlements. Rwanda Biomass is the most used. Kenya is among the leading countries in harnessing geothermal energy, which accounts for over 40% of the country's energy mix. Bottlenecks in Djibouti are linked to limited human, financial, legal and institutional capacities. Rwanda has untapped resources for power generation amount to about 1,200 MW. Ethiopia is one of the countries in the East African Rift with significant geothermal potential. Strong partnership and collaboration with development partners and private investors will be the major driver for energy transition.

Kenya has a population of about 55 million, with annual population growth of about 2%. Djibouti has a population of about 12 million, with annual population growth of about 1.4%. Rwanda has 14 million people (2022), it is the most densely populated mainland African country. Population growth (annual %) = 2.3 percent. Ethiopia has a population of about 124 million, with annual population growth of about 2.5%. There are significant gaps in access to services. Kenya; Access such as clean fuels and technologies for cooking; access to electricity; clean water and sanitation services. Most of *the population live on low and insecure incomes* with high unemployment rates. The countries are dependent on foreign markets, making it more vulnerable to exogenous shocks. Vulnerability also differs geographically, but mostly related to climatic (drought or floods) and economic shocks.

The countries face the challenges of rapid environmental degradation of forests, wildlife landscapes, pollution coupled with climate change impacts such as droughts and flooding. Most countries have undertaken to reduce greenhouse gas emissions by 40% by 2030 focusing on renewable energies. In May 2020, Rwanda became the first African country to submit its enhanced NDC to the United Nations Framework Convention on Climate Change (UNFCCC), committing to a reduction in greenhouse gas emissions of up to 38% in 2030. Except for climate change, the major environmental issues affecting Ethiopia are soil erosion and land degradation, deforestation and forest degradation, water scarcity, biodiversity loss, and various types of pollution.

Recent Economic Development Contexts in Other African Countries - Egypt, Tanzania, Mozambique, and Algeria

In terms of economic growth: Tanzania had average real GDP growth of 5.9% over the last decade. In 2019, Mozambique had average real GDP growth of 4.3% over the last decade. In 2022, Algeria had average real GDP growth of 3% over the last decade. The economic structure is dominated by services -Egypt in 2021 services accounted for 57%

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of overall GDP, Tanzania in 2021 services accounted for 45% of overall GDP, Mozambique in 2020 services accounted for 53% of overall GDP, Algeria in 2021 services accounted for 66% of overall GDP. Egypt falls within the High Human Development category globally, (HDI) is ranked 105 at 0.728. Tanzania Global Human Development Index (HDI) is ranked 167 at 0.532. Algeria falls within the High Human Development category globally; it's Global Human Development Index (HDI) is ranked 95 at 0.745. Mozambique The country is one of the 10 poorest in the world, with a Human Development Index (HDI) of 0.461, which ranks 176 among 191 countries.

Egypt Natural gas is the largest source of energy, accounting for 54. % of total energy supply (TES) in 2020. Tanzania in 2021, Tanzania's power generation comes mostly from natural gas (48%), followed by hydro (31%). Mozambique has the largest power generation potential of all Southern African countries. Mozambique is a net exporter of energy to countries in the Southern African Power Pool (SAPP) – South Africa being the largest importer. Algeria's Total Primary Energy Supply (TPES) is largely based on Natural Gas and Crude Oil, which represent 50.61% and 48.94% respectively. Most of the countries have undertaken to develop modern renewable energy. Egypt has sought to develop several other forms of modern renewable energy, including through solar and wind projects. Tanzania is endowed with diverse renewable energy resources, ranging from biomass and hydropower to geothermal, solar and wind. Much of this potential has not been fully exploited. Mozambique The country has one of the world's largest natural-gas reserves, vast amounts of arable land and miombo forests, considerable hydropower resources. Algeria possesses significant renewable energy resources. Its most abundant renewable resources are solar, followed by wind, hydro, and biomass. In most the countries, Transition towards a renewables-based energy system involves large-scale deployment of renewable energy technology, these will require international and global partner involvements. Access to moden energy is diverse: Egypt Access to electricity stands at 100%, mainly in urban areas. Tanzania access to electricity stands at 65%, mainly in urban areas. Mozambique Access to clean fuels and technologies for cooking remain very low at 5%. Access to electricity stands at 41%, mainly in urban areas. Algeria access to electricity stands at 99%, mainly in urban areas.

Egypt Global Environmental Performance Index (EPI) rank is 127, with a score of 35.5 percent. Air pollution and waste management are also major environmental challenges in Egypt. Tanzania Global Environmental Performance Index (EPI) rank is 134, with a score of 34.2 percent. Tanzania is vulnerable to increasing climate variability over most parts of the country. Mozambique Global Environmental Performance Index (EPI) rank is 144, with a score of 31.7 percent. Despite being one of the lowest greenhouse gases (GHG) emissions

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contributors, Mozambique is one of the 10 countries most affected by climate change, according to the Global Climate Risk Index (GCRI). Algeria Global Environmental Performance Index (EPI) rank is 155, with a score of 29.6 percent. Algerian forests face several challenges including forest fires, overgrazing, agricultural expansion, and climate change that contribute to deforestation and degradation over time.

Institutional and regulatory frameworks

Most of the eight countries of focus in this deliverable have adapted their frameworks to the specific requirements of geothermal development, but not to the same degree. Kenya has by far the most elaborate institutional and regulatory framework in place, congruent with its leading position in geothermal development in Africa. This includes dedicated policy, legal and regulatory guidelines/terms for the different stages of geothermal development and exploitation and a specific geothermal agency. Ethiopia does not yet have such an agency, but it does have elaborate geothermal regulations in place, including for geothermal direct use. Djibouti and Tanzania both have a geothermal agency, but hardly or no specific regulatory framework for geothermal development. Mozambique, Egypt and Algeria have neither a geothermal agency nor specific regulations.

Cases of renewable energy development across Africa

Our analysis of renewable energy projects found that geothermal, wind, and hydropower require specific natural conditions to function efficiently. Geothermal needs particular underground features, while wind and hydro rely on strong winds and moving water. Solar energy is more flexible in location but still depends on sufficient sunlight.

Involved players in renewable energy projects include governments, funders, private companies, and local communities. Benefits of renewable energy include reduced dependence on fossil fuels, lower emissions, and job creation. Challenges include funding, infrastructure limitations, local concerns, and environmental impact assessments.

For geothermal projects, we recommend partnering with governments and international organizations for funding and permits. Communication with communities and officials is key, and exploring direct use of geothermal heat can provide additional benefits. Thorough environmental impact assessments are essential, and experienced companies are important for technology and maintenance, especially in remote locations.

Lessons learned from other renewable energy projects include proactive community engagement, balancing reduced emissions with wildlife conservation, and responsible development practices.

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Keywords

Socio-Economic, Context, Geothermal, Case-Studies, Africa

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1. Introduction

The Geothermal Atlas for Africa (GAA) will present an overview of the occurrence of geothermal resources across the African continent and their potential for electricity production and other uses. The aim is to provide researchers, policy/ decision makers and project developers and investors with an accessible and user-friendly tool that features the latest and most relevant knowledge on geothermal resources in Africa, thereby facilitating their projects or development plans. In so doing, GAA brings together geological, technological, and social insights and elements regarding these geothermal resources. This report focuses on the social elements and dynamics of geothermal resources in Africa, drawing on different types of social scientific disciplines.

Considering GAA's aim, specifically, this report develops a socio-economic analysis for eight African countries that we singled out, namely:

- Djibouti
- Ethiopia
- Kenya
- Rwanda
- Algeria
- Egypt
- Mozambique
- Tanzania

The socio-economic analysis for each of these countries pays attention to several key elements/dynamics. Firstly, the macro-economic context at the national scale is described. This includes Economic growth, Dominant Economic Activities, Incomes and poverty wellbeing, Energy Balance and Transitions. Renewable energy potential and development, Global and local drivers of energy transitions, Population and household dynamics, Access to social Services, Socio-Economic Vulnerabilities, Social and Economic Transformations, and Environmental Factors. The main methodology used for this part of the analysis are questionnaires, secondary data and review of literature from published institutional sources.

Regarding the social perspective, there is a general trend of increasing population in each of these countries, with men being slightly more than women in each case. Levels of access to social services, including access to water and electricity vary across these countries. High poverty levels is a cross cutting socio-economic vulnerability with various root causes including climate change-induced factors. Social and economic

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transformations are varied across the countries and include human capital development increased access to basic services and introduction of social protection programmes, structural reforms, improving citizen service delivery, post-war reconstruction investments, policy reforms and infrastructure development. Environmental factors include loss of water resources, deforestation, climate-change effects including drought.

Thirdly, we provide an overview of the institutional and regulatory framework for geothermal development in each of these countries. This includes brief summaries of, and key principles deriving from, policies, laws and regulations that apply to geothermal development and renewable energy more generally. Special regulations for community involvement, if available, are also specified. The data for this part derives in part from fieldwork in the upper four countries mentioned above, augmented by literature research and documentary analysis. Documents used include policy and strategic documents, constitutions, laws and decrees and annual reports of key agencies involved in energy/ geothermal development.

Fourth, because geothermal development in most countries except for Kenya is still in its infancy, we present an overview and analysis of renewable energy cases (one from each country) from which we derived key messages and , lessons learned on features as dimension, location, promoting actors, stakeholders, beneficiaries and use of energy, sustainability challenges and achieved goals and potential success factors and barriers for the development of geothermal projects. Except for one, these cases focus on other REs rather than geothermal energy, due both to the lack of geothermal experiences, and on the potential best practices existing in RE exploitation. The methods used to select the cases were based on the following criteria: type of RE sources prevalent in each country; dimension of the power plant, with a preference for high installed capacity; contribution of power stations to national energy mix.

The structure of this report corresponds with these parts of the socio-economic analysis. Thus, the next chapter presents an overview of the main macro-economic indicators for each of the countries. This national scale-analysis is followed by a local-scale analysis of social perspectives in chapter three. Chapter two has been developed by the University of Nairobi and Geo2D. Chapter three outlines the regulatory and institutional frameworks for geothermal development, and it has been developed by the University of Turin. Chapter four presents the analysis of the renewable energy cases and chapter six summarizes and concludes the key insights for each of the countries. Chapter four has been developed by Sant'Anna School of Advanced Studies. The report concludes with a conclusion chapter.

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2. Analysis of Socio-Economic Context

2.1 Macro-economic context in Djibouti, Ethiopia, Kenya and Rwanda

2.1.1 Djibouti

Economic growth

Djibouti posted average economic growth of 5.3% over the 2016–2021 period. With Gross National Income (GNI) per capita of USD 3,310, Djibouti is a lower-middle-income country, falling among the Least Developed Countries.

Dominant Economic Activities

The structure of the economy is dominated by the service sector - transport, communications, commerce and tourism. These contribute to more than 80% of Djibouti's gross domestic product (GDP) and employ about 60% of the active population. The primary sector (agriculture and fisheries) contributes to about 3%, while the industrial and manufacturing sector accounts for 17% of GDP.

Incomes and poverty, wellbeing

Djibouti falls within the low Human Development category globally, it's Global Human Development Index (HDI) is 0.515, ranking 171. Life Expectancy is 62.9 while the mean year of schooling is 3.2. The Gender Inequality Index is unknown, with Labour Participation Rates among Females at 18.2 and Males 48.1. The Gender Development Index (GDI) is 0.844, a breakdown of scores shows females HDI to be 0.466 and males 0.552. Life Expectancy at birth is higher for females at 65.5 years while males is 60.3 years. The mean year of schooling is 2.9 for females and 5.1 for males. Finally, the Gross National Income per capita is lower for females at US$2,307 and 7,481 for males (UNDP, 2024).

Energy Balance and Transitions

Djibouti relies on imported energy electricity with about 70% supplied from hydropower by Ethiopia and the rest from diesel-powered generators (World Bank, 2017). Furthermore, Djibouti has an installed off-grid capacity of 0.3 MWe from solar PV. Djibouti has a dual energy system with coexisting traditional and modern energy and practice, although the traditional system composed of biomass has been shrinking over time. Total Primary Energy Supply in Djibouti is dominated by biomass, accounting for about 67%, with the remaining share from oil products in 2010. African Development Bank (2022).

Renewable energy potential and development

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Global push for clean energy development and technological innovations (including solar) offers the potential for Djibouti to overcome the critical barriers to energy transition. Non-technical barriers to geothermal development and energy transition in Djibouti are also linked to limited human, financial, legal and institutional capacities. Lack of adequate finance to undertake exploration drilling has helped slow the projects. African Development Bank (2022). Djibouti, Country Strategy Paper 2023-2027. The main technical barriers to geothermal development in Djibouti include extreme salinity of the reservoir fluids, cold seawater incursion into the reservoir, and extremely hot weather conditions (Moussa and Souleiman, 2015).

Global and local drivers of energy transitions

In the area of renewable energy, the Djibouti government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. The country has plans to improve access to clean and more affordable energy. Currently, the African Development Bank (AfDB) support focuses on electric power generation and transmission using renewable energies. This aims to strengthen economic competitiveness and reduce energy dependency on thermal generators fired by diesel and fuel oil. This support forms part of the expansion of investments made in the energy sector and will provide the population with affordable clean energy to reduce carbon emissions.

Population and household dynamics

Djibouti has a population of about 12 million, with annual population growth of about 1.4%. The social indicators remain weak. The estimated poverty rate was 34.3% in 2021. The distribution of income remains unequal with a Gini coefficient of 0.44 in 2017. The unemployment rate dipped from 54% of the labour force in 2010 to 47% in 2017, affecting young people most. Little progress has been made in terms of sustainable development African Development Bank (2022). Age dependency ratio (% of working-age population) = 54 percent; Age dependency ratio, young (% of working-age population) = 47 percent; Age dependency ratio, old (% of working-age population) = 7 percent.

Access to social Services

Access to clean fuels and technologies for cooking (% of population) 10, Access to electricity (% of population) 65, Access to electricity, rural (% of rural population) 37, Access to electricity, urban (% of urban population) 74, People using safely managed sanitation services (% of population) 40 (World Development Indicators. Accessed in January 2024).

Socio-Economic Vulnerabilities

Djibouti remains heavily dependent on imported fossil fuels and power. This exposes it to fluctuating oil prices, creating uncertainties affecting economic and social development. The social situation remains fragile, and the socio-economic impact of the successive crises

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could exacerbate it. Djibouti is affected by several dimensions of fragility. The country is dependent on foreign markets, making it more vulnerable to exogenous shocks. Weak civil society limits citizen participation in socio-economic life. The country is handicapped by the scarcity of water resources, food insecurity and weak institutional capacity. (African Development Bank, 2022). Unemployment in Djibouti is high at 60%, and poverty remains pervasive with nearly 42% of the population living below the absolute poverty line. Djibouti has among the lowest health, education, and other social indicators in the world.

Social and Economic Transformations

Djibouti is vulnerable to the impacts of climate change which weaken a large part of the population and productive capacity. Djibouti is affected by climate change in the form of recurrent droughts or floods. These scourges are also compounded by the steady influx of refugees and prospective illegal immigrants to the Arabian Gulf countries. (African Development Bank, 2022).

Environmental Factors

Djibouti Global Environmental Performance Index (EPI) rank is 60, with a score of 29.6 percent. Since 2015, Djibouti has undertaken to reduce greenhouse gas emissions by 40% by 2030 focusing on renewable energies. In terms of adaptation, drought resilience programmes have been implemented including (i) the facilitation of access to water by constructing water retention dams, wells and sea water desalination plants; (ii) development of greenhouse farming, (iii) improved access to basic infrastructure and (iv) support to improve household incomes. Despite the existence of a legal framework governing national environmental provisions and requirements and TFP readiness to support the country, Djibouti is still faced with many climate and environmental challenges. African Development Bank (2022).

2.1.2 Ethiopia

Economic growth

In 2021, Ethiopia had nominal GDP of USD 120.4 billion. GDP per capita of USD 1,156 compared to the global average of USD 10,589. Average real GDP growth of 8.4% over the last decade (Focus Economics, 2023, World Bank 2023).

Dominant Economic Activities

Ethiopia economic structure shows that in 2021, services accounted for 41% of overall GDP, manufacturing 5%, other industrial activity 16%, and agriculture 38%. Looking at

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GDP by expenditure, private consumption accounted for 72% of GDP in 2021, government consumption 9%, fixed investment 28%, and net exports -9%.

Incomes and poverty, wellbeing

Falling within low Human Development category globally, Ethiopia's Global Human Development Index (HDI) is ranked 176 at 0.492. Life Expectancy is 62.1 while the mean year of schooling is 7.7. The Gender Inequality Index is 0.494, with Labour Participation Rates among Females at 57.6 and Males 79.2. The Gender Development Index (GDI) is 0.922, a breakdown of scores shows females HDI to be 0.472 and males 0.512. Life Expectancy at birth is higher for females at 68.9 years while males are 62.6 years. The mean year of schooling is 1.7 for females and 3.2 for males. Finally, the Gross National Income per capita is lower for females at US$1,762 and 2,970 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.367, based on 2019 studies. The proportion of the population vulnerable to multidimensional poverty is 18.4 percent.

Energy Balance and Transitions

In 2019, renewable energy sources accounted for about 98% of installed capacity in Ethiopia. Among renewable energy sources, hydropower accounted for about 84%; wind, 7%; and bioenergy and municipal waste, 6% each. In addition to grid-connected electricity, Ethiopia derived about 29.3 MWe of electricity from off-grid solutions consisting of bioenergy (17 MWe), solar (11 MWe), hydropower (1.3 MWe) and wind (0.01 MWe).

Renewable energy potential and development

Ethiopia is one of the countries in the East African Rift with significant geothermal potential. Among the important prospects from south to north are Abaya, Corbetti, Abiata, Aluto, Butajira, Tulu Moye, Gedemsa, Boku, Boseti, Kone, Fantale, Dofan, Arabi, Meteka, Teo, Danab, Damali, Tendaho, Boina and Dallol.

Global and local drivers of energy transitions

In the area of renewable energy, the government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Ethiopia has a huge potential to build a low-carbon development pathway considering its vast forestry resources and immense potential for renewable energy generation through solar, hydro, wind, and geothermal energy. The main challenge to energy transition is social, as the concerned population (generally pastoralist) is rarely aware of the possibilities of geothermal resources to offer better solutions when captured below the surface. A lack of proper co-ordination of the relevant stakeholders at the local level is a challenge that AGAP is trying to resolve with the support of the Afar Regional State. The full development of geothermal resources requires the participation of all the stakeholders such Ministry of Finance and Economic Cooperation for public financing, the Ministry of Trade for providing

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tax incentives, and the Ministry of Environment, Forest and Climate Change for environmental policies and regulations.

Population and household dynamics

Ethiopia has a population of about 124 million, with annual population growth of about 2.5%. Female headed households (% of households with a female head) = 22 percent; Age dependency ratio (% of working-age population) = 75 percent; Age dependency ratio, young (% of working-age population) = 69 percent Age dependency ratio, old (% of working-age population) = 5.5.

Access to social Services

Access to clean fuels and technologies for cooking remain very low at 7.5%. Access to electricity stands at 43%, mainly in urban areas. Access to safe sanitation is only 40%. Agricultural land is only about 34% of the total land area. Access to clean fuels and technologies for cooking (% of population) 7.5, Access to electricity (% of population) 54.2, Access to electricity, rural (% of rural population) 43, Access to electricity, urban (% of urban population) 94, People using safely managed sanitation services (% of population) 7.2 *(*World Bank, World Development Indicators. Accessed in January 2024).

Socio-Economic Vulnerabilities

Many Ethiopians remain poor and highly vulnerable. A significant proportion of the population finds itself in conditions of mass poverty. In the same period that poverty rates came down, vulnerability to poverty, whether measured as the probability to fall into poverty in the future or movement in and out of poverty between periods, remained high. Vulnerability also differs geographically, but mostly related to climatic (drought or floods) and economic shocks.

Social and Economic Transformations

The process of economic growth is not driven by natural resources extraction, as in most of the African countries. In the last years the rise of Ethiopian GDP resulted from public capital investments (infrastructures like roads, dams and power plants, housing projects) and from productivity growth in key economic sectors, particularly agriculture but also manufacturing. Public investments and expenditure have also concentrated for more than 60 per cent on poverty-oriented sectors and basic services delivery, thus causing social and economic transformation.

Environmental Factors

Ethiopia Global Environmental Performance Index (EPI) rank is 143, with a score of 47.5 percent. Except for climate change, the major environmental issues affecting Ethiopia are soil erosion and land degradation, deforestation and forest degradation, water scarcity, biodiversity loss, and various types of pollution.

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2.1.3 Kenya

Economic growth

The average real gross domestic product (GDP) growth over the last decade was 4.5% In 2022, Kenya had nominal GDP of USD 114.3 billion, GDP per capita of USD 2,257 compared to the global average of USD 10,589. (Focus Economics, 2023, World Bank 2023). The GDP was projected to increase by 5.9% in 2023 and by 6% in 2024, premised on the assumption that commodity prices and global inflation would recede in the medium term.

Dominant Economic Activities

Kenya's economic structure in 2021 shows that services was dominant sector accounting for 61% of overall GDP, manufacturing 7%, other industrial activity 10%, and agriculture 22%. Looking at GDP by expenditure, private consumption accounted for 76% of GDP in 2021, government consumption 12%, fixed investment 20%, and net exports -8%.

Incomes and poverty, wellbeing

Kenya falls within Medium Human Development category globally, Globally, its Human Development Index (HDI) is 0.601, ranking 146 in 2024. Life Expectancy is 62.1 years while the mean year of schooling is 7.7. The Gender Inequality Index is 0.533, with Labour Participation Rates among Females at 62.9 and Males 72.6. The Gender Development Index (GDI) is 0.948, a breakdown of scores shows females HDI to be 0.585 and males 0.617. Life Expectancy at birth is higher for females at 64.7 years while males is 59.6 years. The mean year of schooling is 7.1 for females and 8.3 for males. Finally, the Gross National Income per capita is lower for females at US$3,977 and 5,654 for males. The Multidimensional Poverty Index is 0.171, based on 2014 studies. The proportion of population vulnerable to multidimensional poverty is 35.6 percent (UNDP, 2024).

Energy Balance and Transitions

The main sources of modern energy in Kenya are petroleum and electricity. Even so, biomass fuel is the most prevalent energy source within rural and informal urban settlements. Biomass, inclusive of wood fuel makes up approximately 68 percent of the total energy consumed in Kenya, followed by petroleum (22%) and electricity (9%) (LCPDP, 2018). The Kenya Energy Transition and Investment Plan (ETIP) details a vision for Kenya's energy transition, specifically aimed to contribute to the attainment of Net Zero by 2050 while growing the economy and taking advantage of the green growth opportunities (AfDB, 2023).

Renewable energy potential and development

Kenya is endowed with significant natural capital for renewable energy generation through hydropower, wind, solar, and geothermal, as well as forests and land that can support transitions to green growth. Kenya is among the leading countries in harnessing geothermal energy, which accounts for over 40% of the country's energy mix. Kenya's

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progress in geothermal applications ranks among the top ten globally. Ramping up investments in geothermal energy will enable the EA region to enhance energy security and reduce costly energy imports. The vast geothermal prospects of Kenya are located mainly along the Kenya Rift. The country's geothermal prospects correspond to the volcanic centres in Homa Hills, Barrier, Emuruangogolak, Menengai, Eburru, Korosi, Longonot, Suswa, Olkaria and Paka. There are other geothermal prospects that are not associated with central volcanoes in Lake Bogoria, Namarunu, Lake Magadi, Lake Baringo, Akiira and Elementaita. Kenya has enormous geothermal resources, which can contribute to increasing local energy and the low carbon pathway. Kenya lacks adequate green skills across sectors, with existing skills are mostly concentrated in the renewable energy sector.

Global and local drivers of energy transitions

Strong partnership and collaboration with development partners and private investors will drive Kenya's ability to gain from the benefits of energy transition (AfDB, 2023). Transitions to green growth and the implementation of climate change adaptation and mitigation requires green skills and capacities within key sectors. A readiness assessment by Global Green Growth Initiative (GGGI) and AfDB found that Kenya lacked sufficient skills and capacities to realise its green growth and climate action plans (AfDB, 2023). Success on the energy transition course will depend on the ability to harness about USD 600 billion of near-term investment opportunities by 2050. As such, the plan will be used to engage with national, regional and global partners for mutual benefits (AfDB, 2023).

Population and household dynamics

Kenya has a population of about 55 million, with annual population growth of about 2%. The average household size is approximately 4.5 persons. Poor households tend to be larger than the rich, implying that the livelihoods burden tends to fall on the vulnerable women in the rural areas.

Access to social Services

Access to clean fuels and technologies for cooking (% of population) 25, Access to electricity (% of population) 77.2, Access to electricity, rural (% of rural population) 68, Access to electricity, urban (% of urban population) 98, People using safely managed sanitation services (% of population) 31. This suggests the need to address the gaps to social services access.

Socio-Economic Vulnerabilities

The majority of the population in Kenya live on low and insecure incomes. About 80 per cent of the population could be considered as being 'poor' or 'insecure,' given that their daily expenditures amount to less than KES280 (US$2.80) per person. Female headed households (% of households with a female head) are about 31 percent; Age dependency

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ratio (% of working-age population) is 68.5 percent, Age dependency ratio, old (% of working-age population) is 5 percent, informing the dynamics of most households.

Social and Economic Transformations

The economic wellbeing of many Kenyan households changes constantly. Household consumption and incomes are highly dynamic, as people experience numerous shocks and crises that impact their living standards. Among households in rural Kenya, many experienced a relative fall in their standards of living at some point. Rapid urbanization and expansion of agricultural activities characterizes growth of population with a growing number of unemployed youths. As agricultural productivity has stagnated over the years, the services sector has tended to thrive.

Environmental Factors

Kenya Global Environmental Performance Index (EPI) rank is 148, with a score of 30.8 percent. Kenya faces the challenges of rapid environmental degradation of forests, wildlife landscapes, pollution coupled with climate change impacts such as droughts and flooding. Kenya has committed to addressing climate change challenges though significant environmental and social issues such as income inequalities remain that can be addressed by promoting green growth (AfDB, 2023). Key barriers preventing the mobilisation of private sector finance at scale to meet the country's green growth and climate action goals relate to the high levels of external debt emerging from the high cost of capital, the low levels of skills and capacities within institutions to develop and implement viable green growth and climate action projects for private sector investments (AfDB, 2023).

2.1.4 Rwanda

Economic growth

In 2022, Rwanda had nominal GDP of USD 13.3 billion. GDP per capita of USD 1,006 compared to the global average of USD 10,589. Average real GDP growth of 6.5% over the last decade (Focus Economics, 2023, World Bank 2023).

Dominant Economic Activities

Rwanda economic structure shows that in 2021, services accounted for 56% of overall GDP, manufacturing 9%, other industrial activity 11%, and agriculture 24%. Looking at GDP by expenditure, private consumption accounted for 72% of GDP, government consumption 17%, fixed investment 26%, and net exports -15%.

Incomes and poverty, wellbeing

Rwanda falls within low Human Development category globally; Rwanda's Global Human Development Index (HDI) is ranked 161 at 0.548. Life Expectancy is 67.1 while the mean year of schooling is 4.9. The Gender Inequality Index is 0.400, with Labour Participation

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Rates among Females at 54.8 and Males 66.2. The Gender Development Index (GDI) is 0.921, a breakdown of scores shows females HDI to be 0.524 and males 0.569. Life Expectancy at birth is higher for females at 69.2 years while males is 64.8 years. The mean year of schooling is 4.5 for females and 5.4 for males. Finally, the Gross National Income per capita is lower for females at US$1,662 and 3,000 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.231, based on 2020 studies. The proportion of the population vulnerable to multidimensional poverty is 22.7 percent.

Energy Balance and Transitions

Biomass is the most used and dominates both the demand and supply sides of the Rwandan economy. The current national energy balance of 86 per cent biomass, 11 per cent hydrocarbons and 3 per cent electricity of all energy consumed. Forests provide around 86% of the primary energy source, mainly as domestic cooking energy.

Renewable energy potential and development

Rwanda has considerable opportunities for energy development – from hydro sources, methane gas, solar and peat deposits. Untapped resources for power generation amount to about 1,200 MW. Most of these energy sources have not been fully exploited. The methane gas resources, which can contribute to increasing local energy and contributing to the low-carbon pathway, provided leakages are well accounted for. Work is needed on a more refined estimation of the value of renewable energy sources such as sunshine, methane gas in Lake Kivu, wind, and hydro, Rwanda lacks adequate green skills across sectors, with existing skills mostly concentrated in the renewable energy sector.

Global and local drivers of energy transitions

In the area of renewable energy, the government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Rwanda hopes to take advantage of several funds and financial instruments available within the region and globally. To apply creative financing schemes to help enhance the widespread adoption of renewable energy. The country has already implemented power purchase agreements for renewable energy and developed feed-in tariffs for providers of clean energy to encourage private sector participation in energy provision.

Population and household dynamics

Rwanda is among the smallest countries in Africa by landmass, and with 14 million people (2022), it is the most densely populated mainland African country. Population growth (annual %) = 2.3 percent; Female headed households (% of households with a female head) = 32 percent; Age dependency ratio (% of working-age population) = 71 percent; Age dependency ratio, young (% of working-age population) = 66 percent; Birth rate, crude (per 1,000 people) = 30 per cent; Women who were first married by age 18 (% of

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women ages 20-24) = 5 percent Age dependency ratio, old (% of working-age population) = 5.5 percent.

Access to social Services

Agricultural land is only about 80% of the total land area. Access to clean fuels and technologies for cooking (% of population) 5.5, Access to electricity (% of population) 48.2, Access to electricity, rural (% of rural population) 38, Access to electricity, urban (% of urban population) 98, People using safely managed sanitation services (% of population) unknown. (World Bank, Accessed in January 2024).

Socio-Economic Vulnerabilities

With the 1994 genocide against the Tutsis, the country lost an estimated one million people. Subsequently. more women were left as widows and children became orphans and were forced into work for their survival. In addition, millions of Rwandans who were in exile for several decades returned to the country following the liberation further aggravating population pressure challenges. The most significant challenge of the on-going social protection support programme is the ability of the social protection to support target beneficiaries to graduate from extreme poverty and sustain their new income level to points where they are able to resist poverty shocks and disasters.

Social and Economic Transformations

Rapid population growth, youthful age structure, and rapidly growing urban population characterize Rwanda's demographic profile The Rwanda government is pursuing social transformation via promotion of unifying Kinyarwanda as a language, values and culture; Promoting unity and reconciliation; Promoting home grown solutions; Fight corruption in all its forms; Fighting against genocide ideology in Rwanda and anywhere in the world; Eradication of extreme poverty; improving access to services. Economic transformation is promoted via job creation, exports, tourism, digital literacy and enhancing agriculture productivity.

Environmental Factors

Rwanda Global Environmental Performance Index (EPI) rank is 138, with a score of 32.8 percent. In May 2020, Rwanda became the first African country to submit its enhanced NDC to the United Nations Framework Convention on Climate Change (UNFCCC), committing to a reduction in greenhouse gas emissions of up to 38% in 2030.

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2.2 Macro-economic context in Other African Countries – Algeria, Egypt, Mozambique, Tanzania.

2.2.1 Algeria

Economic growth

In 2022, Algeria had nominal GDP of USD 195 billion, GDP per capita of USD 4,301 compared to the global average of USD 10,589. Average real GDP growth of 3% over the last decade (Focus Economics, 2023, World Bank 2023).

Dominant Economic Activities

Algeria economic structure in 2021 shows that In 2021, services accounted for 66% of overall GDP, manufacturing 19%, other industrial activity 3%, and agriculture 12%. Looking at GDP by expenditure, private consumption accounted for 43% of GDP in 2021, government consumption 18%, fixed investment 40%, and net exports -1%.

Incomes and poverty, wellbeing

Algeria falls within the High Human Development category globally; it's Global Human Development Index (HDI) is ranked 95 at 0.745. Life Expectancy is 77.1 while the mean year of schooling is 7.0. The Gender Inequality Index is 0.460, with Labour Participation Rates among Females at 17.6 and Males 65.5. The Gender Development Index (GDI) is 0.881, a breakdown of scores shows females HDI to be 0.682 and males 0.774. Life Expectancy at birth is higher for females at 78.5 years while males is 75.9 years. The mean year of schooling is 6.5 for females and 7.5 for males. Finally, the Gross National Income per capita is lower for females at US$3,842 and 17,859 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.005, based on 2019 studies. The proportion of the population vulnerable to multidimensional poverty is 5.0 percent.

Energy Balance and Transitions

Algeria's Total Primary Energy Supply (TPES) is largely based on Natural Gas and Crude Oil, which represent 50.61% and 48.94% respectively. More than 98% of electricity production comes from Natural Gas with an average efficiency of Power Thermal Plants, 40.1% and Transmission & Distribution losses represent 13.7%. Final consumption is mainly split between Natural Gas and represent 43.96%, Petroleum Products 43.55% and 12.33% for electricity.

Renewable energy potential and development

Algeria possesses significant renewable energy resources. Its most abundant renewable resources are solar, followed by wind, hydro, and biomass. Amid profound shifts in global

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energy and its first new government in nearly twenty years, Algeria announced the transition of its energy model away from hydrocarbons to renewable energy. This is significant given that Algeria generates almost all its power from hydrocarbon resources. Algeria's energy transition plan consists of three structural components - a new government ministry, a regulatory reform, and a new national renewable energy company. The country's energy mix model aims to reach at least 30 percent power generation from renewables by 2030 and generate 25 gigawatts of power from green and blue hydrogen by 2050.

Global and local drivers of energy transitions

Transition towards a renewables-based energy system involves large-scale deployment of renewable energy technology, the development of enabling infrastructure, the implementation of appropriate regulatory frameworks, and the creation of new markets and industries. Algeria government will work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Interventions in the energy sector will aim to improve the efficiency, organization, and governance of the energy sector, as well as to gradually support Algeria's energy transition.

Population and household dynamics

Algeria has a population of about 45 million, with annual population growth of about 1.6%. Age dependency ratio (% of working-age population) =59 percent; Age dependency ratio, young (% of working-age population) = 49 percent; Women who were first married by age 18 (% of women ages 20-24) = 3.8 per cent; Age dependency ratio, old (% of working-age population) = 10 percent.

Access to social Services

Access to clean fuels and technologies for cooking stands at 100%. Access to electricity stands at 99%, mainly in urban areas. Access to safe sanitation is only 60%. Agricultural land is only about 17% of the total land area., People using safely managed sanitation services (% of population) 62 (World Bank, World Development Indicators. Accessed in January 2024). People practicing open defecation, rural (% of rural population) = 0 percent; UHC service coverage index = 74.

Socio-Economic Vulnerabilities

Prevalence of stunting, height for age (% of children under 5) = 10 percent; Current health expenditure (% of GDP) = 6.3 percent; Prevalence of moderate or severe food insecurity in the population (%) = 20 percent.

Social and Economic Transformations

Algeria, in addition to these two “circumstantial” crises, is suffering from a deep structural crisis, the crisis of economic and social development, and the crisis of the economic pattern adopted for more than 40 years, on which many studies

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agree. The Algerian economy has generated an unregulated economy that today competes with the organized eco-nomy in almost every sector of activity and poses a threat to the economy with its size, whether the monetary mass it deals with or the volume of operation, which all statistics collect as fragile and inappropriate. There is a scarcity of non-hydrocarbon exports and a clear dependence on imports.

Environmental Factors

Algeria Global Environmental Performance Index (EPI) rank is 155, with a score of 29.6 percent. Algerian forests face several challenges including forest fires, overgrazing, agricultural expansion, and climate change that contribute to deforestation and degradation over time.

2.2.2 Egypt

Economic growth

In 2023, Egypt had nominal GDP of USD 394billion, The GDP per capita is about 4295 (US$), the annual GDP growth of about 6 % over the last five years.(Focus Economics, 2023, World Bank 2023).

Dominant Economic Activities

Egypt economic structure in 2021 shows that services accounted for 57% of overall GDP, manufacturing 15%, other industrial activity 16%, and agriculture 12%. Looking at GDP by expenditure, private consumption accounted for 89% of GDP in 2021, government consumption 8%, fixed investment 12%, and net exports -9%.

Incomes and poverty, wellbeing

Falling within the High Human Development category globally, Egypt's Global Human Development Index (HDI) is ranked 105 at 0.728. Life Expectancy is 70.2 while the mean year of schooling is 9.8. The Gender Inequality Index is 0.389, with Labour Participation Rates among Females at 15.3 and Males 69.1. The Gender Development Index (GDI) is 0.884, a breakdown of scores shows females HDI to be 0.664 and males 0.752. Life Expectancy at birth is higher for females at 72.6 years while males is 67.9 years. The mean year of schooling is 10.2 for females and 9.6 for males. Finally, the Gross National Income per capita is lower for females at US$3,739 and 20,790 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.020, based on 2014 studies. The proportion of the population vulnerable to multidimensional poverty is 6.1 percent.

Energy Balance and Transitions

Natural gas is the largest source of energy, accounting for 57.6% of total energy supply (TES) in 2010 and 54.0% in 2020. Oil is the second largest source of energy, with around 45.1% in 2010 and 33.7% in 2020. Egypt is therefore largely dependent on oil and gas,

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with oil's declines accounted for in part by the increased use of gas for power generation (Climate Action tracker, 2022, IRENA, 2023). Egypt is also planning to announce a package of incentives for companies willing to invest in green hydrogen production projects in the country. As part of its National Climate Strategy 2050.

Renewable energy potential and development

The country has been at the forefront of renewable energy deployment in Africa, particularly through its large hydro resources, tied to the river Nile. To meet its growing energy needs and contribute to job creation, Egypt has sought to develop several other forms of modern renewable energy, including through solar and wind projects, since the start of the century. These include the Zafarana wind farm and ambitious plans such as the Green Corridor Initiative for Egypt's renewable energy, a memorandum of understanding (MoU) signed in 2022 to build a 10 GW onshore wind project. As of 2020, the country had the continent's second largest installed capacity of solar energy, after South Africa. Egypt also had Africa's third largest wind power generation capacity, accounting for more than a fifth of the continent's total (IRENA, n.d.).

Global and local drivers of energy transitions

Egypt possesses substantial energy resources, including both conventional fossil fuels and renewable energy, with the former crucial to the country's socio-economic development. Historically a net exporter of oil and gas, Egypt became a net importer in the 2010s due to rising energy use and depleting energy resources. As a result, the energy sector has faced new challenges and barriers, such as intermittent power outages. Egypt is at risk of becoming a net gas importer since its natural resources will likely not be able to keep up with domestic energy demand. Indeed, moving Egypt's energy strategy away from fossil fuels towards renewables is expected to have a substantial positive impact. Egypt aims to green its economy and transition it to a low carbon future, while improving the quality of life for Egyptian citizens.

Population and household dynamics

Egypt has a population of about 112 million, with annual population growth of about 1.6%. Egyptians inhabit approximately 13.7% (as of 2021) of Egypt's vast land area (which exceeds one million square kilometers). This represents an increase of about 2.5% from around 8% in 2016. The state has embraced a policy of expanding into the desert and establishing new urban foundations outside the populated region, disrupting traditional patterns of urban growth and the sprawl of informal settlements. Egypt witnessed a notable decline in birth rates over the previous years, from 30.3 live births per 1000 population in 2013 to 21.1 in 2022. The results of the 2021 Egyptian Family Health Survey reflected a decrease in the total fertility rate (the average number of children per woman of reproductive age between 15 to 49 years old), as the rate reached 2.85 children per woman compared to 3.5 in 2014.

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Access to social Services

Access to electricity stands at 100%, mainly in urban areas. Access to safe sanitation is only 67%. Agricultural land is only about 4% of the total land area. Access to clean fuels and technologies for cooking (% of population) 99, Access to electricity (% of population) 100, Access to electricity, rural (% of rural population) 100, Access to electricity, urban (% of urban population) 100, People using safely managed sanitation services (% of population) 67 (World Bank, World Development Indicators. Accessed in January 2024).

Socio-Economic Vulnerabilities

Poverty headcount ratio at national poverty lines (% of population) = 30 percent; Multidimensional poverty headcount ratio (World Bank) (% of population) = 2.4 percent; Age dependency ratio (% of working-age population) = 60 percent; Age dependency ratio, young (% of working-age population) = 53 percent; Age dependency ratio, old (% of working-age population) = 7.8 percent. Although Egypt strengthened social protection, expanded existing programs and introduced key poverty mitigation measures during the early stages of the COVID-19 pandemic, increasing inflationary pressures call for further intensification of efforts to reduce poverty and improve welfare.

Social and Economic Transformations

Egypt's population growth rate and poverty rate, with 32.5% of the population living under the national poverty line in 2018 (World Bank, 2023), places significant fiscal and infrastructure burdens on the country's social services. Fiscal space remains limited due to the large interest burden and low revenue mobilization. Government spending on energy subsidies remains high, leading to continued limited fiscal space for social spending. According to the World Bank, allocations to the health and education sectors remain limited, representing around 1.5% and 2.4% of GDP in the 2021-2022 financial year.

Environmental Factors

Egypt Global Environmental Performance Index (EPI) rank is 127, with a score of 35.5 percent. Air pollution and waste management are also major environmental challenges in Egypt. Air pollution has a significant negative impact on public health, while waste production is increasing due to population growth, changes in consumption patterns, changes in waste characteristics and inadequate technology for waste disposal. These environmental issues will have a significant impact on Egypt's economy, particularly on its agricultural sector. Egypt contributes to approximately 0.6 percent of global greenhouse gas emissions. The country has taken bold steps to accelerate national action on climate change and implemented measures to reduce greenhouse gases emissions such as increasing investment in renewables which are set to make 42 percent of the energy mix by 2035.

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2.2.3 Mozambique

Economic growth

In 2019, Mozambique had nominal GDP of USD 18.4billion, GDP per capita of USD 560 compared to the global average of USD 10,589. Average real GDP growth of 4.3% over the last decade (Focus Economics, 2023, World Bank 2023). The real GDP grew from 2.3% in 2021 to 3.8% in 2022, consolidating an ongoing recovery process from recent shocks such as the pandemic, conflict in the North, and global geopolitical tensions. The agriculture, health and social action, transport and logistics sectors were the fastest growing from 2018 to 2021, with an average growth of 3.4%, 4.7% and 3.5%, pushed by an increase in the use of inputs and public expenditures. African Development Bank (AfDB), 2023b).

Dominant Economic Activities

Mozambique economic structure in 2020 shows that services accounted for 53% of overall GDP, manufacturing 8%, other industrial activity 13%, and agriculture 26%. Looking at GDP by expenditure, private consumption accounted for 65% of GDP in 2020, government consumption 21%, fixed investment 58%, and net exports -44%. (World Bank, 2023).

Incomes and poverty, wellbeing

The country is one of the 10 poorest in the world, with a Human Development Index (HDI) of 0.461, which ranks 176 among 191 countries. Life Expectancy is 59.1 while the mean year of schooling is 3.9. The Gender Inequality Index is 0.477, with Labour Participation Rates among Females at 73.9 and Males 80.1. The Gender Development Index (GDI) is 0.929, a breakdown of scores shows females HDI to be 0.443 and males 0.477. Life Expectancy at birth is higher for females at 62.7 years while males is 56.3 years. The mean year of schooling is 3.2 for females and 4.4 for males. Finally, the Gross National Income per capita is lower for females at US$1,060 and 1,385 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.372, based on 2020 studies. The proportion of the population vulnerable to multidimensional poverty is 13.9 percent.

Energy Balance and Transitions

Mozambique has the largest power generation potential of all Southern African countries. Power Africa estimates that it could generate 187 gigawatts of power from coal, hydro, gas, wind, and solar. Mozambique is a net exporter of energy to countries in the Southern African Power Pool (SAPP) – South Africa being the largest importer.

Renewable energy potential and development

The country has one of the world’s largest natural-gas reserves, vast amounts of arable land and miombo forests, considerable hydropower resources, one of the region’s longest coastlines and is strategically located to serve as a gateway to global markets.; Mozambique’s ambitions for economic and social development depend in large measure on its ability to develop its large natural gas resources (World Bank Group, 2023).

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Global and local drivers of energy transition

In the area of renewable energy, the government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. The recent surge in fossil fuel prices has intensified interest in delivering approved projects as quickly as possible and developing a new wave of projects in these countries. Financing new projects is still a challenge, since most are either debt-financed by banks or export credit agencies domiciled in countries with net zero emissions targets or equity-financed by IOCs with similar climate goals. There is an opportunity to channel finance into developing a local gas market through domestic market obligations on LNG export projects, which could help make revenues less vulnerable to volatile global market conditions.

Population and household dynamics

Mozambique has a population of about 33 million, with annual population growth of about 2.7%. Age dependency ratio (% of working-age population) = 86 percent; Age dependency ratio, young (% of working-age population) = 81 percent; Age dependency ratio, old (% of working-age population) = 4.8 percent.

Access to social Services

Access to clean fuels and technologies for cooking remain very low at 5%. Access to electricity stands at 41%, mainly in urban areas. Agricultural land is only about 53% of the total land area. Challenges in this arena include (i) regional disparities in service delivery and a rural-urban divide that undermines cohesion and (ii) rapid and unmanaged urbanization that has strained the capacities of poorly serviced peri-urban settlements, contributing to frustrations, particularly among the youth. These two challenges have acted as a vector of social exclusion and undermined national cohesion. Water scarcity is expected to be exacerbated by climate change. All scenarios predict an increase in water demand in most of Mozambique. Coupled with population growth, this trend will put more pressure on water supply for domestic, agricultural, and industrial water demand. (World Bank Group 2023).

Socio-Economic Vulnerabilities

Poverty rate estimates pointed to an increase to 68.2% in 2019/2020, poverty in Mozambique is overwhelmingly concentrated in rural areas, with a large share of the population still engaged in informal rural activities, predominantly smallholder agriculture, especially in the northern provinces. (World Bank Group 2023). Climate change hinders much needed human capital development. It is estimated that 70 percent of schools in Mozambique are in high-risk areas for one or more hazards. World Bank Group 2023. Infrastructure is under threat of damage from natural hazards, leading to disruption of service provision and deepening the infrastructure gap and reducing the benefits of urbanization. The impact of climate change is particularly significant on Mozambican

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women, increasing the incidence of poverty and widening gender inequalities**.** The share of women in non-agricultural employment has slightly increased but remains considerably low (World Bank Group 2023).

Social and Economic Transformations

In terms of Leave No One Behind, the central tenet of the 2030 Agenda, large cohorts of the population continue to experience poverty, inequality, discrimination and exclusion. An analysis of Mozambique's progress on the Sustainable Development Goals (SDGs) shows high levels of internal disparities based on geography, gender, age and other characteristics, an indication that vulnerable groups are at serious risk of being left behind.

Environmental Factors

Mozambique Global Environmental Performance Index (EPI) rank is 144, with a score of 31.7 percent. Despite being one of the lowest greenhouse gases (GHG) emissions contributors, Mozambique is one of the 10 countries most affected by climate change, according to the Global Climate Risk Index (GCRI). Its location, extensive coastline, and large expanse of low-lying hinterland contribute to its vulnerability. The impacts of climate change are expected to increase over the next decades. Projected rising temperatures, more irregular rainfalls and related sea level rise will increase the frequency and intensity of droughts, floods, and cyclones. (World Bank Group 2023).

2.2.4 Tanzania

Economic growth

In 2022, Tanzania had nominal GDP of USD 73.2 billion, GDP per capita of USD 1,191 compared to the global average of USD 10,589. Average real GDP growth of 5.9% over the last decade (Focus Economics, 2023, World Bank 2023).

Dominant Economic Activities

Tanzania economic structure in 2021 shows that services accounted for 45% of overall GDP, manufacturing 8%, other industrial activity 21%, and agriculture 26%. Looking at GDP by expenditure, private consumption accounted for 57% of GDP in 2021, government consumption 9%, fixed investment 43%, and net exports -9%. The services sector remains the main driving force behind Tanzania's overall economic growth, supported by buoyant economic activities in financial and insurance, transport and storage, and trade and repair subsectors. The concentration of growth in sectors with limited employment opportunities for poor households has led to only a moderate reduction in the national poverty rate.

Incomes and poverty, wellbeing

Falling within the low Human Development category globally, Tanzania's Global Human Development Index (HDI) is ranked 167 at 0.532. Life Expectancy is 66.8 while the mean

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year of schooling is 5.6. The Gender Inequality Index is 0.513, with Labour Participation Rates among Females at 51.6 and Males 65. The Gender Development Index (GDI) is 0.940, a breakdown of scores shows females HDI to be 0.516 and males 0.549. Life Expectancy at birth is higher for females at 68.9 years while males is 64.7 years. The mean year of schooling is 5.1 for females and 6.3 for males. Finally, the Gross National Income per capita is lower for females at US$2,195 and 2,970 for males (UNDP, 2024). The Multidimensional Poverty Index is 0.284, based on 2016 studies. The proportion of the population vulnerable to multidimensional poverty is 23.4 percent.

Energy Balance and Transitions

In 2021, Tanzania's power generation comes mostly from natural gas (48%), followed by hydro (31%), petrol (18%), solar (1%), and biofuels (1%). However, it is important to note that access to electricity remains low in Tanzania, with only about 45% of the population having access to grid electricity as of 2020. In the past 20 years, the production and distribution of energy in Tanzania has faced enormous challenges including capacity shortages, lack of private investments, and low level of reliability of the power supply.

Renewable energy potential and development

Tanzania is endowed with diverse renewable energy resources, ranging from biomass and hydropower to geothermal, solar and wind. Much of this potential has not been fully exploited. If properly utilized, such renewable resources would contribute significantly to Tanzania's energy supply, thus moving the country closer to achieving middle-income status, as envisioned in the Tanzania National Development Vision 2025. Tanzania aims to develop massive resources with large, export-driven LNG projects. The recent surge in fossil fuel prices has intensified interest in delivering approved projects as quickly as possible and developing a new wave of projects. Financing new projects is still a challenge, since most are either debt-financed by banks or export credit agencies domiciled in countries with net zero emissions targets or equity-financed by IOCs with similar climate goals.

Global and local drivers of energy transitions

In the area of renewable energy, the government needs to work with international and private development partners and capital markets to exploit the potential for such energy at a much faster rate.

Population and household dynamics

Tanzania has a population of about 66 million, with annual population growth of about 3%. Age dependency ratio (% of working-age population) = 87 percent; Age dependency ratio, young (% of working-age population) = 81 percent; Age dependency ratio, old (% of working-age population) = 5.8 percent

Access to social Services

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Access to clean fuels and technologies for cooking remain very low at 9%. Access to electricity stands at 65%, mainly in urban areas. Access to safe sanitation is only 7%. Agricultural land is about 45% of the total land area. Access to clean fuels and technologies for cooking (% of population) 7, Access to electricity, rural (% of rural population) 23, Access to electricity, urban (% of urban population) 77, People using safely managed sanitation services (% of population) 25 *(*World Bank, World Development Indicators. Accessed in January 2024).

Socio-Economic Vulnerabilities

Tanzania boasts vast agricultural production zones that generate tons of food products annually, food price fluctuations, poor market structures, weak market information, poor infrastructure and road networks are among the impediments to attaining resilient and sustainable food security in the country. The farmers suffer from poor marketing and pricing policies that lead to no income or low profits. The situation is compounded by weak market infrastructure that lacks market information about prices, input costs as well as fragile transport and storage facilities.

Social and Economic Transformations

On 1 July 2020, the World Bank announced the upgrading of the Tanzanian economy from low to lower-middle income status. The country has seen a reduction in poverty, increases in access to education, antiretroviral (ART) treatment for AIDS, better coverage of social protection, and strengthened governance systems. However, further analysis highlights disparities that remain, including feminized poverty; low levels of educational achievement – especially at secondary school level; high rates of maternal mortality; high ver-tical transmission rate of HIV; high numbers of new HIV cases among adolescents and youth; and low productivity in agriculture/farm sector. All these factors negatively impact economic growth.

Environmental Factors

Tanzania Global Environmental Performance Index (EPI) rank is 134, with a score of 34.2 percent. Tanzania is vulnerable to increasing climate variability over most parts of the country. Rising temperatures, longer dry spells, more intense heavy rainfall and sea level rise hinder poverty alleviation and rural development efforts. Production losses are expected to rise for most crops with more frequent droughts. The nationally determined contributions recommend several actions, including scaling up agricultural land and water management; increasing yields through climate smart agriculture (CSA), protecting smallholder producers against climate-related shocks, strengthening capacity of agricultural research institutions, and strengthening knowledge, extension services and agricultural infrastructure to target climate actions.

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2.3 Summary of Socio-Economic Context of Geothermal Resources Development

This chapter analysed socio-economic context for renewable energy power in Africa. The economies selected were in two geographical groups: 1) *East Africa*: Djibouti, Ethiopia, Kenya, and Rwanda; 2) *Other African regions*: Algeria, Egypt, Mozambique, and Tanzania. The issues analysed covered Economic growth, Dominant Economic Activities, Incomes and poverty wellbeing, Energy Balance and Transitions. Renewable energy potential and development, Global and local drivers of energy transitions, Population and household dynamics, Access to social Services, Socio-Economic Vulnerabilities, Social and Economic Transformations, and Environmental Factors.

Economic growth: In Kenya, the average real GDP growth over the last decade was 4.5% In 2022, Kenya had nominal GDP of USD 114.3 billion, GDP per capita of USD 2,257 compared to the global average of USD 10,589. Djibouti posted average economic growth of 5.3% over the 2016–2021 period. With GNI per capita of USD 3,310. In 2022, Rwanda had nominal GDP of USD 13.3 billion. GDP per capita of USD 1,006 compared to the global average of USD 10,589. Average real GDP growth of 6.5% over the last decade. In 2021, Ethiopia had nominal GDP of USD 120.4 billion. GDP per capita of USD 1,156 compared to the global average of USD 10,589. Average real GDP growth of 8.4% and has been highest over the last decade. In 2022, Tanzania had nominal GDP of USD 73.2 billion, GDP per capita of USD 1,191 compared to the global average of USD 10,589. Average real GDP growth of 5.9% over the last decade. In 2019, Mozambique had nominal GDP of USD 18.4billion, GDP per capita of USD 560 compared to the global average of USD10,589. Average real GDP growth of 4.3% over the last decade. In 2022, Algeria had nominal GDP of USD 195 billion, GDP per capita of USD 4,301 compared to the global average of USD 10,589. Average real GDP growth of 3% over the last decade.

Dominant Economic Activities: The dominant sectors for economic growth are services, agriculture and manufacturing. Kenya's economic structure in 2021 shows that services was dominant sector accounting for 61% of overall GDP, manufacturing 7%, other industrial activity 10%, and agriculture 22%. Djibouti The structure of the economy is dominated by the service sector - transport, communications, commerce and tourism. These contribute to more than 80% of Djibouti's gross domestic product (GDP) and employ about 60% of the active population. The primary sector (agriculture and fisheries)

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contributes to about 3%, while the industrial and manufacturing sector accounts for 17% of GDP. Rwanda economic structure shows that in 2021, services accounted for 56% of overall GDP, manufacturing 9%, other industrial activity 11%, and agriculture 24%. Ethiopia economic structure shows that in 2021, services accounted for 41% of overall GDP, manufacturing 5%, other industrial activity 16%, and agriculture 38%. Egypt economic structure in 2021 shows that services accounted for 57% of overall GDP, manufacturing 15%, other industrial activity 16%, and agriculture 12%. Tanzania economic structure in 2021 shows that services accounted for 45% of overall GDP, manufacturing 8%, other industrial activity 21%, and agriculture 26%. Mozambique economic structure in 2020 shows that services accounted for 53% of overall GDP, manufacturing 8%, other industrial activity 13%, and agriculture 26%. Algeria economic structure in 2021 shows that In 2021, services accounted for 66% of overall GDP, manufacturing 19%, other industrial activity 3%, and agriculture 12%.

Incomes and poverty wellbeing: The countries are in different levels of development (based on human development index 2024), both Egypt and Algeria are in the high human development. Kenya lies in the medium category of development while the rest of the economics (Ethiopia, Mozambique, Djibouti, Tanzania and Rwanda) are in the lowest category of human development. Kenya falls within Medium Human Development category globally, Globally, its Human Development Index (HDI) is 0.601, ranking 146 in 2024. Life Expectancy is 62.1 years while the mean year of schooling is 7.7. The Gender Inequality Index is 0.533, with Labour Participation Rates among Females at 62.9 and Males 72.6. The Gender Development Index (GDI) is 0.948, a breakdown of scores shows females HDI to be 0.585 and males 0.617. Life Expectancy at birth is higher for females at 64.7 years while males is 59.6 years. Djibouti falls within the low Human Development category globally, it's Global Human Development Index (HDI) is 0.515, ranking 171. Life Expectancy is 62.9 while the mean years of schooling is 3.2. The Gender Inequality Index is unknown, with Labour Participation Rates among Females at 18.2 and Males 48.1. The Gender Development Index (GDI) is 0.844, a breakdown of scores shows females HDI to be 0.466 and males 0.552. Life Expectancy at birth is higher for females at 65.5 years while males is 60.3 years. Rwanda falls within low Human Development category globally; Rwanda's Global Human Development Index (HDI) is ranked 161 at 0.548. Life Expectancy is 67.1 while the mean year of schooling is 4.9. The Gender Inequality Index is 0.400, with Labour Participation Rates among Females at 54.8 and Males 66.2. The Gender Development Index (GDI) is 0.921, a breakdown of scores shows females HDI to be 0.524 and males 0.569. Life Expectancy at birth is higher for females at 69.2 years while males is 64.8 years. Ethiopia Falling within low Human Development category globally, Ethiopia's Global Human Development Index (HDI) is ranked 176 at 0.492. Life Expectancy is 62.1

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while the mean year of schooling is 7.7. The Gender Inequality Index is 0.494, with Labour Participation Rates among Females at 57.6 and Males 79.2. The Gender Development Index (GDI) is 0.922, a breakdown of scores shows females HDI to be 0.472 and males 0.512. Life Expectancy at birth is higher for females at 68.9 years while males are 62.6 years. Egypt Falling within the High Human Development category globally, Egypt's Global Human Development Index (HDI) is ranked 105 at 0.728. Life Expectancy is 70.2 while the mean year of schooling is 9.8. The Gender Inequality Index is 0.389, with Labour Participation Rates among Females at 15.3 and Males 69.1. The Gender Development Index (GDI) is 0.884, a breakdown of scores shows females HDI to be 0.664 and males 0.752. Life Expectancy at birth is higher for females at 72.6 years while males is 67.9 years. Tanzania Falling within the low Human Development category globally, Tanzania's Global Human Development Index (HDI) is ranked 167 at 0.532. Life Expectancy is 66.8 while the mean year of schooling is 5.6. The Gender Inequality Index is 0.513, with Labour Participation Rates among Females at 51.6 and Males 65. The Gender Development Index (GDI) is 0.940, a breakdown of scores shows females HDI to be 0.516 and males 0.549. Life Expectancy at birth is higher for females at 68.9 years while males is 64.7 years. the population vulnerable to multidimensional poverty is 23.4 percent. Algeria falls within the High Human Development category globally; it's Global Human Development Index (HDI) is ranked 95 at 0.745. Life Expectancy is 77.1 while the mean year of schooling is 7.0. The Gender Inequality Index is 0.460, with Labour Participation Rates among Females at 17.6 and Males 65.5. The Gender Development Index (GDI) is 0.881, a breakdown of scores shows females HDI to be 0.682 and males 0.774. Life Expectancy at birth is higher for females at 78.5 years while males is 75.9 years. The mean year of schooling is 6.5 for females and 7.5 for males. Mozambique The country is one of the 10 poorest in the world, with a Human Development Index (HDI) of 0.461, which ranks 176 among 191 countries. Life Expectancy is 59.1 while the mean year of schooling is 3.9. The Gender Inequality Index is 0.477, with Labour Participation Rates among Females at 73.9 and Males 80.1. The Gender Development Index (GDI) is 0.929, a breakdown of scores shows females HDI to be 0.443 and males 0.477. Life Expectancy at birth is higher for females at 62.7 years while males is 56.3 years.

Energy Balance and Transitions: The main sources of modern energy in Kenya are petroleum and electricity. Even so, biomass fuel is the most prevalent energy source within rural and informal urban settlements. Djibouti relies on imported energy electricity with about 70% supplied from hydropower by Ethiopia and the rest from diesel-powered generators (World Bank, 2017). Rwanda Biomass is the most used and dominates both the demand and supply sides of the Rwandan economy. In 2019, renewable energy sources accounted for about 98% of installed capacity in Ethiopia. Among renewable energy

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sources, hydropower accounted for about 84%; wind, 7%; and bioenergy and municipal waste, 6% each. Egypt Natural gas is the largest source of energy, accounting for 57.6% of total energy supply (TES) in 2010 and 54.0% in 2020. Oil is the second largest source of energy, with around 45.1% in 2010 and 33.7% in 2020. Tanzania In 2021, Tanzania's power generation comes mostly from natural gas (48%), followed by hydro (31%), petrol (18%), solar (1%), and biofuels (1%). Mozambique has the largest power generation potential of all Southern African countries. Power Africa estimates that it could generate 187 gigawatts of power from coal, hydro, gas, wind, and solar. Mozambique is a net exporter of energy to countries in the Southern African Power Pool (SAPP) – South Africa being the largest importer. Algeria's Total Primary Energy Supply (TPES) is largely based on Natural Gas and Crude Oil, which represent 50.61% and 48.94% respectively.

Renewable energy potential and development: Potential for renewable energy development diverges. Kenya is endowed with significant natural capital for renewable energy generation through hydropower, wind, solar, and geothermal, as well as forests and land that can support transitions to green growth. Kenya is among the leading countries in harnessing geothermal energy, which accounts for over 40% of the country's energy mix. Non-technical barriers to geothermal development and energy transition in Djibouti are also linked to limited human, financial, legal and institutional capacities. Rwanda has considerable opportunities for energy development – from hydro sources, methane gas, solar and peat deposits. Untapped resources for power generation amount to about 1,200 MW. Most of these energy sources have not been fully exploited. Ethiopia is one of the countries in the East African Rift with significant geothermal potential. To meet its growing energy needs and contribute to job creation, Egypt has sought to develop several other forms of modern renewable energy, including through solar and wind projects, since the start of the century. Tanzania is endowed with diverse renewable energy resources, ranging from biomass and hydropower to geothermal, solar and wind. Much of this potential has not been fully exploited. If properly utilized, such renewable resources would contribute significantly to Tanzania's energy supply, thus moving the country closer to achieving middle-income status, as envisioned in the Tanzania National Development Vision 2025. Tanzania aims to develop massive resources with large, export-driven LNG projects. Mozambique The country has one of the world's largest natural-gas reserves, vast amounts of arable land and miombo forests, considerable hydropower resources, one of the region's longest coastlines and is strategically located to serve as a gateway to global markets. Algeria possesses significant renewable energy resources. Its most abundant renewable resources are solar, followed by wind, hydro, and biomass.

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Global and local drivers of energy transitions: Strong partnership and collaboration with development partners and private investors will drive Kenya's ability to gain from the benefits of energy transition (AfDB, 2023). Djibouti In the area of renewable energy, the Djibouti government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Rwanda hopes to take advantage of several funds and financial instruments available within the region and globally. Ethiopia In the area of renewable energy, the government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Historically a net exporter of oil and gas, Egypt became a net importer in the 2010s due to rising energy use and depleting energy resources. As a result, the energy sector has faced new challenges and barriers, such as intermittent power outages. Egypt is at risk of becoming a net gas importer since its natural resources will likely not be able to keep up with domestic energy demand. Tanzania In the area of renewable energy, the government needs to work with international and private development partners and capital markets to exploit the potential for such energy at a much faster rate. Mozambique In the area of renewable energy, the government needs to work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Algeria Transition towards a renewables-based energy system involves large-scale deployment of renewable energy technology, Algeria government will work with development partners and capital markets to exploit the potential for such energy at a much faster rate. Interventions in the energy sector will aim to improve the efficiency, organization, and governance of the energy sector, as well as to gradually support Algeria's energy transition.

Population and household dynamics: Kenya has a population of about 55 million, with annual population growth of about 2%. Djibouti has a population of about 12 million, with annual population growth of about 1.4%. The social indicators remain weak. Rwanda is among the smallest countries in Africa by landmass, and with 14 million people (2022), it is the most densely populated mainland African country. Population growth (annual %) = 2.3 percent. Ethiopia has a population of about 124 million, with annual population growth of about 2.5%. Egypt has a population of about 112 million, with annual population growth of about 1.6%. Egyptians inhabit approximately 13.7% (as of 2021) of Egypt's vast land area (which exceeds one million square kilometers). Tanzania has a population of about 66 million, with annual population growth of about 3%. Mozambique has a population of about 33 million, with annual population growth of about 2.7%. Algeria has a population of about 45 million, with annual population growth of about 1.6%.

Access to social Services: Kenya; Access to clean fuels and technologies for cooking (% of population) 25, Access to electricity (% of population) 77.2, Djibouti Access to clean fuels

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and technologies for cooking (% of population) 10, Access to electricity (% of population) 65,. Access to clean fuels and technologies for cooking (% of population) 5.5, Access to electricity (% of population) 48.2, Access to electricity, rural (% of rural population) 38, Ethiopia Access to clean fuels and technologies for cooking remain very low at 7.5%. Access to electricity stands at 43%, mainly in urban areas. Egypt Access to electricity stands at 100%, mainly in urban areas. Access to safe sanitation is only 67%.. Access to clean fuels and technologies for cooking (% of population) 99, Access to electricity (% of population) 100, Tanzania Access to clean fuels and technologies for cooking remain very low at 9%. Access to electricity stands at 65%, mainly in urban areas. Access to safe sanitation is only 7%. Access to clean fuels and technologies for cooking (% of population) 7, People using safely managed sanitation services (% of population) 25 *(*World Bank, World Development Indicators. Accessed in January 2024). Mozambique Access to clean fuels and technologies for cooking remain very low at 5%. Access to electricity stands at 41%, mainly in urban areas. Algeria Access to clean fuels and technologies for cooking stands at 100%. Access to electricity stands at 99%, mainly in urban areas.

Socio-Economic Vulnerabilities: The majority of the population in Kenya live on low and insecure incomes. Female headed households (% of households with a female head) are about 31 percent. Djibouti is affected by several dimensions of fragility. The country is dependent on foreign markets, making it more vulnerable to exogenous shocks. Unemployment in Djibouti is high at 60%, and poverty remains pervasive with nearly 42% of the population living below the absolute poverty line. Djibouti has among the lowest health, education, and other social indicators in the world. Rwanda With the 1994 genocide against the Tutsis, the country lost an estimated one million people. Subsequently. more women were left as widows and children became orphans and were forced into work for their survival. Many Ethiopians remain poor and highly vulnerable. Vulnerability also differs geographically, but mostly related to climatic (drought or floods) and economic shocks. Although Egypt strengthened social protection, expanded existing programs and introduced key poverty mitigation measures during the early stages of the COVID-19 pandemic, increasing inflationary pressures call for further intensification of efforts to reduce poverty and improve welfare. In Tanzania the vast agricultural production zones that generate tons of food products annually, food price fluctuations, poor market structures, weak market information, poor infrastructure and road networks are among the impediments to attaining resilient and sustainable food security in the country. Poverty rate estimates pointed to an increase to 68.2% in 2019/2020, poverty in Mozambique is overwhelmingly concentrated in rural areas, with a large share of the population still engaged in informal rural activities, predominantly smallholder agriculture, especially in the northern provinces. (World Bank Group 2023. The impact of climate change is

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particularly significant on Mozambican women, increasing the incidence of poverty and widening gender inequalities**.** The share of women in non-agricultural employment has slightly increased but remains considerably low (World Bank Group 2023).

Social and Economic Transformations: The economic wellbeing of many Kenyan households changes constantly. Household consumption and incomes are highly dynamic, as people experience numerous shocks and crises that impact their living standards. In Ethiopia, the process of economic growth is not driven by natural resources extraction, public investments and expenditure have also concentrated for more than 60 per cent on poverty-oriented sectors and basic services delivery, thus causing social and economic transformation. Djibouti is vulnerable to the impacts of climate change which weaken a large part of the population and productive capacity. Djibouti is affected by climate change in the form of recurrent droughts or floods. Rapid population growth in Rwanda, youthful age structure, and rapidly growing urban population characterize Rwanda's demographic profile. Economic transformation is promoted via job creation, exports, tourism, digital literacy and enhancing agriculture productivity. Egypt's population growth rate and poverty rate, with 32.5% of the population living under the national poverty line in 2018 (World Bank, 2023), places significant fiscal and infrastructure burdens on the country's social services. Tanzania On 1 July 2020, the World Bank announced the upgrading of the Tanzanian economy from low to lower-middle income status. Further analysis highlights disparities that remain, including feminized poverty; low levels of educational achievement – especially at secondary school level; high rates of maternal mortality; high ver-tical transmission rate of HIV; high numbers of new HIV cases among adolescents and youth; and low productivity in agriculture/farm sector. An analysis of Mozambique's progress on the Sustainable Development Goals (SDGs) shows high levels of internal disparities based on geography, gender, age and other characteristics, an indication that vulnerable groups are at serious risk of being left behind. The Algerian economy has generated an unregulated economy that today competes with the organized eco-nomy in almost every sector of activity and poses a threat to the economy with its size, whether the monetary mass it deals with or the volume of operation, which all statistics collect as fragile and inappropriate.

Environmental Factors: Kenya Global Environmental Performance Index (EPI) rank is 148, with a score of 30.8 percent. Kenya faces the challenges of rapid environmental degradation of forests, wildlife landscapes, pollution coupled with climate change impacts such as droughts and flooding. Djibouti Global Environmental Performance Index (EPI) rank is 60, with a score of 29.6 percent. Since 2015, Djibouti has undertaken to reduce greenhouse gas emissions by 40% by 2030 focusing on renewable energies. Rwanda Global

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Environmental Performance Index (EPI) rank is 138, with a score of 32.8 percent. In May 2020, Rwanda became the first African country to submit its enhanced NDC to the United Nations Framework Convention on Climate Change (UNFCCC), committing to a reduction in greenhouse gas emissions of up to 38% in 2030. Ethiopia Global Environmental Performance Index (EPI) rank is 143, with a score of 47.5 percent. Except for climate change, the major environmental issues affecting Ethiopia are soil erosion and land degradation, deforestation and forest degradation, water scarcity, biodiversity loss, and various types of pollution. Egypt Global Environmental Performance Index (EPI) rank is 127, with a score of 35.5 percent. Air pollution and waste management are also major environmental challenges in Egypt. Tanzania Global Environmental Performance Index (EPI) rank is 134, with a score of 34.2 percent. Tanzania is vulnerable to increasing climate variability over most parts of the country. Mozambique Global Environmental Performance Index (EPI) rank is 144, with a score of 31.7 percent. Despite being one of the lowest greenhouse gases (GHG) emissions contributors, Mozambique is one of the 10 countries most affected by climate change, according to the Global Climate Risk Index (GCRI). Algeria Global Environmental Performance Index (EPI) rank is 155, with a score of 29.6 percent. Algerian forests face several challenges including forest fires, overgrazing, agricultural expansion, and climate change that contribute to deforestation and degradation over time.

3. Institutional and regulatory framework

This chapter outlines the key aspects of the policy, regulatory and legal framework for geothermal development in Kenya, Ethiopia, Djibouti, Rwanda, Tanzania, Mozambique, Egypt and Algeria. Most of these countries have adapted their frameworks to the specific requirements of geothermal development, although not to the same degree. Kenya has by far the most elaborate institutional and regulatory framework in place, congruent with its leading position in geothermal development in Africa. This includes dedicated policy, legal and regulatory guidelines/terms for the different stages of geothermal development and exploitation and a specific geothermal agency. Ethiopia does not yet have such an agency, but it does have elaborate geothermal regulations in place, including for geothermal direct use. Djibouti and Tanzania both have a geothermal agency, but hardly or no specific regulatory framework for geothermal development. Mozambique, Egypt and Algeria have neither a geothermal agency nor specific regulations.

All countries have formally embraced the liberalization of their energy sectors. Yet the extent to which liberalization policies are implemented differs significantly. Kenya’s and Rwanda’s liberalization trajectories can be considered most advanced, considering the

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unbundling of former public energy monopolies and a reasonably developed 'enabling environment' (e.g. incentives) for private sector participation. Ethiopia also made strides in this direction, with some of its geothermal projects being developed in a Public-Private Partnership construction. The other countries all have PPP legislation in place for (renewable) energy projects, often combined with incentives to attract private sector investment. Such frameworks, however, are not yet very well established 'on the ground' for renewable energy projects, and state agencies still exert monopoly power over all stages of energy projects. Generally, geothermal development is still dominated by (national) state agencies, also in countries with more liberalized energy sectors.

For each of the countries, the regulatory and institutional frameworks is discussed next. Each starts with a general introduction of these frameworks, followed by more specific elements, including the key agencies involved in geothermal development. Each ends by providing some key sources for further information.

3.1 Djibouti

3.1.1 General

Djibouti has no installed capacity for geothermal power generation yet, but geothermal is foreseen to play a key role in the country's ambition to become energy autonomous. The Djibouti Vision 2035 included the objective of 100% electricity generation from renewable energy by 2020, including geothermal. This goal was not met but is still in place for the longer term as outlined in its National Development Policy 2020 – 2024. Its estimated potential for electricity generation is about 1000 MWe. A specific public agency for geothermal development, residing under the president's office, was established in 2014 called the Djiboutian Office for Geothermal Energy Development (ODDEG). This follows the key role attributed to geothermal in diversifying its energy mix, but the regulatory and institutional framework is still very much in development. In principle, ODDEG is doing the preliminary stages of geothermal development, after which it seeks to involve private developers (IPPs) to build and operate power plants. Important policies include the National Energy Policy of 2015, which emphasizes the importance of electrification in rural areas.

3.1.2 Specific elements

Resource ownership & oversight

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All land and (naturally occurring) property assets found on/ underneath land in Djibouti belong to the state. State agencies control the designation of land, including for geothermal development.

Licenses for geothermal development, private sector participation

There is no specific legal or policy document outlining the licensing procedures for geothermal development. ODDEG is the public agency tasked with the exploration of geothermal resources, conducting studies and identifying potential operators. Private operators – IPPs – are especially encouraged to enter a PPP for power generation from geothermal resources. There exists specific legislation for PPPs and (the regulation of and sale of electricity by) IPPs. Operational IPPs are required to sell electric energy to EDD, a State-Owned Enterprise that dominates the electricity/ energy sector in Djibouti. Despite available legislation, there is still a lack of clarity regarding the procedures for independent operators to enter phases in geothermal development in the country. A separate regulatory body has formally been established but is not yet fully operational. The Ministry of Energy is therefore still regulating the sector in practice.

Social and Environmental Impact Assessment, social development

For all activities that may have negative effects on the environment, an Environmental Impact Assessment is required. This includes an Environmental and Social Management Plan. There is an Environmental Code that prescribes the content of an Environmental and social Impact assessment (Law no. 51/ AN/ 09/ 6 L).

Key agencies

The following agencies play a key role in geothermal development:

1. Ministry of Energy and Natural Resources: energy policymaking and oversight, energy regulation
2. Office Djiboutien de Développement de l'Energie Géothermique (ODDEG): geothermal exploration, investigation and early-stage development
3. Electricité de Djibouti (EDD): public utility responsible for the electricity sub-sector, falls under the ministry.
4. Multi-sectoral Regulatory Authority of Djibouti (ARMD): regulates the energy and ICT sectors but is not yet fully operational.

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Key sources / more information

1. Government of Djibouti (2012). Décrete No. 2012-257/PRE portant creation et fonctionnement des Organes de Supervision et de Gestion des Projets de Développement de la Géothermie
2. Government of Djibouti (2013). Act No. 32/AN/13/7th L Establishing the Djiboutian Office for Geothermal Energy Development
Government of Djibouti (2014). Vision 2035
Government of Djibouti (2020). Djibouti ICI. Plan National de développement 2020-2024.

3.2 Ethiopia

3.2.1 General

Geothermal development is still in its infancy in Ethiopia. Even though the electrical energy potential is estimated at about 10,000 MWe, the current net installed capacity is only 8,5 MWe. Two main legal documents specify the rules and regulations for geothermal development: the Geothermal Resources Development Proclamation No. 981/2016 and the Geothermal Resource Development Council of Ministers Regulations No. 453/2019. A geothermal development strategy and a geothermal master plan has been in the making for a while, but these are still awaiting finalization. Whereas the one functioning geothermal power plant is state-built and -owned, the private sector is expected and encouraged to play a major role in current and future geothermal developments. This follows the liberalization of the country's electricity sector in the late 1990s.

3.2.2 Specific elements

Resource ownership, oversight and declaration of an energy resource area

Land is a common property in Ethiopia and cannot therefore be sold. Ownership of land and natural resources such as geothermal is vested in the national state and republic's peoples. Any land shall nevertheless be available for geothermal operations. The licensing authority, i.e. the Petroleum and Energy Authority (PEA), may designate an area as 'geothermal resources area' through public notice. These areas are a maximum of 2000 km^2 for reconnaissance license, 200 km2 (about twice the area of Manhattan) for exploration and 50 km^2 for well-field development and use.

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Two types of geothermal resources are distinguished: Grade I (for electric power generation, direct heating and combined heat and power) and Grade II (for purposes such as direct heating, applications in agriculture and industry, bathing, but not for electric power generation – the temperature should not exceed 120 degrees Celsius, and volume should not exceed 2 million m^3).

Licenses for geothermal development

The PEA grants three types of operation licenses for Grade I geothermal resources:

Reconnaissance License: valid for max. 24 months, non-renewable.

- *Exploration License*: valid for max. 5 years, may be renewed twice, each time for max. 1 year. Applicant needs to demonstrate technical know-how and availability of financial resources and should have conducted a social and environmental impact assessment.
- *Well-field Development and Use License*: valid for max. 25 years, after which the government may continue operations. Next to requirements listed under exploration license, applicants need a feasibility study, a valid Power Purchase Agreement (PPA) and, if applicable, a community development plan. This license gives the right to either generate electricity only or combine this with the sale of the resource for direct use by the government or for self-use.

Licensing occurs on a competitive basis. Licensees have several rights and obligations, outlined in the 2016 Proclamation.

Regional States grant operation licenses for Grade II geothermal resources. The granting of operation licenses for Grade I geothermal resources takes precedence over Grade II ones. An exploration license takes precedence over a reconnaissance license, and a well-field development and use license over the former two. Except for reconnaissance, licenses can be transferred with written consent of the PEA. Licensees need to record and submit data/ reports on their activities. Licenses may be suspended or revoked under circumstances specified in the Proclamation. Activities are subject to inspection. Licenses are subject to fees.

Social and Environmental Impact Assessment, social development

An Environmental Impact Assessment is required for the exploration and well-field development and use licenses and must be submitted to the Environmental Protection Agency. Applicants for a well-field development and use license should submit a written

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community development plan developed in consultation with communities living in or adjacent to the geothermal resource area designated in the license. This plan should include an implementation plan and allocation of a community welfare fund.

Incentives, Private sector participation

Ethiopia opened its energy sector for private sector participation in 2014. Private developers have since been engaged in various stages of geothermal development, at various sites in Ethiopia. Two IPPs were contracted for developing and running geothermal power plants in two sites, Tulu Moye and Corbetti. Incentives are in place as tax waivers, e.g. for importing equipment and supplies. Private developers should negotiate a PPA, which can take time – although a specific PPP proclamation adopted in 2018 sought to speed up the process of developing PPPs in the electricity as well as in other sectors through competitive bidding. However, PPA negotiation is still challenging due to unclear distribution of roles and responsibilities. Formally, the state agency Ethiopian Electric Power (EEP) acts as the contracting authority and buys electricity generated by IPPs. Yet, other agencies are also involved in the process, with the PPP Directorate General within the Ministry of Finance often acting as de facto contracting authority.

Key agencies

The following agencies play a key role in geothermal development:

- The Ministry of Water and Energy: energy policymaking and oversight
- Regional states: issue licenses for Grade II geothermal prospects
- Petroleum and Energy Authority (PEA): state agency that regulates the energy sector, issues licenses
- Ethiopian Geological Institute (within Ministry of Mines): mapping and exploring geological sites, including geothermal resources
- Ethiopian Electric Power (EEP): state agency that generates and transmits electricity nation-wide
- Ethiopian Electric Utility (EEU): state agency that distributes, sells and manages electricity operations
- Ministry of Finance: involved in approving PPPs and negotiating PPAs

The establishment of new state agencies for geothermal development is foreseen but evolves slowly.

Key sources / more information

This project has received funding from the European Union's Horizon 2020
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- Government of Ethiopia (2016). Geothermal Resources Development Proclamation No. 981/2016
- Government of Ethiopia (2019). Geothermal Resource Development Council of Ministers Regulations No. 453/2019

3.3 Kenya

3.3.1 General

Geothermal resources play a major role in Kenya's energy policies and energy generation. Current capacity stands at almost 1000 MWe, while the estimated potential capacity is about 10,000 MWe. The Government of Kenya seeks to harness more of the hitherto untapped potential by 2030 as part of its Vision 2030. Most of Vision's 'flagship projects' related to the 'energy subsector' focus on increasing geothermal energy capacity. The most important policy and legal documents for geothermal development are the Energy Policy of 2018 and the Energy Act of 2019. This Energy Act consolidated and repealed policies that dealt with specific energy matters, including the Geothermal Resources Act. It incorporates the basic legal and regulatory requirements for geothermal development. Kenya's energy development is liberalized, meaning the functions of electricity generation, transmission and distribution that were once concentrated in one state agency were unbundled in the late 1990s. This is aimed at separating commercial functions from policymaking and regulation, creating more competitive conditions in the electricity supply sector and opening the sector for private sector participation. Geothermal direct use is less extensively developed, but it is encouraged and (increasingly) applied for diverse ends such as greenhouse heating and bathing/ swimming.

3.3.2 Specific elements

Resource ownership, oversight and declaration of an energy resource area
Unextracted geothermal resources under/on land are vested in the National Government of Kenya. Operations and development of geothermal resources are a function of the national government. The Cabinet Secretary for Energy and Petroleum (hereafter: CS-EP) may declare an area that is suitable for the conservation and management of an energy resource, or for the promotion of energy development projects, as an energy resource area.

Licenses for geothermal development

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The CS-EP grants authorities to search for geothermal resources. Such an authority is provided for 2 years and may be renewed upon expiration. The CS can revoke an authority on various grounds, for instance in case the authorized person has not commenced a search within 5 years after gaining the authority. Interested parties need to apply for a license for the extraction of geothermal resources overall or part of a geothermal/ energy resource area, which is granted by the CS-EP for a maximum of 30 years, to be renewed for 5-year terms. The license gives various rights to licensees, including the drilling of wells, use of machinery, construction of buildings and roads, use of water resources – although ancillary activities, if undertaken, likely require additional licenses. Geothermal resources may be used in accordance with the purpose specified in the license. Mineral by-products that can be used/ sold are subject to another license related to mining. Transfer of license need written approval of the CS-EP. The CS-EP may forfeit a license, for instance if the licensee ceases work for a continuous period of 6 months, or may close a well, for instance if it constitutes a danger for persons or harms the environment. Licensees are subject to payment of royalties, 'charges' (i.e. fees, rentals) as well as taxation.

License for electricity generation/ use

A license from the Energy and Petroleum Regulatory Authority (EPRA) is required for the generation/ transmission/ distribution of electricity. The exception is the generation and use of max. 1 MWe for own use. All electricity intended for sale is subject to licensing.

Social and Environmental Impact Assessment, social development

The Environmental Management and Coordination Act stipulates that an Environmental Impact Assessment should be done when drilling to use ground water resources, including geothermal resources. Regarding social development, the Energy Act stipulates that 5% of any royalties received by the National Government will be put into a trust fund for community development where geothermal exploration takes place.

Incentives, Private sector participation

Kenya has legislation for Public-Private Partnerships (PPPs) that encourages and organizes the involvement of the private sector in various stages of public infrastructure (including energy) infrastructure. It also adopted a feed-in tariff system that seeks to promote the generation of electricity from renewable energy sources, including geothermal. Feed-in means an agency produces electricity from renewable sources and sells it at a pre-determined tariff for a given time. It is another support mechanism for the private sector – under the banner of 'Independent Power Producers' (IPPs) – to become involved in the market. A Power Purchase Agreement (PPA) with EPRA is required. A Policy on 'Licensing

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of Geothermal Greenfields' is currently being developed for the procurement of geothermal projects that will take over the procurement of all geothermal development projects.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Energy and Petroleum: energy policy- and strategy making and oversight. Issues licenses for geothermal search and extraction.
- Geothermal Development Company (GDC): state-owned company, operating as Special Purpose Vehicle, responsible for the development of geothermal resources
- Kenya Electricity Generating Company PLC (KenGen): responsible for generating electricity through development, management and operation of power plants. Listed on the Nairobi Securities Exchange, KenGen's shares are 70% owned by the GoK, with the remaining 30% owned by the public.
- Kenya Power and Lightning Company Ltd (KPLC): state corporation with 50,1% of its shares government-owned, 49.9% private shareholding. Buys electricity from KenGen and IPPs and undertakes transmission, distribution, supply and retail of electricity
- Kenya Electricity Transmission Company Ltd (KETRACO): state-owned company responsible for development, maintenance and operation of the national grid and for regional power trade
- Energy and Petroleum Regulatory Authority (EPRA): regulates electricity generation/ distribution/ use, sets tariffs
- Ministry of Finance

Key sources / more information

- Government of Kenya (2019). Energy Act (especially p. 64-72)
- Government of Kenya (2018). National Energy Policy
- Government of Kenya (2021). Public Private Partnerships Act
- Government of Kenya (2007). Kenya Vision 2030
- Government of Kenya (2022). Kenya Vision 2030 Flagship programmes and projects progress report (FY 2020/2021).

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3.4 Rwanda

3.4.1 General

Rwanda was forced to downsize its ambitions for electricity generation from geothermal resources after exploration and drilling exposed a lower occurrence of high-enthalpy geothermal resources than anticipated. As such, there is also no installed capacity yet. Nonetheless, geothermal exploration continues in the hope of finding some high-enthalpy resources that can help diversify the power generation mix, as outlined in key development documents such as Vision 2050, the Rwanda Energy Policy and the Energy Sector Strategic Plan. Like other countries in the region, Rwanda has a liberalized model, in which on the one hand a public corporation called the Rwanda Energy Group (REG) deals with the development of new energy generation projects and the operations of the electricity network, and on the other, private sector participation is encouraged. The national energy policy states that specific legislation for geothermal development will be prepared, but this is yet to be done.

3.4.2 Specific elements

Resource ownership & oversight

The government is the overall guarantor of the country's land heritage and is said to ensure its proper use and management.

Licenses for geothermal development, private sector participation, incentives

There is no specific legal or policy document outlining the licensing procedures for geothermal development. REG – and specifically its subsidiary Energy Development Corporation Ltd. – is tasked with exploring and conducting studies on potential geothermal resources, although other parties are invited to become active in all parts of the geothermal development process (e.g. exploration, prospecting, feasibility studies, construction, power generation). There are elaborate policy and legal guidelines on private sector participation/ PPPs and IPPs in power generation in Rwanda. The default policy line is to procure energy-related projects via competitive bidding. IPPs are encouraged to enter the market and there are incentives and support frameworks in place, including a feed-in tariff and investment support agencies such as the Rwanda Development Board. IPPs require a concession agreement with the government of Rwanda, a PPA with REG and an electricity production license from the Rwanda Utilities Regulatory Authority. They ought to sell electricity to

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REG's second subsidiary Energy Utility Corporation Limited (EUCL).

Social and Environmental Impact Assessment, social development

All infrastructural projects are subject to an environmental and social impact assessment, for which the Rwanda Environment Management Authority (under the Ministry of Environment) is responsible.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Infrastructure: energy policy and strategy-making and oversight
- Rwanda Energy Group (REG): state-owned energy and electricity corporation
- Energy Development Corporation Limited (EDCL): a REG subsidiary, responsible for exploring and developing new energy projects
- Energy Utility Corporation Limited (EUCL): a REG subsidiary, responsible for generation, transmission and distribution of electricity
- Rwanda Utilities Regulatory Authority (RURA): regulates a number of sectors, including energy and its subsectors electricity, renewable energy, petroleum and gas.
- Rwanda Environment Management Authority: state agency responsible for environmental management and coordination
- Rwanda Development Board: state agency mandated to accelerate private sector-driven economic growth. Has an advisory role in PPPs.

Key sources / more information

- Government of Rwanda (2015). Rwanda Energy Policy
- Government of Rwanda (2018). Energy Sector Strategic Plan 2018/19 – 2023/24
- Government of Rwanda (2020). Vision 2050
- Government of Rwanda (2017). 7 Years Government Programme: National Strategy for Transformation (NST-1) 2017 – 2024

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3.5 Algeria

3.5.1 General

Algeria is endowed with lower enthalpy geothermal resources. These have been put to direct use in a variety of ways, notably balneology, but also for other uses including greenhouse heating and aquaculture. Algeria is Africa's leading country when it comes to geothermal direct use. The country has a Renewable Energy and Energy Efficiency Development Plan that outlines the objectives for 2030, the overarching one which is to create an additional 22 GW from renewable energy by 2030. This overambitious goal was downgraded to 15 GW by 2035, but still, the country still predominantly relies on oil. Developing a 15 MW geothermal power plant is part of this plan, to be realized using binary cycle technologies at one geothermal resource. The plan also foresees the growth of geothermal energy development for direct use. Algeria's renewable energy plans had to be supported by a stronger institutional framework for renewable energy, but little of this materialized. A special Ministry of Energy Transition and Renewable Energies was established and set up from 2020 onwards but was never operational and was disbanded in 2022.

3.5.2 Specific elements

Resource ownership & oversight

Natural energy sources are public property, meaning an asset of the national community. It is the state that strives to make 'rational use' of natural resources, including geothermal resources.

Licenses for geothermal development, private sector participation, incentives

Algeria's government has opened up its renewable energy sector for private investment and private sector participation, as it stands mainly for solar and wind power projects. IPPs need to negotiate a PPA with the Electricity and Gas Regulation Commission, the power utility Sonelgaz and/ or SONATRACH, the national oil and gas company.

Social and Environmental Impact Assessment, social development

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An environmental impact assessment is required for energy development projects, obtained from the National Agency for Environmental Protection.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Energy and Mines: energy sector policymaking and oversight
- Ministry of Environment and Renewable Energy: environmental policymaking and oversight, including regarding renewable energy projects
- Sonelgaz Group: state-owned power utility, with a large number of subsidiaries responsible for power/ electricity generation, transmission and distribution
- Algerian Electricity and Gas Regulation Commission (CREG): regulates the electricity sector
- Algerian Society for Renewable Energies (SHAEMS): state agency, in part owned by Sonelgaz, that helps develop renewable energy projects and the involvement of the private sector herein

Key sources / more information

- Government of Algeria (2015). Renewable Energy and Energy Efficiency Development Plan 2015 – 2030

3.6 Egypt

3.6.1 General

Egypt has no installed power generation capacity based on geothermal resources today. Its geothermal resources are mostly in the medium-to-low temperature range. As such, geothermal direct use is already well-established in the country, with geothermal energy used for swimming pools/ bathing, district heating systems and greenhouse heating, among other uses. The government wishes to increase the share of renewable energy for electricity generation from 20% currently to 42% in 2035. It does not yet foresee a major role for geothermal in this ambition, but this may change if studies confirm potential for electricity production from some of the geothermal resources present in Egypt. Egypt is in the process of reforming – i.e. liberalizing – its electricity sector and promotes the private sector-driven generation of electricity from renewable resources. This process evolves slowly.

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3.6.2 Specific elements

Resource ownership & oversight

Natural resources belong to the people, and their preservation and exploitation is done by the state. The constitution moreover states that the state shall make best use of renewable energy sources and motivate investment herein.

Licenses for geothermal development, private sector participation, incentives

No policy for geothermal development exists, but generally, the exploitation of natural resources or public utility concessions could be obtained for a period not exceeding 30 years. A renewable energy law came into force in 2014, which seeks to promote the private sector to enter the market for electricity generation from renewable energy sources. IPPs need to negotiate a PPA with the Egyptian Electric Utility and Consumer Protection Regulatory Agency. There is a feed-in tariff, but this is currently only available for solar PV and wind technologies. Other incentives are available for renewable energy projects, such as tax breaks.

Social and Environmental Impact Assessment, social development

An Environmental and Social Impact Assessment is required for energy infrastructure projects, to be obtained from the Egyptian Environmental Affairs Agency.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Electricity and Renewable Energy (MOERE): electricity and renewable energy policy making and oversight
- New and Renewable Energy Authority (NREA): state agency responsible for renewable energy developments
- Egyptian Electricity Holding Company (EEHC): joint stock energy company owned by the state, owns various subsidiaries in the electricity sector
- Egyptian Electricity Transmission Company (EETC): manages, maintains and operates the electricity transmission system. In the process of being unbundled from EEHC
- Electricity Distribution Companies: distribute and sell electricity to subscribers
- Electricity Production Companies: generate and produce electric energy and sells this to EETC or the distribution companies

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- Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptEra): regulates the electricity sector in Egypt, protects consumer rights and issues licenses for power production/ distribution/ sale

Key sources / more information

- Government of Egypt (2014). Presidential Decree-Law No. 203/2014 Regarding the Stimulation of Producing Electricity from Renewable Energy Sources
- Government of Egypt (2014). Egypt Vision 2030

3.7 Mozambique

3.7.1 General

The very southern tip of the East African Rift's western branch reaches into Mozambique's northwestern and central provinces. Some potential geothermal sites have been identified here, but these require additional research if geothermal development is to take place. The government of Mozambique adopted an ambitious energy transition strategy that seeks to harness its hitherto unused renewable energy resources. This strategy is the latest in a long list of energy and electricity policies, strategies and legal documents adopted by the government over decades. Among these, the strategy for the development of renewable energy resources (2011 – 2025) includes an ambition to explore and develop geothermal resources in the country. This ambition is modest, however, with plans to build a 20 MW geothermal power plant. Mozambique welcomes IPPs into the energy sector since the late 1990s.

3.7.2 Specific elements

Resource ownership & oversight

Land is owned by the state. The state promotes the knowledge, inventory and valorization of natural resources, including geothermal, and determines and oversees its use.

Licenses for geothermal development, private sector participation, incentives

Mozambique has no specific policy or legal framework, nor a dedicated agency, for geothermal development. There is a PPP law that allows IPPs to enter the (renewable) energy market as power generators. A PPA must be negotiated and formalized with the national electricity utility EDM and a concession agreement with the government. Electricity must be sold to EDM. Incentives such as a feed-in tariff and tax exemptions are in place or

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in preparation but are not yet very clear or not well operationalized and have so far done little to attract investments in the renewable energy sector.

Social and Environmental Impact Assessment, social development

Building a power plant requires an environmental impact assessment dealing with various types of environmental and social issues. Environmental licenses are to be gained from the Ministry of Land, Environment and Rural Development.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Mineral Resources and Energy: energy policymaking and oversight
- Electricidade de Moçambique (EDM): public utility responsible for generation, transmission and distribution of electricity throughout Mozambique
- Energy Regulatory Authority (ARENE): state entity responsible for regulating the electricity and (renewable) energy sector

Key sources / more information

- Government of Mozambique (2011). Estratégia de Desenvolvimento de Energias Novas e Renovais. Para o Período de 2011 – 2025
- Government of Mozambique (2018). Integrated Master Plan. Mozambique Power System Development 2018 – 2043

3.8 Tanzania

3.8.1 General

Tanzania has a potential of around 5000 MWe from geothermal resources, but there is no installed capacity as yet. The Power System Master Plan forecasts the generation of 200 MWe by 2025, to be increased to almost 1000 MWe by 2044. To this end, a dedicated geothermal development company (TDGC) has been established to spur geothermal exploration and development – yet the 2025 objective will likely not be met. There is no specific policy or legislation for geothermal development, but there are general guidelines for (renewable) energy projects. A key strategy to meet these goals, as indicated in the National Energy Policy, is to encourage private capital and players to become active in geothermal/ renewable energy projects. Geothermal direct use is also encouraged.

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3.8.2 Specific elements

Resource ownership & oversight

The government, on behalf of its peoples, exercises control over natural resources – including geothermal.

Licenses for geothermal development, private sector participation, incentives

As said, geothermal development is being spurred by GDTC and the private sector is encouraged to become active in prospective power generation developments. Projects that aim at generating more than 10 MWe require a license, which needs to be obtained from the Energy and Water Utilities Regulatory Authority (EWURA). EWURA has standard PPAs that can be downloaded from its site, including for geothermal projects. The National Energy Policy foresaw the establishment of a feed-in tariff for renewable energy technologies, but this is yet to be realized.

Social and Environmental Impact Assessment, social development

An environmental impact assessment is required from the National Environmental Management Council.

Key agencies

The following agencies play a key role in geothermal development:

- Ministry of Energy: energy policymaking and oversight
- Tanzania Electric Supply Company Limited (TANESCO): state-owned company responsible for generating, transmitting and distributing electricity on the mainland
- Tanzania Geothermal Development Company (TGDC): a subsidiary of TANESCO tasked with geothermal exploration and development
- Energy and Water Utilities Regulatory Authority (EWURA): multi-sector regulatory agency, responsible for the technical and economic regulation of electricity

Key sources / more information

- Government of Tanzania (2015). National Energy Policy

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- Government of Tanzania (2020). Power System Master Plan 2020 Update
- Government of Tanzania (1999). The Tanzania Development Vision 2025 (a new 'Vision 2050' is in the making)

4. Cases of renewable energy developments

4.1 Introduction

Africa is vast, rich in resources, and holds immense potential for renewable energy (RE) development. Indeed, the continent is experiencing a significant diffusion of RE sources, with an increasing number of power plants installed to exploit the clean energy potential and guarantee affordable access to energy[1]. The RE energy mix provides to Africa 25.5% of the energy generated in the continent (Statista, 2024 on 2021 data[2]). Hydropower and pumped storage count for 16.7%, while solar, even if is the most spread RE around the continent, produces just 4.7%. Wind power counts for 3%, while biomass and geothermal follow with 0.6% and 0.4%. Solar has a high potential, considering technological readiness and solar availability, and compared to other REs, low initial investments. Hydro and wind have a high potential too, especially for large-scale power plants, but they are limited in number of installed plants because of the high initial investment and the limits of availability of water and wind resources. Geothermal energy still has a low level of development, basically because of a lack of exploration of the subsurface – due to prohibitive costs and high risks of failure – and the concentrated location of geothermal resources compared to REs (e.g., solar and wind energy).

Even though the positive trend in the development of RE installations in African countries and the limits exposed before, there are still several opportunities to exploit particularly in terms of diffusion of geothermal energy. Therefore, this section contains an analysis of successful cases of RE developments in Africa which can offer valuable insights and lessons for facilitating the diffusion of geothermal energy in the East Africa region and the selected countries for the *Geothermal Atlas for Africa*.

In doing this, we selected the cases exposed in the following section considering these criteria:

- Type of RE sources prevalent in each country.
- Dimension of the power plant: preferably plants with an installed capacity of more than 100 MW, with the only exception or Rwanda's one (8.5 MW). On the other side, we find Ethiopia's with 6,400 MW installed.
- Contribution of the power plants to the national energy mix.

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The combination of the three above mentioned criteria highlights the most relevant national trends in terms of investments in RE power plants. North African countries are experiencing a boom for solar photovoltaic developments, due to their huge solar irradiance availability. Ethiopia is almost producing 100% of energy from hydropower due to its favourable hydrography. Djibouti lacks RE power stations, except for the wind ones.

The analysis focused on 8 countries, which we divided in two groups: East African countries, which have a geological structure with a high geothermal energy potential, and “followers” countries which are a step behind in the geothermal exploration. The first group consists of Djibouti, Ethiopia, Kenya, and Rwanda, whereas the second one includes Algeria, Egypt, Mozambique, and Tanzania. The selected cases integrate diverse criteria to provide an exhaustive depiction of possible project for developing REs in Africa: type of RE, power plant’s dimension, actors involved, year of development, etc.

The cases are listed in alphabetical order:

1. Ghoubet Wind power station in *Djibouti*
2. Great Ethiopia Renaissance Dam in *Ethiopia*
3. Olkaria Geothermal power plant in *Kenya*
4. Rwamagana Solar Power Station in *Rwanda*
5. Big Reeba North in *Algeria*
6. Benban Solar Park in *Egypt*
7. Metoro Solar Power Station in *Mozambique*
8. Kihansi Hydroelectric Power Station in *Tanzania*

Each case study provides a comprehensive analysis of the selected RE project by showcasing key features of the power plant and highlighting the impacts on the country, the local community and environment. Our analysis is willing to highlight best practices, but also drawbacks, to give a comprehensive picture to support further investment initiatives to foster the diffusion of geothermal energy in Africa. The analysis, we collected information and exposed them in categories aiming at favouring a comparison among the cases and with other potential projects for the geothermal development. These categories are location, dimension, promoting actors and enablers (including technology providers, owners, government agencies, and financial institutions), stakeholders, energy usage, beneficiaries, sustainability elements (economic, environmental, social), drivers, barriers,

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and any controversies surrounding the projects. The analysis also provides key takeaways for triggering geothermal development in East Africa and potential countries.

4.2 The analysis of the cases of renewable energy developments

4.2.1 Djibouti

Case: Ghoubet Wind Power Station

RE type: Wind

Location

The Ghoubet Wind Power Station-GWPS in Located in the Ghoubet area near Lake Assal, in Djibouti.

Figure 1. Ghoubet Wind Power Station. Photo credit: Africaenergy.com

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Dimension

The GWPS covers about 395 hectares, making it one of the largest wind farms in the region.

Promoting Actors and Enablers

- **Main actor:** Red Sea Power Limited SAS.

Owners and financial investors:

The GWPS is owned by a consortium called Red Sea Power Limited SAS which constructed, operates, and manages the power station. The members of the consortium are Africa Finance Corporation (Nigeria); Construction Equity Fund, FMO, Climate Fund Managers on behalf of Climate Investor One (Netherlands); Great Horn Investment Holdings (Djibouti).

Technology providers:

The engineering, procurement and construction contract was awarded to a consortium formed by Siemens Gamesa Renewable Energy and Grupo Auxiliar Metalúrgico S.A. (Spain). The power generated from GWPS will be sold to Electricité de Djibouti under a power purchase agreement for a period of 25 years.

Government agencies:

The Government of Djibouti has initiated a Public-Private Partnership to develop and build the wind on-shore power plant. Moreover, the Great Horn Investment Holdings is an investment company owned by a unit of the Djibouti Ports and Free Zones Authority (DPFZA) and the Djibouti Sovereign Fund (DSF).

Stakeholders

The stakeholders involved in the project include the Djiboutian government, the international funding agencies and actors involved, the construction companies, and the local community. The government plays a crucial role in setting energy policies and regulations to promote the use of renewable energy sources. Djibouti's goal is relying exclusively on renewable energy sources by 2035. The local community benefits from a few employment opportunities (i.e., security).

Use of energy and beneficiaries

The primary use of energy from the GWPS is to supply electricity to the national grid, benefiting thousands of households and businesses across Djibouti. The plant helps to reduce the country's dependence on import of electricity from neighboring countries. By

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harnessing wind energy, the plant also contributes to the country's energy security and economic development.

Elements of sustainability

The GWPS plant incorporates several elements of sustainability to ensure its long-term viability and impact.

Economic sustainability

- **Long-term viability:** economic sustainability is achieved through the generation of revenue from the sale of electricity to energy consumers.
- **Contribution to country's independence:** the plant limits the country's imports of electricity (95 MW) from neighboring Ethiopia. The power is enough to supply energy to around 35,000 households.
- **Job creation:** by investing in renewable energy infrastructure, Djibouti is also creating new job opportunities and stimulating economic growth in the country.

Environmental sustainability

- **GHG emissions:** According to Red Sea Power, the wind farm will prevent the emission of 252,500 tons of CO2 per year or the equivalent of 55,000 buses.
- **Fossil fuels' independency and Climate change:** by generating clean, renewable energy, Djibouti can reduce its reliance on fossil fuels, contributing to a more sustainable energy future.
- **Biodiversity protection:** The project aims to protect local biodiversity by observing migratory and resident birds to track changes in population and behavior, including endangered species like Egyptian vultures. Despite the potential risks of bird collisions from wind farms in Djibouti's migration corridor, the project's strategic location below the northeastern high mountains makes it a prime spot for harnessing wind energy with minimal impact on bird populations.

Social Sustainability

- **Opportunity for economic development:** the wind farm benefits the citizens by providing reliable and affordable electricity to households and businesses.

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- **Skills training:** the development of the plant also created opportunities for skills development and training in the renewable energy sector, helping to build a more sustainable workforce for the future.
- **Water supply to residents:** In addition to the new wind farm, the Red Sea Power partners have built a solar-powered desalination plant which will provide drinking water to villages near the farm. It will supply 800 residents of two villages near the farm with access to around 40 liters per day, reducing the risk of water-borne diseases and increasing time in education as children are frequently sent out to collect water. The goal is for the wind farm to power larger desalination plants in the future.

Drivers and Barriers

Drivers	**Barriers/Controversies**
Government commitment and support: through the Public-Private Partnership, the Government of Djibouti has developed and built the wind on-shore power plant. One of the shareholders, the Great Horn Investment Holdings, is an investment company owned by a unit of the Djibouti Ports and Free Zones Authority (DPFZA) and the Djibouti Sovereign Fund (DSF).	**High initial investment and Lack of local developers:** high initial capital investment required for the construction of the plant has been high, and there was a lack of an industrial ecosystem for renewable energy. These barriers have been overcome through the involvement of international investors and financial institutions.
Availability of wind: the location of Lake Assal of the plant was strategically chosen due to its consistent wind patterns, which make it an ideal spot for harnessing wind energy.	**Intermittent nature of wind**: energy production can make it difficult to ensure a stable and consistent electricity supply, requiring backup solutions or energy storage options.

Table 1. Drivers and barriers Ghoubet Wind Power Station.

Key Sources:

- https://redseapower.dj/
- https://tractebel-engie.com/en/news/2020/blowin-the-wind-in-djibouti
- https://tractebel-engie.com/en/news/2021/laying-the-foundations-for-djibouti-s-first-onshore-wind-farm
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- https://energycentral.com/news/djibouti-inaugurates-red-sea-power-countrys-first-wind-farm
- https://www.reuters.com/article/idUSL4N3AK2D8/
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This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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4.2.2 Ethiopia

Case: Grand Ethiopian Renaissance Dam

RE type: Hydroelectric

Location

The Grand Ethiopian Renaissance Dam (GERD) Hydroelectric power plant is in Ethiopia, on the Blue Nile River near the Sudanese border.

Figure 2. GERD Hydropower plant and water reservoir. Photo credit: Nasa.com

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

Dimension

The GERD is set to be 145 meters (about 475.72 ft) tall and 1,800 meters long, with a total volume of 74,000 cubic meters. The reservoir created by the dam will have over 74 billion cubic meters of water, making it one of the largest in Africa. Currently, the GERD is equipped with 750 MW turbines. To date, the dam is expected to have a total installed capacity of 6,400 megawatts, which will make it the largest hydropower plant in Africa and the seventh largest in the world.

Promoting Actors and Enablers

- **Main actors:** Ethiopian Government**,** Webuild
- **Other actors:** Tratos Cavi spa, Alstom, Exim Bank of China

<u>Technology providers:</u>

The main contractor for the GERD project is the Italian company Webuild (formerly Salini Impregilo), which has also been involved in constructing other dams such as Gilgel Gibe II, Gilgel Gibe III, and Tana Beles. In 2012, Salini awarded a contract to Tratos Cavi SPA to supply low and high-voltage cable for the dam. Alstom has been contracted to provide eight 375 MW Francis turbines for the first phase of the project.

<u>Government agencies:</u>

The government of Ethiopia has played a crucial role in achieving the energy independence of the country from fossil fuels and from foreign supply. Ethiopia is currently producing the 95% of the energy from hydropower generation.

<u>Financial institutions:</u>

The GERD has been funded by Ethiopian national funds, crowdsourcing through internal fundraising in the form of selling bonds and persuading employees to contribute a portion of their incomes and the contribution of foreign banks, as the Exim Bank of China.

Stakeholders

Besides to local stakeholders and communities involved by the construction of the dam, the main stakeholders in the GERD project include Ethiopia, Sudan, and Egypt. The dam is located close to their respective borders and will have a significant impact on Sudan and Egypt water supply and energy security (see barriers and controversies).

Use of energy and beneficiaries

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

The primary use of the energy generated by the GERD will be to power Ethiopia's growing economy and provide electricity to millions of households that currently lack access to reliable power. The beneficiaries of the dam include both urban and rural communities in Ethiopia, who will benefit from increased access to electricity and the economic opportunities that come with it.

Elements of sustainability

In terms of sustainability, the GERD project aims to be both economically, environmentally, and socially sustainable.

Economic sustainability

- **Long-term viability:** Ethiopian government has taken steps to ensure that the dam is financially viable through domestic funding and partnerships with international investors.
- **Attraction of investment opportunities:** as well as other energy investment, the GERD will priorly serve to provide energy to Ethiopia, considering the consistent economic growth of the country and the growing energy demand. GERD will contribute to ensure the energy need for such development.
- **Energy sale:** economic sustainability will be also achieved in case of abundancy of electricity production in the country. GERD, as well as other power plants, can serve to sale of electricity to bordering countries, providing a stable source of revenue for the Ethiopian government.

Environmental sustainability

- **Fossil fuels' independence:** by harnessing the power from water, the GERD will improve the country's independence from fossil fuels. Currently, Ethiopia's energy mix is fossil fuels-free.
- **Climate change:** by generating clean, renewable energy, the plant is helping to protect the environment for future generations.
- **Wildlife, ecosystems, and land use: the dam can have a significant impact on the local ecosystem and wildlife.** Although the Ethiopian government has declared to have conducted and environmental initial analysis and put in place measures to mitigate the environmental impact of the dam, there are some negative impacts (see barriers and controversies.

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

Social sustainability

- **Job creation:** GERD has created jobs for local communities, supporting economic development in the region.
- **Community engagement:** the Ethiopian government has declared to have worked closely with local communities to address their concerns and ensure that they benefit from the project through job creation and investments in local infrastructure. Nevertheless, some controversies on the issues have been highlighted (see barriers and controversies).

Drivers and Barriers

Drivers	**Barriers/Controversies**
Growing demand for electricity: Ethiopia's demand for electricity has been growing every year. The need for energy security and economic development, as well as the potential for increased regional cooperation and integration through the sharing of electricity with neighboring countries, has pushed for GERD realization.	**Tensions with bordering countries:** while Ethiopia sees the dam as a crucial source of renewable energy and economic development, Sudan and Egypt are concerned about the potential impact on their water supply and agriculture.
Availability of water resource irradiance: Ethiopia is crossed by the Blue Nile River. This is undoubtedly a positive element for hydropower generation.	**Wildlife:** GERD project will have major negative impacts on aquatic life and fisheries. GERD blocks the upriver fish migrations, knowing that downriver passage through turbines or over spillways are often ineffective.
Government support: one of the key drivers for the project is the support of the Ethiopian government, which has prioritized energy as a key component of the country's economic development.	**Public consultation:** the NGO International Rivers states that conversations with civil society groups in Ethiopia reveal that questioning the government's energy sector plans is risky due to concerns of persecution. As a result, no groups are addressing issues with hydro-power dams or raising concerns about the lack of public consultation during major dam implementation.
Economy of scale and country readiness to hydropower: Ethiopia has been developing hydropower generation since decades and, together with DRC, is the most advanced country in hydropower generation in Africa, considering the long	

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

existing collaboration with the Italian company Impregilo.	

Table 2. Drivers and barriers in GERD hydropower plant.

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- Ron Matthews & Vlado Vivoda (2023) 'Water Wars': strategic implications of the grand Ethiopian Renaissance Dam, Conflict, Security & Development, 23:4, 333-366, DOI:10.1080/14678802.2023.2257137
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- https://archive.internationalrivers.org/campaigns/grand-ethiopian-renaissance-dam
- https://direct.mit.edu/daed/article/150/4/159/107371/The-Grand-Ethiopian-Renaissance-Dam-Africa-s-Water
- https://www.washingtonpost.com/world/interactive/2020/grand-ethiopian-renaissance-dam-egypt-nile/
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- https://www.aljazeera.com/news/2023/9/10/filling-of-grand-renaissance-dam-on-the-nile-complete-ethiopia-says

4.2.3 Kenya

Case: Olkaria Geothermal power plant

RE type: Geothermal

Location

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

The Olkaria Geothermal Plant is a series of geothermal power plants located in the Olkaria geothermal field in the Great Rift Valley of Kenya, in the Hell's Gate National Park, Nakuru County, Kenya.

Figure 3. Olkaria Geothermal Plant. Photo credit: Afrik21

Dimension

The plant consists of six individual power stations, each with its own units and dimensions. The total MWe installed are 779. The first unit was built in 1981. The plant has provided clean and reliable electricity to Kenyans for over 40 years.

Promoting Actors and Enablers

- **Main actor:** Kenya Electricity Generating Company (KenGen)

Government agencies:

The Ministry of Energy (MOE) is responsible for formulating and implementing Kenya's energy policy, including the development of geothermal energy. The National Environment

This project has received funding from the European Union's Horizon 2020
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Management Authority (NEMA) is responsible for environmental regulation in Kenya, including the environmental impact assessment of the Olkaria Geothermal Plant.

Financial institutions:

The World Bank has provided loans to KenGen for the development of the Olkaria Geothermal Plant. The European Investment Bank (EIB) has also provided loans to KenGen for the project._Besides these two big international institutions,_other commercial banks: Other commercial banks have also provided loans to KenGen for the Olkaria Geothermal Plant.

Technology providers:

KenGen owns and runs Olkaria I, II, IV, V, and VI. Ormat owns and runs Olkaria III (150 MW). Then, other technological providers are involved, such as Mitsubishi Corporation and GE Power, which have provided turbines and other equipment for the Olkaria Geothermal Plant, and others minor providers, such as Baker Hughes, Schlumberger, and Siemens.

Research institutions:

Kenyan National Geothermal Laboratory (KNLGL) is a research institution that is responsible for geothermal research and development in Kenya. Other research institutions have also been involved in the project, including the University of Nairobi and the Geothermal Resources Council.

Stakeholders

The main stakeholders of the plant are the communities living near the Olkaria Geothermal Plant, within Nakuru county. Olkaria has been known as a Maasai land. The local communities have been involved in the project through community engagement programs and benefit-sharing arrangements, even if some controversies occurred (see below). During the project's construction, NGOs have been involved by supporting local communities and advocating for sustainable development.

Use of energy and beneficiaries

The energy produced at the Olkaria Geothermal Plant is primarily used to generate electricity for Kenya's national grid. This electricity is used to power homes, businesses, industries, and other facilities throughout the country, including public services (i.e. institutions, schools, hospitals, etc.).

In addition to generating electricity, the Olkaria Geothermal Plant also provides some direct heat applications. For example, some of the steam generated by the plant is used to heat

This project has received funding from the European Union’s Horizon 2020
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greenhouses for agricultural production. Moreover, KenGen has developed a spa for direct use applications connected to tourism activities, such as hot water bathing for therapeutic effects, sauna, steam bathing. Other possible minor uses include cooking, drying of fruits and vegetables, refrigeration, crop irrigation and fish farming.

Elements of sustainability

The Olkaria Geothermal Plant is an energy project that incorporates elements of economic, environmental, and social sustainability.

Economic sustainability

- **Tax revenue:** KenGen and Ormat activities generates tax revenue for the Kenyan government.
- **Attraction of investment:** The Olkaria Geothermal Plant has attracted international investment to Kenya (see: Actors>Financial institutions)

Environmental sustainability

- **Reduced air pollution:** Geothermal energy does not produce air pollution, unlike fossil fuels.
- **Water conservation:** The Olkaria Geothermal Plant uses a closed-loop system that minimizes water consumption. Spent geothermal water is reinjected into the ground to maintain reservoir pressure and prevent geothermal resources from being depleted.
- **Land use:** Geothermal energy is the least consuming RE per MW in terms of land use. Nevertheless, Olkaria is based in a national park (see also: controversies).

Social sustainability

- **Job creation:** the development and operation of the Olkaria (the second geothermal power plant in the world) has created thousands of jobs, including the involvement of local companies in the construction of the plant (i.e., H. Young & Company Ltd);
- **Cultural heritage:** The project has taken steps to protect the cultural heritage of the area, such as avoiding construction in areas of cultural significance.

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- **Economic development:** lack of stable energy is a serious problem in Sub-Saharan Africa. Olkaria is fighting this problem, providing almost half of the country's energy need and ensuring possibilities for business activities.

Drivers and Barriers

Drivers	Barriers/Controversies
Growing demand for electricity: Kenya's demand for electricity has been growing rapidly in recent years, and geothermal energy is a clean and reliable source of power that can help to meet this demand. This demand will favor the development of new plants (i.e., Olkaria VII under tender).	**Environmental impact:** Olkaria has some environmental impacts, such as air and water pollution, noise pollution, and visual impacts.
Availability of geothermal resources: Kenya has abundant geothermal resources, and the Olkaria geothermal field is one of the largest in the world.	**Community opposition:** There has been some opposition to geothermal projects from local communities, who are concerned about the potential environmental impacts and displacement of houses.
Government support: The Kenyan government has provided strong support for the development of geothermal energy, including financial incentives and regulatory support. KenGen is a public company owned by the state and it will benefit from government support.	**Location:** the Olkaria geothermal plant is in the Hell's Gate National Park. The location, therefore, can hinder some future development of new units.
Technological advancements: Technological advancements in geothermal drilling and power generation have made geothermal energy more cost-competitive and efficient	**Community displacement:** One of the most significant concerns surrounding the Olkaria Geothermal Plant is the displacement of local communities, especially Maasai People. The plant's construction required land acquisition from these communities, which led to the loss of homes, farmland, and cultural sites. In some cases, communities have not been adequately compensated for their losses, and they have faced challenges in finding alternative livelihoods.

Table 3. Drivers and barriers and controversies in Oklaria.

Key Sources:

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This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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- https://www.iwgia.org/images/publications/0623_BRIEFING_OLKARIA_FINAL.pdf
- https://www.esi-africa.com/magazine-article/olkaria-project-drive-kenyas-geothermal-energy-ambitions/
- https://power.mhi.com/case/kenya

4.2.4 Rwanda

Case: Rwamagana Solar Power Station

RE type: Photovoltaic

Location

The Rwamagana Solar Power-RSP plant is located on leased land, at the campus of Agahozo Shalom Youth Village, in Rwamagana District, Eastern Rwanda, approximately 58 kilometres by road, southeast of Kigali.

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

Figure 4. Rwamagana Solar Power plant. Photo credit: Sameer Halai/SunFunder/Gigawatt Global

Dimension

RSP plant covers an area of approximately 250 hectares and has 8.5 MW installed, making it a significant contributor to Rwanda's renewable energy capacity. The plant is comprised of 28,600 solar photovoltaic modules each with 300Wp (Watt-peak), eight inverters and is connected to the national grid.

Promoting Actors and Enablers

- **Main actors:** Gigawatt Global, Government of Rwanda.

Technology providers:

Gigawatt global has built the power plant. The project is the brainchild of American-Israeli green entrepreneur Yosef Abramowitz, a pioneer of Israel's solar industry. The panels are made in China while the inverters and transformers come from Germany. The solar field is linked to a central server in Oslo and can be monitored remotely via the internet.

Government agencies:

The Government of Rwanda, through the former Energy, Water and Sanitation Authority (EWSA), currently Rwanda Energy Group Limited (REG Ltd) signed a Power Purchase Agreement with Gigawatt Global Rwanda to build, operate and maintain the on-grid solar power plant for a period of 25 years.

Financial institutions:

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

The Government of Rwanda played a crucial role in facilitating the development of the project by funding the plant through the agreement, which included Gigawatt Global, Norfund and Scatec Solar. Other funders are FMO-Dutch entrepreneurial development bank and the Emerging Africa Infrastructure Fund.

Stakeholders

The stakeholders of the RSP station include the local community, government agencies, Gigawatt Global Rwanda, and energy consumers. The local community has been actively involved in the project, providing labor and support during the construction phase.

Use of energy and beneficiaries

The primary use of energy from the Rwamagana Solar Power Station is to supply electricity to the national grid, benefiting millions of households and businesses across Rwanda. The plant helps to reduce the country's dependence on fossil fuels and mitigate the effects of climate change. By harnessing solar energy, the plant also contributes to the country's energy security and economic development.

Elements of sustainability

The RSP plant incorporates several elements of sustainability to ensure its long-term viability and impact.

Economic sustainability

- **Long-term viability:** economic sustainability is achieved through the generation of revenue from the sale of electricity to energy consumers.
- **Job creation:** the plant development and maintenance also created jobs and stimulates economic growth in the local community.

Environmental sustainability

- **Fossil fuels' independence and GHG emissions:** solar power is a clean, renewable energy source that reduces greenhouse gas emissions and pollution.
- **Climate change:** by generating clean, renewable energy, the plant is helping to protect the environment for future generations.

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

Social sustainability

- **Synergies with local NGO:** the utility-scale solar field is located at the Agahozo Shalom Youth Village, an organization whose mission is to care for Rwanda's most vulnerable children orphaned before and after the 1994 Genocide against the Tutsi. Agahozo Shalom leased the land for the solar facility, the fees from which will help pay for a portion of the Village's expenses.
- **Training on solar power:** Gigawatt Global will also be providing training on solar power to students at the Liquid Net High School at Agahozo Shalom.
- **Gender equality:** through the direct benefit to Agahozo Shalom, the project also promotes gender equality and social inclusion by ensuring that women and marginalized groups have access to employment and training opportunities.

Drivers and Barriers

Drivers	**Barriers/Controversies**
Government commitment: the project supports Rwanda's goal of achieving universal access to electricity by 2024, as outlined in the National Electrification Strategy. Moreover, the Government of Rwanda is committed to reducing carbon emissions.	**Initial investment:** high initial capital investment required for the construction of the plant. This barrier has been overcome through the involvement of international investors and financial institutions.
Availability of solar irradiance: the plant is strategically situated in an area with high solar radiation, ensuring optimal energy production throughout the year	
Government support: the development of the plant has been fast. Through Government support, the $23.7m (£15.6m) solar field went from contract signing phase to construction and connection in just a year, defying skeptics of Africa's ability to realize projects fast. Financial incentives and regulatory support have also played a significant role in facilitating investment.	
Corruption free: Rwanda has an excellent business environment – no corruption – and that played a role.	

Table 4. Drivers and barriers in Rwamagana Solar Power plant.

Key Sources:

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

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4.2.5 Algeria

Case: Big Reeba North photovoltaic power plant

RE type: Photovoltaic

Location

The Bir Reeba North-BRN photovoltaic plant is in the Bir Reeba region of Algeria.

This project has received funding from the European Union’s Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Figure 5. Bir Reeba North photovoltaic plant. Photo credit: Eni.com

Dimension

The Bir Reeba North solar power plant covers about 200 hectares, making it one of the largest solar facilities in the country. The total power installed is 10 MW.

Promoting Actors and Enablers

- **Main actors:** Eni Algeria Production B.V, Sonatrach.

Technology providers:

The BRN project was developed by a consortium of international partners, including Algerian energy company Sonatrach and the Italian energy company Eni. The plant is co-operated by Eni and Sonatrach through the GSA (Groupement Sonatrach-Agip),

Government agencies:

The government of Algeria has played a crucial role in promoting renewable energy projects in the country, providing incentives and policies to encourage investment in the sector.

Financial institutions:

Besides these two big international industrial partners, BRN has received support from the European Investment Bank and other commercial banks.

Research institutions:

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

During the opening ceremony, to further boost their partnership in the renewable energy sector, Eni and Sonatrach signed an agreement to implement the construction of an advanced research and development laboratory at the BRN site to test solar and hybrid technologies in a desert environment. The laboratory, which is open to universities and other public institutions for research purposes, has different types of photovoltaic panels to be tested in extreme solar irradiation conditions in southern Algeria to collect and analyze data. The Solar Lab is identical to an already existing one at the Eni Research Centre in Novara. This enables ENI to compare the behavior of photovoltaic devices in two locations with differing irradiation and climate.

Stakeholders

The stakeholders involved in the BRN photovoltaic plant include the Algerian government, local communities, and various international investors. Local communities have benefited from the plant, through job creation and the provision of clean energy to the surrounding region.

Use of energy and beneficiaries

The energy produced at the BRN photovoltaic plant is primarily used to generate electricity for Algeria's national grid, benefiting millions of Algerians who rely on this energy source for their daily needs. This electricity is used to power homes, businesses, industries, and other facilities throughout the country, including public services (i.e. institutions, schools, hospitals, etc).

Elements of sustainability

The BRN photovoltaic plant is an energy project that incorporates elements of economic, environmental, and social sustainability.

Economic sustainability

- **Long-term viability:** economic sustainability is achieved through the sale of electricity generated by the plant, providing a stable source of revenue for the project developers.
- **Attraction of investment:** the BRN has attracted international investment in a rural area in North Africa, such as the Big Reeba valley.

This project has received funding from the European Union's Horizon 2020
Research and Innovation Program under Grant Agreement 963530.

Environmental sustainability

- **Fossil fuels' independence:** by harnessing the power of the sun, the BRN photovoltaic plant is reducing the country's reliance on fossil fuels and contributing to the transition towards a more sustainable energy system.
- **GHG emissions:** the BRN photovoltaic plant proves that renewable projects can efficiently support upstream oil and gas operations and contribute to the reduction of GHG emissions.
- **Climate change:** by generating clean, renewable energy, the plant is helping to protect the environment for future generations.
- **Land use:** the photovoltaic plant has been often contested for land use. In this case, the land use is desert, therefore unproductive land.

Social sustainability

- **Job creation:** the plant has created jobs for local communities, supporting economic development in the region.
- **Community engagement:** even if communities are scattered, the plant has implemented community engagement programs to ensure that the concerns and needs of residents are taken into account.
- **Research opportunities:** the Solar Lab is a good example of merging industrial activity and research and development, though the creation of synergies.

Drivers and Barriers

Drivers	**Barriers/Controversies**
Growing demand for electricity and fossil fuels' independence: Algeria's demand for electricity has been growing rapidly in recent years, and international pressure for climate change targets has facilitated the development of alternative energy sources.	**Context isolation:** the Big Reeba North region is desertic and quite isolated. This condition has determined high upfront costs associated with such power projects and may foresee high costs for maintenance and monitoring the plant's continued operation.
Availability of solar irradiance: Algeria has abundant solar resources, and the Sahara Desert has one of the most irradiance availability in the world.	**Bureaucracy**: regulatory hurdles and bureaucratic processes can slow down the development of other similar renewable energy projects in Algeria.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Government support: one of the key drivers for the project is the support of the Algerian government, which has prioritized renewable energy as a key component of its energy strategy. Additionally, the plant benefits from supportive policies and incentives that encourage investment in the renewable energy sector.	

Table 5. Drivers and barriers in Big Reeba North photovoltaic plant.

Key Sources:

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- https://www.pv-tech.org/eni-and-sonatrach-complete-10mw-solar-project-in-algeria-plan-hybrid-solar/

4.2.6 Egypt

Case: Benban Solar Park

RE type: Photovoltaic

Location

The Benban Solar Park is located amidst the vastness of the Egyptian desert, approximately 650 kilometers south of Cairo.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Figure 6. Benban Solar Park. Photo credit: UNFCCC.

Dimension

The Benban Solar Park-BSP is a network of 41 individual solar power plants, each with varying capacities, collectively generating a staggering 1,650 megawatts (MW) of clean electricity. This translates to an annual production of approximately 3.8 terawatt-hours (TWh). This massive complex is sprawling over 37.2 square kilometers. BSP is the fourth biggest photovoltaic plant in the world.

Promoting Actors and Enablers

- **Main actor:** Government of Egypt

Technology providers:

The birth of this solar giant involved a multitude of actors. Numerous private companies, both domestic and international, participated in the construction and operation of the individual power plants within the complex. Egypt's government assigned 41 plots to roughly 30 developers, promising to pay a competitive price for all power produced there for 25 years. The developers – which include Infinity 50, Scatec Solar, Alcazar Energy Partners, Schneider Electric, Siemens, Shapoorji Pallonji Group – installed panels, transformers, and inverters. Electricity travels from the panels on each plot to substations through 22-kV cables buried in the sand.

Government agencies:

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The New and Renewable Energy Authority (NREA) of Egypt played a pivotal role in initiating and overseeing the project. The project is a part of Egypt's Nubian Suns Renewable Energy Feed-in Tariff (FiT) programme announced in September 2014, which is in line with the Egyptian government's Sustainable Energy Strategy 2035 that aimed to produce 20% of electricity from renewable sources by 2022.

Financial institutions:

The project has received loans from several institutions, both for the private developed parts, and for the infrastructure and services part. Funding actors involved: Africa Development Bank, the Asian Infrastructure Investment Bank (AIIB), Arab Bank of Bahrain, CDC of the United Kingdom, Europe Arab Bank, Green for Growth Fund, FinnFund, ICBC, OeEB of Austria. In particularly, the European Bank for Reconstruction and Development (EBRD) has financed 16 projects with a combined capacity of 750MW, under a $500m agreement for renewable energy financing in Egypt. The International Finance Corporation and the World Bank have funded the state-owned electricity company built four substations, a control center, and a connection to nearby 220-kilovolt transmission lines.

Stakeholders

The stakeholders of the Benban Solar Park include the private developers, the local community, the government agencies, and Egyptian consumers.

Use of energy and beneficiaries

The primary use of energy from the Benban Solar Park is to supply electricity to the national grid, benefiting millions of households and businesses across Egypt. The generated power caters to various sectors, including residential, commercial, and industrial, contributing to a diversified and reliable energy supply.

Elements of sustainability

The BSP plant incorporates several elements of sustainability to ensure its long-term viability and impact.

Economic sustainability

- **Long-term viability:** economic sustainability of private developers is achieved through the agreement with the Egypt's Government that will buy the energy for

This project has received funding from the European Union's Horizon 2020
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25 years, plus the generation of revenue from the sale of electricity to energy consumers. In fact, the energy produced is enough to power millions of homes and significantly contribute to Egypt's energy needs.

- **Job creation and attraction to foreign investment:** It has created substantial economic opportunities, with estimates suggesting over 20,000 jobs during construction and 6,000 permanent positions in operation and maintenance. This injection of employment and economic activity empowers local communities and fosters long-term development.
- **Energy security:** the clean energy generated reduces reliance on volatile fossil fuel prices, contributing to long-term economic stability.

Environmental sustainability

- **Fossil fuels' independence and GHG emissions:** By harnessing the power of the sun, the Benban Solar Park significantly reduces greenhouse gas emissions compared to traditional fossil fuel power plants.
- **Climate change and public health:** by generating energy from sun, this translates to cleaner air, improved public health, and a crucial step towards mitigating climate change.

Social sustainability

- **Energy access and connected benefits:** the project fosters social development by providing access to reliable electricity for communities, powering essential services like healthcare and education. Additionally, the creation of jobs empowers individuals and contributes to poverty alleviation.

Drivers and Barriers

Drivers	**Barriers/Controversies**
Availability of solar irradiance: the plant is strategically situated in an area with high solar radiation, ensuring optimal energy production throughout the year. NASA has contributed to the identification of the optimal zone.	**Contextual challenges:** the project also faced the challenges of securing financing, navigating complex regulatory frameworks, and ensuring efficient grid integration of the large-scale renewable energy source.
Government commitment: The project is in line with the Egyptian government's Sustainable Energy Strategy 2035.	**Overheated zone:** the area's high temperatures–which frequently top 38°C in summer–could affect the site's many inverters, which convert the DC power produced by the panels to the AC power required for the grid.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Growing energy demand: The development of the Benban Solar Park was driven by Egypt's ever-growing energy demand.	Sand or dust reduced efficiency: to combat that blowing onto the panels, employees will clean all the panels at Benban once or twice a month using specialized tractors equipped with brushes.
Solar technology readiness level: the decreasing costs of solar technology has facilitated the investment	

Table 6. Drivers and barriers in Benban Solar Park.

Key Sources:

- https://www.nsenergybusiness.com/projects/benban-solar-park/
- https://www.presidency.eg/EN/%D8%A7%D9%84%D9%85%D8%B4%D8%A7%D8%B1%D9%8A%D8%B9-%D8%A7%D9%84%D9%82%D9%88%D9%85%D9%8A%D8%A9/%D8%A8%D9%86%D8%A8%D8%A7%D9%86-%D8%A3%D9%83%D8%A8%D8%B1-%D9%85%D8%AD%D8%B7%D8%A9-%D9%84%D8%A5%D9%86%D8%AA%D8%A7%D8%AC-%D8%A7%D9%84%D8%B7%D8%A7%D9%82%D8%A9-%D8%A7%D9%84%D8%B4%D9%85%D8%B3%D9%8A%D8%A9-%D9%81%D9%8A-%D8%A3%D8%B3%D9%88%D8%A7%D9%86/
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- https://www.afdb.org/en/success-stories/egypt-benban-model-clean-energy-production-africa-60169
- https://unfccc.int/news/solar-projections
- https://ieeexplore.ieee.org/abstract/document/8889899
- https://www.egyptindependent.com

4.2.7 Mozambique

Case: Metoro Solar Power Station

RE type: Photovoltaic

Location

The Metoro Solar Power Station (Metoro SPS) is situated in northern Mozambique, in the Cabo Delgado province, near the town of Metoro.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Figure 7. Metoro Solar Power Station. Photo credit: ClubofMozambique.com.

Dimension

The Metoro SPS has a maximum generation capacity of 41 megawatts. It comprises 121,500 solar panels, distributed on a 138-hectare site. The power station provides 68 GWh of energy annually.

Promoting Actors and Enablers

- **Main actors:** Neoen, Electricidade de Moçambique.

<u>Technology providers:</u>

The key actors involved in the development and operation of the Metoro SPS are both international and national. Neoen (France) and Electricidade de Moçambique EP (Mozambique) are currently owning the project through the Metoro Solar Consortium, having ownership stake of 75% and 25% respectively. The construction of the power plant has been agreed within the framework of a Public Private Partnership (PPP), signed with the Mozambican authorities responsible for energy issues. The project was developed by Efacec Power Solutions SGPS (Portugal), which took care of the engineering, procurement, and construction phases, from 2020 to 2022. The energy will be sold with a 20-year power purchase agreement (PPA). After 25 years of operation, it is expected that the ownership of the power station will revert to Electricidade de Moçambique.

This project has received funding from the European Union's Horizon 2020
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Government agencies:

The Government of Mozambique is present through the initiative of the Ministry of Energy, the share in Metoro Solar Consortium and it has also funded the project. France is present through Proparco, a development finance institution partly owned by the French Development Agency.

Financial institutions:

The project has received loans from several institutions, both for the private developed parts, and for the infrastructure and services part. Proparco has funded approximately the 71% of the plant, while the Government of Mozambique the residual part.

Stakeholders

The stakeholders of the Metoro SPS include a state-owned energy company, European private and public investors, and local communities. The former stakeholders have played a crucial role in bringing the project to fruition and ensuring its success, while the latter have benefitted from the plant.

Use of energy and beneficiaries

The primary use of energy from the Metoro SPS is to provide electricity to households, businesses, and infrastructure in the region. The beneficiaries of the Metoro SPS are multi-fold. Local communities benefit from access to reliable and affordable electricity, improving their quality of life and stimulating economic growth. Industries in the region also benefit from a stable source of energy, allowing them to operate efficiently and sustainably. The power of the park is capable of powering 175,000 Mozambican households.

Elements of sustainability

In terms of sustainability, the Metodo SPS embodies several key elements that make it a model for sustainable energy development.

Economic sustainability

- **Long-term viability:** The energy will be bought for 25 years from Electricidade de Moçambique, and this will ensure returns on investment.

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- **Energy security:** the plant provides a stable source of energy that is not only cost-effective but also reliable. The country benefits from reduced carbon emissions and a more diverse energy mix, contributing to its long-term energy security.

Environmental sustainability

- **Fossil fuels' independence and public health:** By tapping into renewable solar energy, the plant helps to reduce the dependence on fossil fuels and contributes to a cleaner and greener environment.
- **GHG emissions:** the power plant will avoid the emission of 49,000 tons of CO_2 per year.

Social sustainability

- **Energy access and community connected benefits:** This shift towards sustainable energy sources is not only beneficial for the environment but also for the economic and social development of the region. The Metoro SPS has a positive impact on the community by providing access to electricity and improving the quality of life for residents. With reliable electricity, households can access modern amenities and services, such as lighting, refrigeration, and communication devices. This leads to improved living standards, enhanced education opportunities, and increased economic activity in the region.

Drivers and Barriers

Drivers	**Barriers/Controversies**
Availability of solar irradiance: The strategic location of the plant allows it to harness the abundant sunlight in the region, ensuring a consistent and reliable source of clean energy.	**Funds and infrastructure:** the lack of infrastructure and financing to support its expansion and long-term operation was a barrier before the implementation and can be a barrier after the 25 years period.
Growing energy demand: The development of the Metoro SPS Solar Park was driven by the growing demand for energy solutions in Mozambique and the region.	**Maintenance:** the plant requires ongoing maintenance and investment to ensure its reliability and efficiency, which can be a challenge in a developing country like Mozambique.

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Solar technology readiness level: the decreasing costs of solar technology have facilitated the investment.	**Terrorism:** the Mozambique is suffering from terrorists' activity. In June 2022, the construction came to a halt after the terrorist attack in Nanduli. Shortly after the Nanduli attack, Efacec raised the alert and decided to evacuate all workers, including security guards.

Table 7. Drivers and barriers in Metoro Solar Power Station.

Key Sources:

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- https://clubofmozambique.com/news/mozambique-construction-of-metoro-solar-power-plant-interrupted-carta-218682/
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4.2.8 Tanzania

Case: Kihansi Hydroelectric Power Station

RE type: Hydroelectric

Location

The Kihansi Hydroelectric Power Station is in Kilombero District of southeast Morogoro Region in southern Tanzania.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Figure 8. Kihansi Hydroelectric Power Station. Photo credit: Esi-africa.com

Dimension

The Kihansi Hydroelectric Power Station covers about 12 hectares and has a total installed capacity of 180 megawatts. The concrete dam measures 25m high, 200m long, and 82 feet high. The reservoir can hold 1,000,000 cubic meters of water when full. This creates a lake of 26 hectares (64 acres). The river plunges approximately 900m (3000 feet) into the Kihansi Gorge over 3km (2 mi). The water is returned to the river approximately 6km (4 mi) downstream.

Promoting Actors and Enablers

- **Main actor:** TANESCO,
- **Other actors:** World Bank, Impregilo Spa

Technology providers:

The construction was initiated in July 1995 and officially launched by President Benjamin Mkapa on July 10, 2000 after its completion. The dam's cost is estimated to be $275 million. Impregilo SpA was hired to construct the main civil works for the Lower Kihansi Hydropower project. The main engineers on the project included Norplan A/S in association with Norconsult and IVO International. Three turbines are currently operating at the facility, which is operated by the TANESCO (Tanzania Electric Supply Company Limited).

Government agencies:

The Government of Tanzania has participated through the former state-owned company TANESCO, now privatized.

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Research and Innovation Program under Grant Agreement 963530.

Financial institutions:

The World Bank jointly funded the KHPS $275 million project along with the European Investment Bank and development agencies from Norway (NORAD), Sweden (SIDA), and Germany (KfW).

Stakeholders

The main stakeholders of KHPS are TANESCO, the international funders, and the communities involved by the construction of the dam, at least 20,000 villagers.

Use of energy and beneficiaries

The primary use of the energy generated by the Kihansi Hydroelectric Power Station is to supply electricity to the national grid, which benefits a wide range of consumers in Tanzania. The plant helps to increase access to reliable and affordable electricity, which is essential for economic growth, social development, and improved living standards in the region. In addition, the plant reduces the country's dependence on fossil fuels and helps mitigate climate change impacts.

Elements of sustainability

In terms of sustainability, the Kihansi Hydroelectric Power Station incorporates various elements to ensure the three pillars, although some shadows appeared during the construction of the dam (see barriers and controversies).

Economic sustainability

- **Long-term viability:** the plant generates revenue through the sale of electricity to the grid. This revenue is then reinvested in the maintenance and improvement of the plant, ensuring its continued operation in the future.

Environmental sustainability

- **Fossil fuels' independence:** by harnessing the power from water, the KHPS improved the country's independence from fossil fuels. The plant utilizes the natural

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flow of the Kihansi River to generate electricity, which minimizes the need for other forms of energy generation that can have negative impacts on the environment.

- **Climate change:** by generating clean, renewable energy, the plant is helping to protect the environment for future generations.
- **Wildlife and ecosystems:** KHSP incorporates technologies to minimize its environmental footprint, such as fish-friendly turbines and sedimentation management systems. Nevertheless, plant installation has significantly changed the environment and caused the extinction of the Kihansi frog (see barriers and controversies).

Social sustainability

- **Job creation:** The plant provides employment opportunities for local communities, both during the construction phase and in ongoing operations.
- **Side-effect on communities:** the KHSP also affected more than 22,000 villagers.

Drivers and Barriers

Drivers	Barriers/Controversies
Growing demand for electricity: the increasing demand for electricity in Tanzania, which has outstripped the capacity of existing power plants. The plant helps to address this gap in supply and meet the growing energy needs of the country.	**Absence of Environmental Initial Assessment**: No EIA was carried out before the project began. The World Bank conducted an environmental assessment as part of the project feasibility study in the early 1990s. When NORAD joined the project in 1994, it found the World Bank's environmental assessment so deficient that it financed an EIA in 1995. This EIA was also found to be of very poor quality because it contained inadequate data and failed to include adequate water–discharge and dam management plans. The pending extinctions are a direct result of the World Bank's failure to require a thorough Environmental Impact Assessment before it financed the plant.
Availability of water resource and experience in hydropower: abundant availability of water in Tanzania has been undoubtedly an element of success. Moreover, Tanzania has a long history in hydropower since Hale Power station built	**Wildlife:** The Kihansi Dam led to the extinction of the Kihansi Spray Toad in the wild by reducing water flow and oxygen spray essential for their survival. Conservation efforts failed to prevent chytrid fungal infection, hastening their

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in 1964 and collaboration with Impregilo Spa.	decline. Despite attempts to save them with a sprinkler system, the goal of preventing extinction was not achieved.
Government support to fight climate change: the plant supports the government's efforts to promote renewable energy and reduce greenhouse gas emissions, in line with international commitments to combat climate change.	**Waterfalls destruction:** the Kihansi Dam destroyed a waterfall that was 800m high.

Table 8. Drivers and barriers in Kihansi Hydroelectric Power Station.

Key Sources:

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4.3 Concluding remarks.

This chapter analysed eight relevant cases of renewable energy power plants in Africa. The selected cases include energy power plants located in eight African countries belonging to two geographical groups: 1) *East Africa*: Djibouti, Ethiopia, Kenya, and Rwanda; 2) *Other African regions*: Algeria, Egypt, Mozambique, and Tanzania. Moreover, these cases considered the type of RE sources prevalent in each country, the dimension of power stations, and the effects of such stations on the national energy policy mix.

For each case study, we provided a comprehensive analysis highlighting the RE development, in particular the key features and impacts on the local community and environment, considering location and dimension, promoting actors and enablers involved, stakeholders, energy use and beneficiaries, sustainability elements, drivers, barriers, and controversies. Following, key features are resumed and compared:

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- *Location and dimension of power plants*: the location depends on the type of RE. Solar photovoltaic offers greater location flexibility, although the energy output is contingent upon solar average irradiance, which varies from Northern Africa to East Africa and even within each country. The location of hydropower and wind power plant depend more on the physical availability of the resource. Geothermal exploitation is strictly linked with geothermal resource availability, therefore is similar in location choices to hydropower and wind. Dimension of the plant is surely higher for hydro and solar, in respect to the geothermal, which is similar in this to wind. Geothermal energy is the RE with the higher ratio between MW and land occupation, followed by wind.
- *Promoting actors and enablers:* this category includes technology providers, owners, government agencies, and financial institutions. The actors involved are various. In all cases, governments typically play a crucial role in addressing energy access issues. Through ministries and agencies, they take the lead in initiating, funding—potentially partially—and managing projects, often leveraging Public-Private Partnerships (PPPs). In addition to public actors, international entities also emerge as significant players, primarily involved in funding initiatives. Institutions like the World Bank, African Development Bank, European Investment Bank, and others take on key roles in financing projects. Moreover, private technological providers are instrumental in developing power plants and associated infrastructures. They may also participate in managing these plants, either in partnership with state-owned companies or independently, often through agreements for energy purchase by the state or public entities.

- *Stakeholders:* Stakeholders of the project can be various from public and private sector. For example, these entities may include state-owned energy companies, private and public investors from various regions such as Europe, Asia, and to a lesser extent, Africa. In addition to the aforementioned stakeholders, local communities also play a vital role in the project's development and success because they can foster direct use of energy for economic activities and potentially exert opposition. While the former stakeholders are instrumental in initiating and sustaining the project, the latter benefit directly from the energy plant's presence.

- *Energy use and related beneficiaries*: this category encompass both the national grid energy destination and the local communities' direct use, although with a prevalence of the former. Local communities are often benefitting indirectly through the energy grid connection, when available.

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- *Sustainability pillars (economic, environmental, social)*. All the analysed projects seem to address all sustainability goals. In terms of economic sustainability, the energy demands of the participating countries typically ensure a favourable return on investment (ROI) for the infrastructure. From an environmental standpoint, achievements include reduced dependency on fossil fuels, decreased greenhouse gas (GHG) emissions, and improvements in public health. Social sustainability is fostered through job creation and work opportunities for local communities, with occasional direct involvement from NGOs serving as additional positive effects.

- *Drivers, barriers, and controversies*: Drivers and barriers can be divided in closely linked to the prevailing RE sources and adopted technologies (i.e., technological readiness) and more common ones (i.e., national context). Regarding the ones connected to specific RE source and technology, we found solar irradiance, and availability of water, wind and geothermal resources. Moreover, technological readiness appears as crucial and, on the other side, maintenance needs to be ensured sometimes in remote areas, for instance when dealing with solar. For the second category regarding common drivers and barriers, we found lack of funds, lack of infrastructures, as well as terrorism, land dispossession, lack of community engagement, and lack of deep initial environmental assessment, with all the direct and indirect effects related to that process. Controversies often arise concerning community engagement and wildlife conservation, particularly in the context of hydropower projects. The only geothermal project exposed (Olkaria) faced controversies on community displacement.

Below are the key takeaways for geothermal development in East Africa and potential countries, derived from the description of various key dimensions:

- *Location and dimension of the power plants*: Considering location constraints and dimensional features, geothermal energy exhibits closer similarities to wind energy than to solar photovoltaic. The similarity between wind and geothermal suggests studying initial environmental assessment documents for wind project to identify common feature that may be helpful in the development of geothermal power stations, in terms of location challenges.

- *Promoting actors and enablers*: The promoting actors and enablers of the projects we have studied are mostly governments and international funding actors (i.e, World Bank, African Development Bank Group, etc). Hence, considering geothermal high initial investment and uncertainties regarding the exploration, we suggest looking for partnerships or strong relations with those public and international actors. They can guarantee, besides the

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resource needed, also the authorization process and the economic sustainability of the power station. Then, different kind of technological providers of geothermal technology should be involved. From our results, we have seen that the majority of them are not African based.

- *Stakeholders*: from the analysis, we have understood the crucial role of two main categories of stakeholders: the public side, with state-owned energy companies and local communities. Both can directly use the energy produced, ensuring the economic sustainability of the plant. Local communities can also show opposition to power stations. We therefore suggest, for a geothermal exploitation success, to establish a dialogue with both categories during the development of the project.

- *Energy use and related beneficiaries*: geothermal energy can have an additional exploitation, in respect to mere electricity production of other REs, considering the possibility of direct use of the heat coming from steam and heat exploitation. We suggest taking into consideration this additional possibility as not residual, but as a part of the project. This suggestion comes from the need for an economic sustainability of other REs, but also from experience in Europe, where direct uses are frequent and can be a lever of engagement with the community.

- *Sustainability p*illars: Geothermal plants developers must immediately try to build good relationships with both the national government and the local communities. This, with the double aim of ensure a return of investment, as the other REs, with purchasing agreements, and sharing of benefits, therefore limiting a possible opposition to the construction of such plants. Another important key aspect in ensuring trust and limiting conflicts are adequate estimation of environmental impacts, which must be carried out to anticipate opposition and modify the development process of the power plant. Moreover, this could help attract investors and convince communities to collaborate. Following environmental care, as other REs, Geothermal will ensure positive environmental effects such as fossil fuel independence, greenhouse gas reduction, and public health benefits. Additionally, geothermal energy exploitation can ensure job creation, local work opportunities, community engagement, and NGO involvement.

- *Drivers, barriers and controversies*: common barriers for other REs which we find also for geothermal energy are as lack of funds, infrastructures, terrorism, land dispossession, and lack of community engagement, while on the drivers' side we find government support and agreements. Regarding technology, we want to highlight that, as other REs, Geothermal energy should consider that technological readiness is crucial for successful

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implementation, but also community engagement. Currently, geothermal private developers should be contracted from other countries, because of the lack of African based ones. The combination of external providers and local community needs can create conflicts more than in other RE development. This situation calls for a community need assessment and engagement, to avoid a possible perception of external technology imposition. This confrontation could ensure the social sustainability of the power station. Moreover, from the previous analysis, we highlight that the maintenance needs to be carefully considered, especially in remote areas where access may be limited, as happened in solar projects. Lessons learnt from the hydropower projects highlight the potential environmental benefits as drivers for geothermal development, as long as wildlife conservation must be carefully managed.

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5. Conclusion

This report has provided a socio-economic analysis for eight African countries, the key data which is to be integrated in the Geothermal Atlas. The report was structured according to different parts of the social analysis. In this concluding chapter, we summarize and conclude the main findings per country...

Ethiopia

In 2021, Ethiopia had nominal GDP of USD 120.4 billion. GDP per capita of USD 1,156 compared to the global average of USD 10,589. Average real GDP growth of 8.4% over the last decade. Falling within low Human Development category globally, Ethiopia's Global Human Development Index (HDI) is ranked 176 at 0.492. Many Ethiopians remain poor and highly vulnerable. A significant proportion of the population finds itself in conditions of mass poverty. The institutional and regulatory framework of Ethiopia is quite advanced, although some important elements are still in development. It is quite advanced in the sense that clear legal and regulatory principles for geothermal development are in place – for instance, when it comes to licensing and private sector participation that the government promotes. Yet, a key strategy and master plan for geothermal development have long been in the making and are still not finalized, nor has a geothermal agency been established.

Djibouti

Djibouti posted average economic growth of 5.3% over the 2016–2021 period. With GNI per capita of USD 3,310, Djibouti is a lower-middle-income country, falling among the Least Developed Countries. Djibouti falls within the low Human Development category globally, it's Global Human Development Index (HDI) is 0.515, ranking 171. Djibouti has a population of about 12 million, with annual population growth of about 1.4%. The social indicators remain weak. The estimated poverty rate was 34.3% in 2021. The distribution of income remains unequal with a Gini coefficient of 0.44 in 2017. Djibouti is vulnerable to the impacts of climate change which weaken a large part of the population and productive capacity. Regarding its institutional and regulatory framework, Djibouti is one of the few countries in Africa that has a public agency solely committed to fostering geothermal development (i.e. ODDEG). This means Djibouti has a clear 'entry point' for actors interested in knowing more about, or becoming engaged in, geothermal development. The

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regulations and procedures for geothermal - or even alternative energy - development are still somewhat unclear and under development.

Kenya

In Kenya, the average real GDP growth over the last decade was 4.5% In 2022, Kenya had nominal GDP of USD 114.3 billion, GDP per capita of USD 2,257 compared to the global average of USD 10,589. Kenya falls within Medium Human Development category globally, Globally, its Human Development Index (HDI) is 0.601, ranking 146 in 2024. Kenya has a population of about 55 million, with annual population growth of about 2%. In reality, the majority of the population in Kenya live on low and insecure incomes. Around 80 per cent of the population could be considered as being 'poor' or 'insecure,' given that their daily expenditures amount to less than KES280 (US$2.80) per person. Kenya's institutional and regulatory framework is the most advanced of all countries assessed in this report. Kenya has clear policy goals and elaborate regulatory guidelines for licensing and other requirements for geothermal developments, and agencies tasked with and experienced in all geothermal development stages. Private sector participation is encouraged and IPPs are involved in some geothermal power plants, but state agencies still dominate geothermal development in the country.

Rwanda

In 2022, Rwanda had nominal GDP of USD 13.3 billion. GDP per capita of USD 1,006 compared to the global average of USD 10,589. Average real GDP growth of 6.5% over the last decade. Rwanda falls within low Human Development category globally; Rwanda's Global Human Development Index (HDI) is ranked 161 at 0.548. Rwanda is among the smallest countries in Africa by landmass, and with 14 million people (2022), it is the most densely populated mainland African country. With the 1994 genocide against the Tutsis, the country lost an estimated one million people. Subsequently. more women were left as widows and children became orphans and were forced into work for their survival. Even though Rwanda has no special agency for geothermal development, its policy, institutional and regulatory framework is elaborate and clearly outlined for (renewable) energy developments. It welcomes private agencies and investors to become involved in such developments. This includes geothermal development, but the potential still needs to be confirmed through additional research.

Algeria

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In 2022, Algeria had nominal GDP of USD **195** billion, GDP per capita of USD **4,301** compared to the global average of USD 10,589. Average real GDP growth of 3% over the last decade. Algeria falls within the High Human Development category globally, it's Global Human Development Index (HDI) is ranked 95 at 0.745. Algeria has a population of about 45 million, with annual population growth of about 1.6%. Algeria is suffering from a deep structural crisis, the crisis of economic and social development, and the crisis of the economic pattern adopted for more than 40 years. Algeria has major ambitions regarding the use of renewable energy and embarked on the institutional restructuring of the energy sector to realize this, but little of this has materialized. Geothermal development was meant to play a role in this ambition, but the country keeps relying predominantly on oil. Geothermal direct-use is well-established, but no clear regulatory structure is in place.

Egypt

In 2023, Egypt had nominal GDP of USD 394billion, The GDP per capita is about 4295 (US$), the annual GDP growth of about 6 % over the last five years. Falling within the High Human Development category globally, Egypt's Global Human Development Index (HDI) is ranked 105 at 0.728. Egypt's population growth rate and poverty rate, with 32.5% of the population living under the national poverty line in 2018. Institutionally, Egypt is in the process of reforming its energy sector so to attract more private sector participation, especially in electricity generation. Geothermal does not play a major role in this institutional reform, nor in the policy objective of increasing the share of renewable energy for electricity production. It has mostly focused on geothermal direct-use, for which exists no particular legislation.

Mozambique

In 2019, Mozambique had nominal GDP of USD 18.4billion, GDP per capita of USD 560 compared to the global average of USD 10,589. Average real GDP growth of 4.3% over the last decade. The country is one of the 10 poorest in the world, with a Human Development Index (HDI) of 0.461, which ranks 176 among 191 countries. Mozambique has a population of about 33 million, with annual population growth of about 2.7%. Poverty rate estimates pointed to an increase to 68.2% in 2019/2020, poverty in Mozambique is overwhelmingly concentrated in rural areas, with a large share of the population still engaged in informal rural activities, predominantly smallholder agriculture, especially in the northern provinces. Climate change hinders much needed human capital development.

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Mozambique's policy, institutional and regulatory framework regarding (renewable) energy development is extensive and expanding, but also fragmented and not well operationalized. Geothermal potential is modest and there is no specific legislation for its development.

Tanzania

In 2022, Tanzania had nominal GDP of USD 73.2 billion, GDP per capita of USD 1,191 compared to the global average of USD 10,589. Average real GDP growth of 5.9% over the last decade. Falling within the low Human Development category globally, Tanzania's Global Human Development Index (HDI) is ranked 167 at 0.532. Tanzania has a population of about 66 million, with annual population growth of about 3%. Tanzania boasts vast agricultural production zones that generate tonnes of food products annually, food price fluctuations, poor market structures, weak market information, poor infrastructure and road networks are among the impediments to attaining resilient and sustainable food security in the country. Tanzania's institutional and regulatory framework is not very elaborate, but there is a geothermal development agency that supports projects for power production and geothermal direct-use. Private actors are encouraged to become active in geothermal development.

Renewable Energy Cases

Our analysis of renewable energy projects revealed some interesting facts. When it comes to choosing a location for a power plant, geothermal shares some similarities with wind and hydropower. All three require specific natural conditions to function efficiently. Geothermal needs particular underground features, while wind and hydro rely on strong winds and moving water, respectively. Solar energy, on the other hand, is more flexible in terms of location but still depends on sufficient sunlight.

The players involved in renewable energy projects are a diverse bunch. Governments, international funders, private companies, and even local communities all have a stake in the game. The current benefits of renewable energy are undeniable. They help us reduce our dependence on fossil fuels, which translates to lower emissions and cleaner air. Additionally, these projects create jobs and, in the case of geothermal energy, offer the potential for local communities to tap into the heat source directly.

Of course, there are challenges to overcome. Funding these projects can be difficult. Sometimes, the infrastructure simply isn't there yet to support them. Local communities might have concerns, and environmental impact assessments are crucial to ensure responsible development.

For geothermal energy specifically, we recommend a multi-directional approach. Partnering with governments and international organizations can help secure funding and necessary

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permits. Proactive communication with local communities and government officials is key to building trust and addressing concerns. Exploring ways to use geothermal heat directly, not just for electricity generation, can provide additional benefits. Thorough environmental impact assessments are essential to minimize any damage and gain community trust. When it comes to technology and maintenance, utilizing experienced companies (potentially international) is important, especially in remote locations where addressing maintenance needs can be challenging.

Looking beyond geothermal, we can learn valuable lessons from other renewable energy projects. Proactive engagement with the community can go a long way in preventing social conflicts. When it comes to environmental impact, it's important to strike a balance between the benefits of reduced emissions and the need to conserve wildlife and habitats.

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Endnotes

[1] See for example https://www.presidence.dj/page/regions#:~:text=La%20région%20de%20Dikhil%20avec,de%20la%20République%20de%20Djibouti). Consulted on 23 March 2024

[2] In full : L'Office Djiboutien de Développement de l'Energie Géothermique (in English) meaning The Geothermal Energy Development Office of Djibouti.

[3] After the 1994 Rwanda genocide, the people of Rwanda no longer identify themselves according to any ethnic or cultural groups, but are all supposed to consider themselves and to be considered as Rwandese.

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