MIDDLE LUSUTFU HYDROPOWER (PROPRIETARY) LIMITED
Certificate of Incorporation No. 2166 of 2015

TECHNICAL REPORT

ON

CLIMATE CHANGE IMPACTS, VULNERABILITIES AND RISKS FOR THE LOWER MAGUDUZA HYDO-ELECTRIC POWER DEVELOPMENT PROJECT

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ACRONYMNS

Abbreviation	Definition
CCRA	Climate Change Risk Assessment
CO_2	Carbon dioxide
DWA	Department of Water Affairs
EEC	Eswatini Electricity Company
ESERA	Eswatini Energy Regulatory Authority
ESIA	Environmental and Social Impact Assessment
GHG	Greenhouse Gases
GOS/FAO	Government of Swaziland/ Food and Agricultural Organization
GT CO_2	Gigaton of Carbon dioxide
GWh	Gigawatts-hour
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
LMHPS	Lower Maguduza Hydro-Power Scheme
LTAS	Long-Term Adaptation Scenarios
LT-LEDS	Long-Term Low Emissions Development Strategies
MLH	Middle Lusutfu Hydropower
MNRE	Ministry of Natural Resources and Energy
MODIS	Moderate Resolution Imaging Spectroradiometer
MW	Megawatts-hour
NDC	Nationally Determined Contributions
NIR	National Inventory Report
PS	Performance Standards
RCP	Representative Concentration Pathway
SNL	Swazi Nation Land
SRES	Special Report on Emissions Scenarios
SSP	Shared Socio-economic Pathway

Abbreviation	Definition
TCFD	Task Force on Climate-Related Financial Disclosures
Tco_2 -eq	Tonnes of carbon dioxide equivalent
UNFCC	United Nations Framework Convention on Climate Change
USL	Ubombo Sugar Limited

1. INTRODUCTION AND BACKGROUND

1.1 Project Overview

The Eswatini Electricity Company (EEC) is proposing to develop the Lower Maguduza Hydro-Power Scheme (LMHPS) at Sidvokodvo, downstream of the current Maguduza Power Station, along the Great Usuthu River. The proposed project is located predominately on remainder of Farm 8, Eswatini Dairy South, Sidvokodvo in the Manzini Region, and with a small, impacted area on Crown Land (Farm 1153) that is used by the Gebeni Community. There are further limited impacts on Farm 1153 and on Swazi Nation Land (SNL) (Farms 1038 and 1037) due to backwater effects. Transmission lines associated with the project will also traverse Farm 45/8 Peebles South, Sidvokodvo in the Manzini Region. The proposed project will be developed in an area which is approximately 9 hectares in size, with the area increasing to approximately 45 hectares when taking into account the extent of land fenced off and secured by servitudes. The project site is accessed through the MR9 Road from Manzini to Nhlangano**.**

The LMHPS will have a generation capacity that is approximately 13.5 MW and this project is being undertaken as part of the EEC's renewable energy programme.

The EEC has partnered with Middle Lusutfu Hydropower (Pty) Ltd, a private sector entity to the private sector to bid for the undertaking of the final design, construction and operation of the LMHPS. Middle Lusutfu Hydropower (Pty) Ltd (MLH), will develop and operate the LMHPS for a period of 30 years, after which EEC will take over the operation of the project

The proposed hydropower power scheme will comprise of the following infrastructure:

- A diversion weir and intake structures at the diversion weir;
- A canal system and penstock linking the intake structures to the hydropower station;
- A power station housing the turbines and the discharge structures, and which may include a surge chamber, head pond and penstocks;
- A substation and power line connecting to the existing EEC network; and
- Two community footbridges over the Usuthu River and Badzinile Stream will also be installed as part of the project, to ensure that local communities can continue to safely cross the river upstream of the weir.

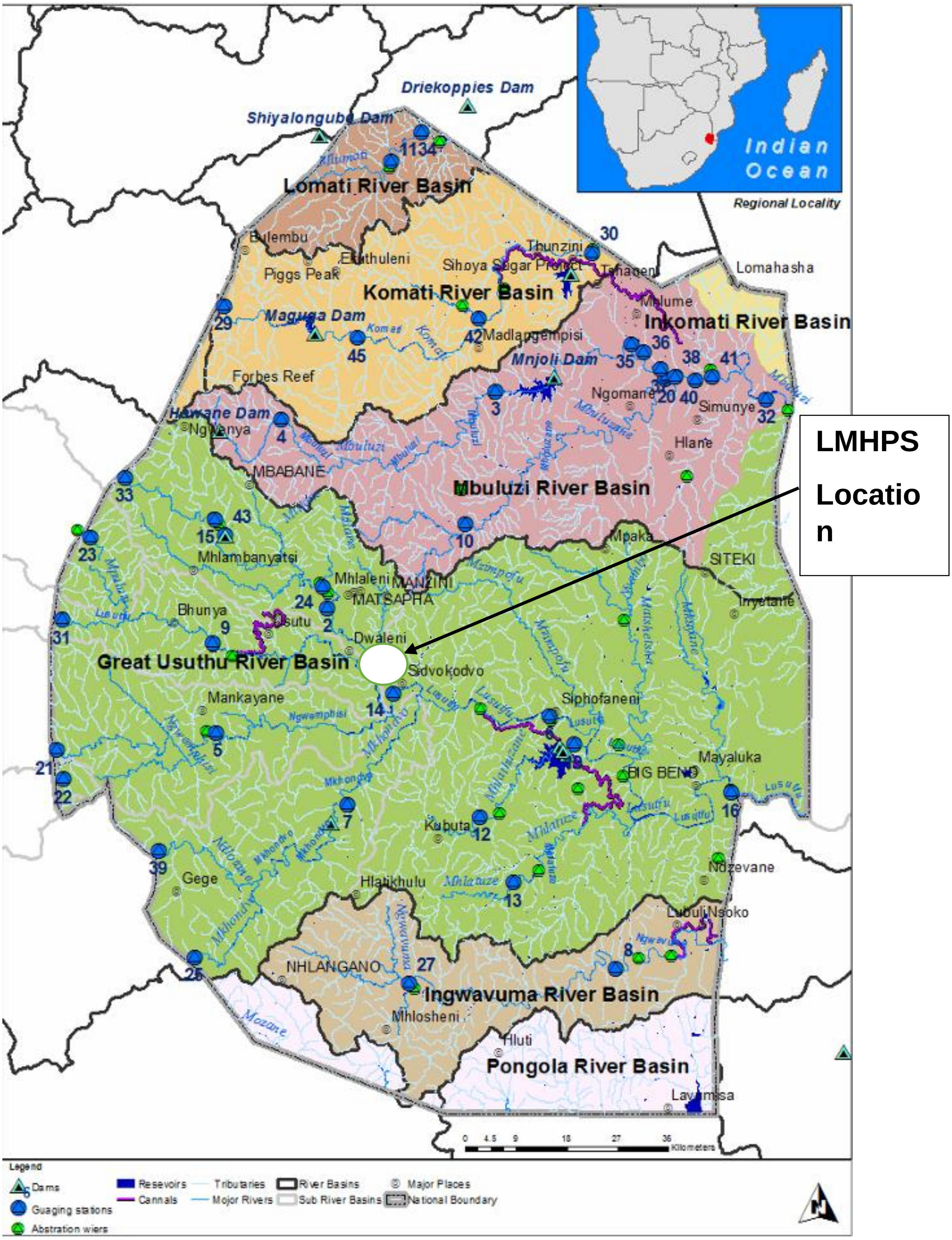

Figure 1 Project Location

Since 2007, the price of imported electricity has increased at a rate that is very significantly above that of inflation, and the supply agreements under which EEC can purchase such imported electricity are unfavourable, subject to unilateral price increases, and provide very little comfort or supply security to Eswatini. Given that Eswatini imports over 70% of its electricity needs (EEC 2015), this is not a favourable position for Eswatini to be in. It is therefore vitally important for the country to develop further its own electricity supply capability. At the 50% assurance level, and with environmental water releases at 10%, the proposed LMHPS will increase local generation by some 65.5 GWh of energy per annum, an increase in EEC local generation of over 26% (EEC 2013).

1.2 Electricity Availability and Demands in Eswatini

Energy Supply is regulated by the Eswatini Energy Regulatory Authority (ESERA). This Authority issues licenses for generation, supply and distribution of electricity. The Eswatini Electricity Company (EEC) is a government owned company established in terms of the Eswatini Electricity Company Act, 2007 (Act No. 1 of 2007). The EEC operates under a set of licenses issued by the ESERA. The electricity sector is dominated by the EEC undertaking power generation, importation, transmission, distribution and supply. According to the ESERA, Eswatini electricity electrification rate in 2021/22 was at 85%. In 2021/22, the local generation was 624.4 GWh and imported power was 901.5 GWh. The EEC owns and operates above 70MW (installed capacity) of power generation stations, amongst which is a 10MW solar PV plant. It also owns and operates a 35kW off-grid solar PV-battery mini-grid that supplies 22 households for pilot purposes. Other key players include co-generators from the sugar industry namely Ubombo Sugar Limited (USL) and the Royal Eswatini Sugar Corporation (RESCorp) with installed capacities of 41.5 MW and 65.5MW, respectively.

Eswatini imports approximately 75% of its annual electricity consumption needs mainly from South Africa and Mozambique[1]. EEC own and operates four hydro power plants that generate 60.4 MW of power, which contributes approximately 15% of total energy consumed in Eswatini[2]. The four power stations are (Maguga -19.8MW), (Ezulwini -20MW), (Edwaleni - 15MW) and (Maguduza -5.6 MW). By 2019, EEC distribution lines covered approximately 21,409 km[3]. According to the EEC annual report, the company generates about 264.3 GWh. The figure below highlights the electricity annual generation trends from 2016-2021.

[1] MNRE - National Energy Policy 2015
[2] SEC Annual Report 2015-2016
[3] EEC annual report 2020/21

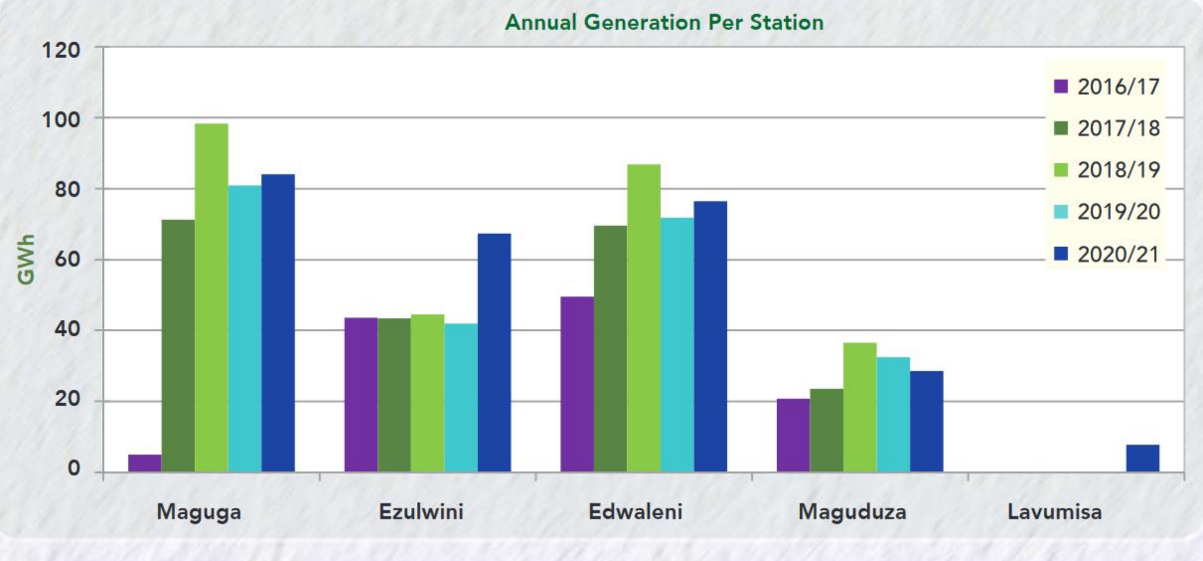

Figure 2 Annual Power Generation per Station *(Source: EEC, 2021)*

1.3 Overview of the Usuthu Basin

The project is located in the middle Usuthu Basin at Sidvokodvo area. The Great Usutu River basin covers an area of about 12,000km^2 which is about two thirds (66%) of the country supporting an estimated 75% of the national population (Matondo and Msibi, 2000). The main river system originates in South Africa, flowing through the four natu ral regions of Swaziland into Mozambique. The project is lying within the lower middleveld agroecological zone which is dominated by the savanna-woodlands ecosystem, covering the central and lower parts of the country. According to the hydrology study for this project conducted by Knight Piesold (2024), describes the climate as typically subtropical with marked seasonal variation in temperature and rainfall. Most of the mean annual precipitation occurs in the summer months (October to March), in the order of 80 to 85%. In summer, the rainfall occurs mainly in the form of sporadic heavy thunder showers which are often accompanied by strong winds. The winter rainfall (June to August) occurs usually during periods of cool drizzly weather. The highest rainfall occurs in the northern and central mountainous areas, with a mean annual precipitation of excess of 1200mm, while the western parts of the catchment receive rainfall of less than 800mm. Tropical cyclonic storms, which originate in the Indian Ocean, occasionally occur in the catchment. High temperatures are experienced in summer, with maximum temperatures of 40ºC in the higher-lying areas increasing to over 47ºC in the low-lying eastern parts of the catchment, and minimum temperatures in winter of below 0ºC in the high-lying areas.

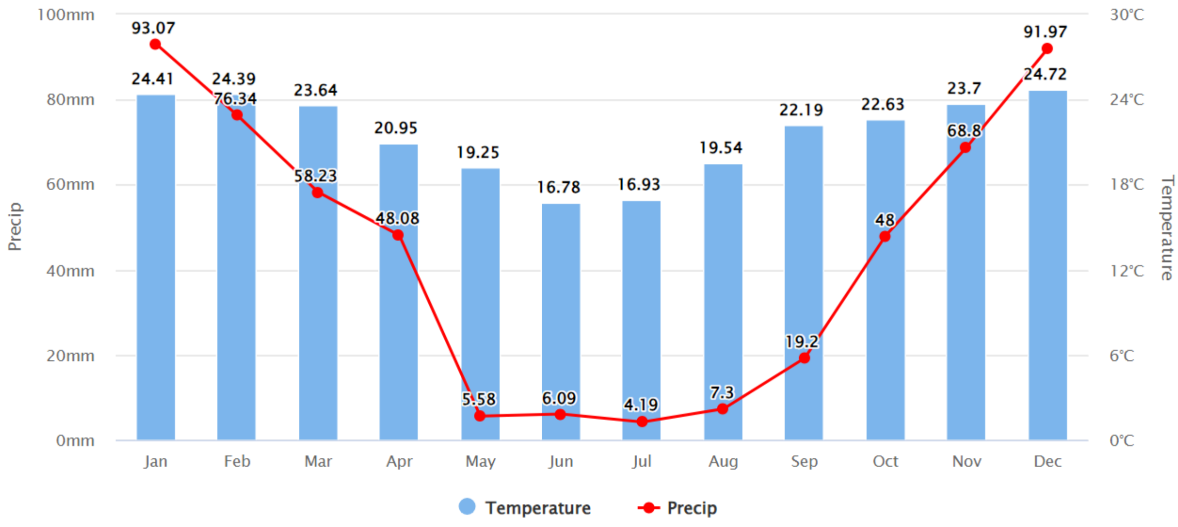

Figure 3 Mean Monthly temperature and precipitation of Sidvokodvo in recent years *(Source: weatherandclimate.com)*

The main river system originates in South Africa, flowing through the four natural regions of Eswatini into Mozambique. The Eswatini Department of Water Affairs (DWA) Climate Change Vulnerability Assessment completed in 2014, established that since 1901 to 2009 there has been an average temperature increase of 1-1.5°C across all the major river basins with the highest warming of 1.5°C occurring in the Komati and Usuthu basins. Eswatini's maximum and minimum temperature between 1962 to 2010 reveals consistent extreme temperature with warming over the whole country. The study further projects a 1.5°C to 3.2°C average temperature increase by 2050 based on the A2 emission scenario[4]. A climate risk country profile rainfall records from 1970 to 2010 indicate an increase in inter-annual rainfall variability in the post 1970 periods with an increase on average of dry spell length. Eswatini's maximum and minimum temperature between 1962 to 2010 reveals consistent extreme temperature with warming over the whole country. The key climate change stressors in Eswatini include the high temperatures, rainfall variability, drought, floods and the frequent occurrence of extreme weather events.

1.4 Climate of Eswatini

Eswatini climate is generally sub-tropical with wet, hot summers. About 75% of the annual rainfall is received from October to March. The country has dry cold winters running from April to September[5]. The highveld of Eswatini is much wetter with cooler temperatures while the Lowveld is predominantly drier and warm. The average mean annual rainfall is estimated at between 400mm to 1500mm across the country with the lowveld receiving the highest and highveld receiving. Eswatini is highly vulnerable to climate change as it lies at the transition of major climatic zones, being influenced by air masses from different origin: equatorial convergence zone (summer rains), subtropical eastern continental moist maritime (onshore

[4] The A2 scenario family is based on a high population growth scenario of 15 billion by 2100 that assumes a significant decline in fertility for most regions and stabilization at above replacement levels. IPCC Special Report Emissions Scenarios, 2000.
[5] Third national communication to the UNFCC

flow with occasional cyclones), dry continental tropical and marine west Mediterranean (winter rains, with rare snow)[6].

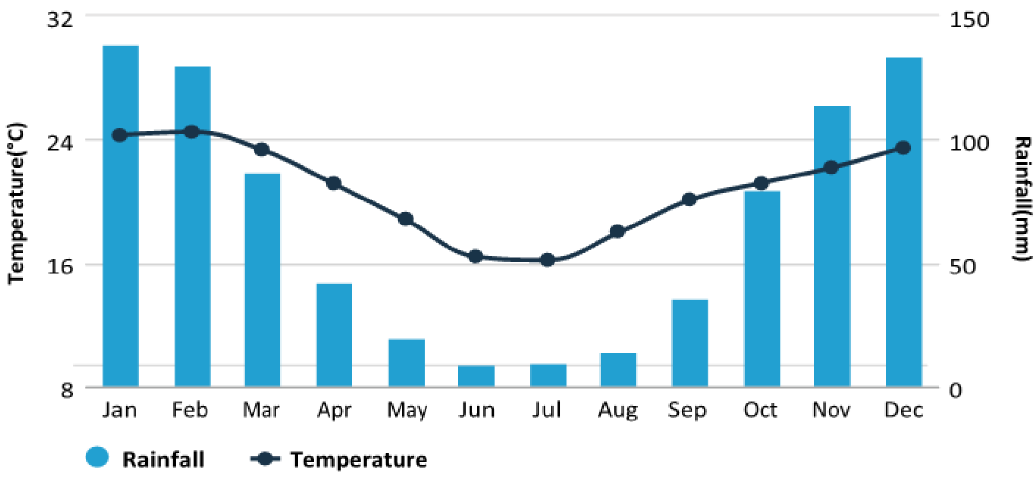

Figure 4 Average Monthly Temperature and Rainfall for Eswatini, 1991-2020 *(Source: World Bank)*

1.5 Temperature Trends

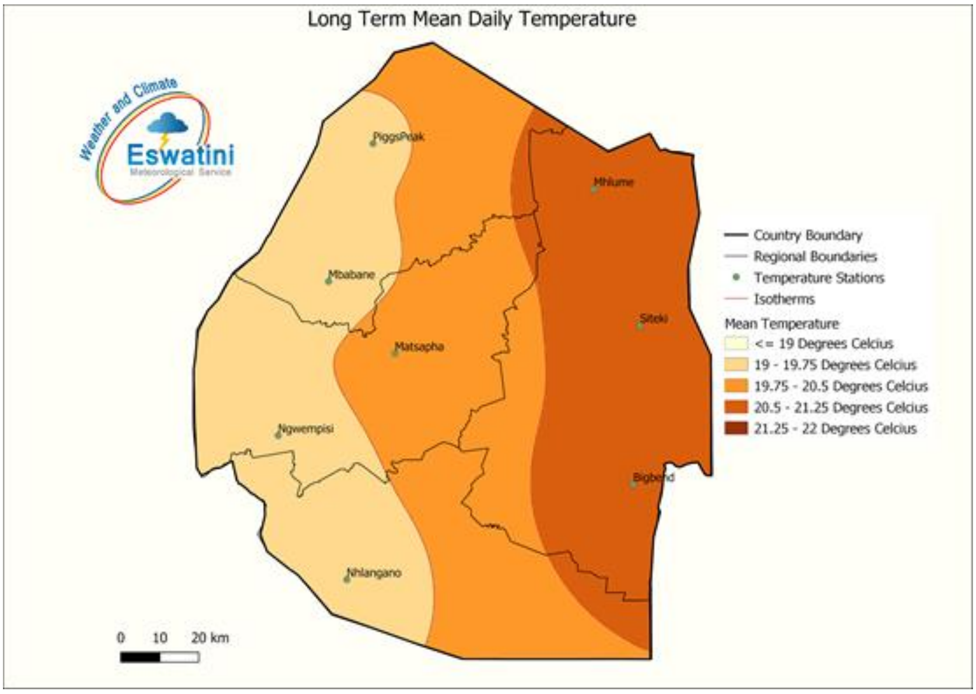

Figure 5: Eswatini Mean annual Temperature 1981-2010 *(Source: Met Department)*

[6] National Climate Change Strategy and Action Plan 2014-2019

1.6 Rainfall Trends

Eswatini's total average rainfall is about 800mm as estimated by the latest climatology report, for the period 1991-2020[7]. The table below summarizes the average rainfall for the different agro-ecological zones.

Table 1 Rainfall in ecological zones of Eswatini

Physiographic Zone	Mean Temperature (°C)			Mean Annual Rainfall (mm)		Köppen Classification
	Annual	January	July	Mean Annual	80% Dependable	
Highveld	17	20	12	850-1,500	700-1,200	Cwb
Upper Middleveld	20	24	15	800-1,000	650-850	Cwa
Lower Middleveld	21	25	16	650-800	500-700	Cwa
Western Lowveld	22	26	18	625-725	425-550	BSh
Eastern Lowveld	22	27	17	550-625	400-500	BSh
Lubombo Ridge	21	26	17	700-825	500-750	Cwa

Source: GOS/FAO, 1994a, 1997

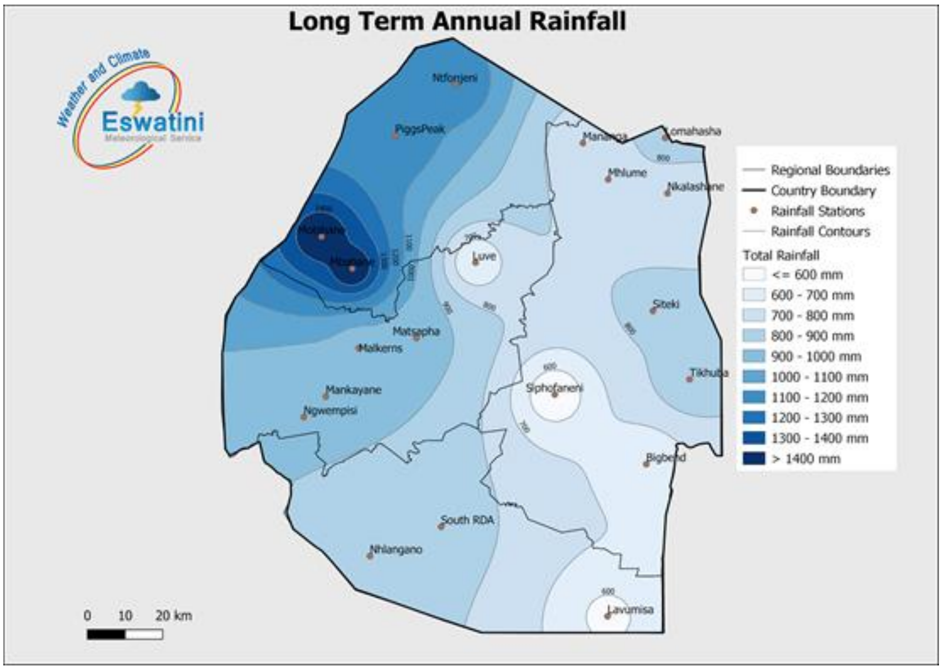

Figure 6 Eswatini Annual precipitation (mm) 1981-2010 *(Source: Met Department)*

Historic annual total rainfall data for the period 1902 to 2009 shows no significant trend in Eswatini[8]. There is high rainfall variability which include periods of flash flooding and prolonged droughts. Recent rainfall trends show a decrease in the number of rainy days with increase in intensities of rainfall events and dry spells duration. The onset of rains, rainfall duration and intensity has changed over the years. According to the World Bank climate risk country profile report (2021), rainfall records from 1970 - 2010 indicate an increase in inter-

[7] World Bank climate risk country profile 2021
[8] Climate change vulnerability assessment for the Water sector, 2014

annual rainfall variability in the post 1970 period with an increase on average in dry-spell length.

1.7 General Overview of Climate Change

1.7.1 Global Trends

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as the change in climate attributed directly or indirectly to human activities that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods. This means long-term shifts in temperatures and weather patterns[9]. The uncontested evidence of the changing climate is reflected by the increasing global average temperatures across the globe. The IPCC AR6 Report (2021) concludes that each of the last four decades has been successively warmer than any decade that preceded it since 1850.[10] in the first two decades of the 21st century (2001-2020) was 0.99 [0.84- 1.10] °C higher than 1850-1900. Global surface temperature was 1.09 [0.95 to 1.20] °C higher in 2011–2020 than 1850–1900.

It is virtually certain that hot extremes (including heatwaves) have become more frequent and more intense across most land regions since the 1950s, while cold extremes (including cold waves) have become less frequent and less severe, with high confidence that human-induced climate change is the main driver of these changes. A warmer climate will intensify very wet and very dry weather and climate events and seasons, with implications for flooding or drought. At 1.5°C global warming, heavy precipitation and associated flooding are projected to intensify and be more frequent in most regions of Africa and Asia. More frequent and or severe agricultural and ecological droughts are projected in a few regions in all continents.

The report further concludes that the frequency and intensity of heavy precipitation events have increased since the 1950s over most land area and human-induced climate change is likely the main driver. Human-induced climate change has contributed to increases in agricultural and ecological droughts in some regions such as Sub-Saharan Africa due to increased evapotranspiration. It is likely that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades. Furthermore, heating of the climate system has caused global mean sea level rise through ice loss on land and thermal expansion from ocean warming. Thermal expansion explained 50% of sea level rise during 1971 – 2018, while ice loss from glaciers contributed 22%, ice sheets 20% and changes in land water storage 8%. Compared to 1850 – 1900, global surface temperature averaged over 2081 – 2100 is very likely to be higher by 1.0°C to 1.8°C under the very low GHG emissions scenario considered (SSP1-1.9), by 2.1°C to 3.5°C in the intermediate scenario (SSP2-4.5) and by 3.3°C to 5.7°C under the very high GHG emissions[11]. The Climate Emergency Institute reports that, by 2050, Southern Africa's temperatures and rainfall are expected to have risen by 2–4°C and to have fallen by 10 – 20 per cent, respectively, compared with the 1961 – 1990 baselines. Droughts are expected to increase in all regions of Africa.

[9] UNFCCC, convention, 1992
[10] IPCC AR6 report,2022
[11] IPCC Sixth Assessment Report of the Intergovernmental Panel on Climate Change (AR6 Report -2021)

1.7.1 Climate Change Patterns in Eswatini

The increase in mean temperature is one of the key indicators that proves the changing climate in Eswatini. The country has been specifically experiencing a rise in daily minimum temperature throughout the year and a rise in daily maximum temperatures during the winter (Eswatini, 2012). Measured change over the 40-year period reaches up to 5°C (Mbabane) at a confidence level of 90% (Eswatini, 2012). Temperature extremes and variations have also been observed from time to time.

In terms of precipitation, trends are less distinct, mostly due to the heterogeneity of rainfall patterns. There is, however, a noticeable increase in rainfall intensity for late summer at certain locations, and that the length of dry spells has decreased (Eswatini, 2012). There is furthermore evidence that the onset of rainfall has been delayed since around 1980, along with a shorter overall rainy season (Eswatini, 2012). Eswatini is also not immune to extreme events, with droughts and floods being relatively common. The effects of tropical cyclones making landfall along the east coast of South Africa and Mozambique are also felt.

1.8 Project's Compatibility with National Climate Commitments (Paris Agreement, NDC and LT-Leds)

The revised Eswatini NDC (2021) outlines the new and enhanced mitigation contributions for Eswatini energy sector as a contribution of Eswatini to the Paris Agreement. The NDC seeks to increase the share of renewable energy to 50% in the electricity mix by 2030 relative to 2010[12] levels through the adoption of solar, wind, biomass, hydro, and solar water heater technologies. Key measures to be implemented include hydropower power generation of about 80MW.

[12] The share of renewable energy in the national energy mix in 2010 was 16%. This includes both grid-connected renewable energy and sustainable/renewable biomass.

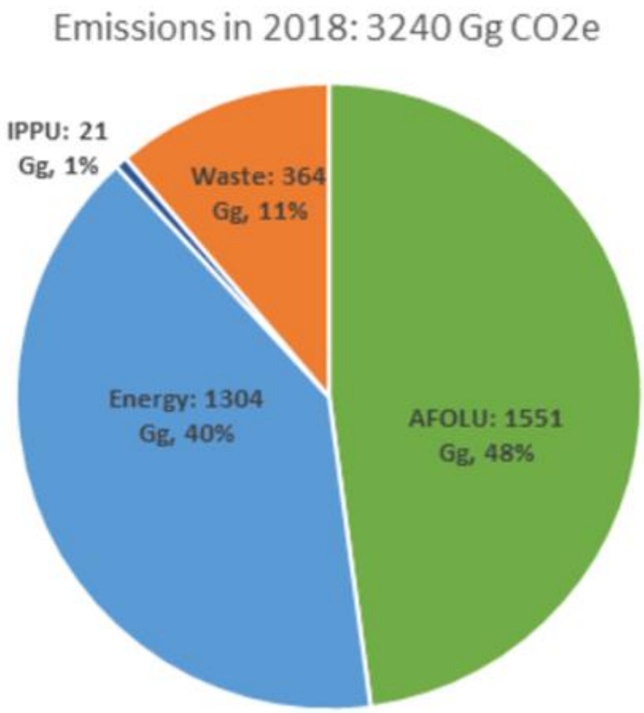

Figure 7 GHG emissions by sector (Source: National Inventory Report (NIR) 2020)

Eswatini's net GHG emissions in 2018 were estimated at 3240.10 Gg CO2e, with the Energy sector contributing 40% of emissions. A low carbon climate resilient development pathway is required to ensure that the country remains low emitters as it develops and takes steps to reduce vulnerability to climate change. Projects such as the Lower Maguduza Hydroelectric power project aligns well with this national commitment and supports the country's renewable energy generation efforts. Developing this project will enhance Eswatini to meet its energy commitment of reducing the use of unclean coal energy imported from South Africa. Pursuing this project the country will reduce its carbon footprint by reducing the use of high carbon energy. Hydropower is regarded as a cleaner energy source hence its promoted in all of the national frameworks of climate change mitigation and adaptation initiatives.

The Kingdom of Eswatini is yet to develop its LT-Leds hence not much of analysis can be drawn on how this project aligns with those initiatives.

2. METHODOLOGY

To assess the impacts of climate change in the project we were guided by the Equator Principles Guidance Note on Climate Risk Assessment, dated May 2023. The guidance ensures that the financing of projects is developed in a manner that is socially responsible and reflect sound environmental management practices while negative impacts on project-affected ecosystems, communities and the climate are avoided where possible[13].

This report is guided by Principle 2 of the Equator principles related to climate assessment, see box below:

Box 1 Principle 2 Guidance for Climate Change Risk Assessment *(Source: Equator Principles)*

> Clients are expected "to include assessments of potential adverse climate change risks as part of the ESIA or other Assessment".
>
> • The Climate Change Risk Assessment should be aligned with Climate Physical Risk and Climate Transition Risk categories of the TCFD.
>
> • PS1 Guidance Note states that the Clients' "risks and impacts identification process will consider the emissions of greenhouse gases, the relevant risks associated with
>
> • Project Categories subject to a CCRA of physical risks (as defined by TCFD) are set; and thresholds (i.e. combined Scope 1 and Scope 2 emissions) are also defined for the inclusion in the CCRA of: 1) climate transition risks (as defined by TCFD); and 2) an alternatives analysis evaluating lower Greenhouse Gas (GHG) intensive alternatives. Requirements under the International Finance Corporation (IFC) Performance Standards (PS), which underpin Principle 2 for Non-Designated Countries and may be used as benchmarks for Designated Countries, include: a changing climate and the adaptation opportunities, and potential transboundary effects."
>
> • PS3 states that Clients should "consider alternatives and implement technically and financially feasible and cost-effective options to reduce Project-related GHG emissions during the design and operation of the Project" and for Projects that are expected to produce more than 25,000 tonnes of CO_2-equivalent annually, the Client to quantify "direct emissions from the facilities as well as indirect emissions associated with the off-site production of energy used by the project".

The other main component of the assessment is to estimate the GHG emissions the project is estimated to produce in tonnes of CO_2-equivalent annually.

To achieve this task, the methodology was limited to the following methods:

a) Literature Review

One of the key reports that were used for the purposes of analysis the impacts of climate change in this study is the hydrology study conducted by Knight Piesold revised in

[13] The Equator Principles_EP_July 2023 (equator-principles.com)

(2024). The study analysed the distribution of rainfall from the time data was available (1970 to 2023). The rainfall trends and data collected from the gauging stations were analysed to establish the changes in the hydrology from which basis of future changes due to climate change could be based.

Other previous assessment studies that were conducted in the Usuthu basin were utilised to validate the projected impacts of climate change in the project area. The analysis was based on local studies conducted by the government whereby analysis of climate change was made. One of the most important literatures was the study conducted by the Department of Water Affairs (DWA, 2014) whereby climate change analysis was conducted to assess the vulnerabilities and impacts of climate change in the Usuthu basin. This study used a combination of GCM models to predict the likely changes in climate and further used a hydrological model to estimate the future stream flows in the 2050's.

The IPCC Climate Change Worst Case Scenario A2/RCP8.5 was used in the assessment. The results from this study were used to understand potential effects of climate change. Several other documents were used to gather more scientific evidence of climate change in the project area. Documents such as the 2nd National communications and Nationally Determined Contributions (NDC) were used in collaboration with international literature specific to our region.

b) Interviews

Various interviews were used to engage with experts in the field to understand how climate change would likely manifest in the project area. The interviews also targeted the communities around the project areas. The communities were engaged to gather their observations on what kind of changes they had experience in the area and how they anticipate will affect the project. This ground truthing help to get the people perspectives on the project on how this the project will be affected by climate change and also how do they think the project can potentially impact climate change.

c) Estimations of GHG Emissions

The Equator Principles guidelines require that projects that produce more than 25,000 tonnes of CO_2-equivalent annually, the Client should quantify "direct emissions from the facilities as well as indirect emissions associated with the off-site production of energy used by the project". This study quantified the estimated ghg emission based on a median greenhouse gas (GHG) emission intensity of 24 gCO_2-eq/kWh - this is the grams of carbon dioxide equivalent per kilowatt-hour of electricity generated allocated over its life-cycle. This was based on an IPP methodology of quantifying /estimating GHG emissions in a hydropower plant.

The evidence collected with these three methods were analysed to access the potential impacts of climate change and expert knowledge was applied to interpret the results. The following section of the report summarises the findings.

3. THE POTENTIAL CLIMATE CHANGE IMPACTS, VULNERABILITIES AND RISKS ON THE PROPOSED LMHPS

3.1 Projected Climate Change Impacts

Projections of future climate are based on global climate simulations known as Global Circulation Models, and these projections are downscaled through various techniques for regional and local forecasts. Different GCM's and downscaling techniques result in a range of possible future climate projections, but it is certain that southern Africa as a whole can expect significant warming trends along with a risk of drying to the west and wetting to the east (South Africa, 2013a). However, it must be noted that the uncertainty with regards to changes to patterns of precipitation remains high, and average variability does not exceed the extremes that already manifest in natural systems (although localised exceedances are expected). As South Africa (2013) indicates: "Many of the projected changes are within the range of historical natural variability, and uncertainty in the projections is high." For the purposes of Eswatini's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), the results of seven statistically downscaled GCM projections were combined to describe likely climate conditions under the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) A1B global emissions scenario1 (Eswatini, 2012). The conditions considered are roughly equivalent to what is currently described as Representative Concentration Pathway (RCP) 6.0 in the Fifth Assessment Report of the IPCC (IPCC, 2013). The results reported in the Second National Communication will be used for this study, along with the projections from the 2013 Climate Trends and Scenarios sub report of the Long-Term Adaptation Scenarios (LTAS) research programme for South Africa (South Africa, 2013a).

The Climate Change Vulnerability Assessment (DWA, 2014) was conducted to understand the possible impacts of climate change in the Usuthu Basin. The climate change projection results are summarized in Table 2 below.

Table 2 Climate change projections in the Usuthu Basin

River Basin	Observed temp. trend (1901-2009)	Observed rainfall trend (1901-2009)	Future projected temp.change (2050)	Future projected rainfall change (2050)
Usuthu	+1.5°C	− High inter-annual variability - − No definitive trend in annual rainfall	+1.5 to +3.5°C	10-15% decrease Some models project 5-10% increase

Source: Climate Change Vulnerability Assessment Report for the Water Sector and Infrastructure (DWA, 2014)

3.1.1 Precipitation Climate Change Projections

From the table above, and through all the literature reviewed it is a common scientific conclusion that there is no clear trend in rainfall whether it will decrease or increase. The Knight Piesold hydrology study (2024) cumulative rainfall analysis shows the accumulated rainfall in a given period of time. This was calculated for the five rainfall stations. The coefficient of determination (R2), values for the linear trend lines show that there is minimal variance in the rainfall data and the projected linear trend line, with the lowest R2 being 99.82% for the closest Matsapha Station, see figure 6 below.

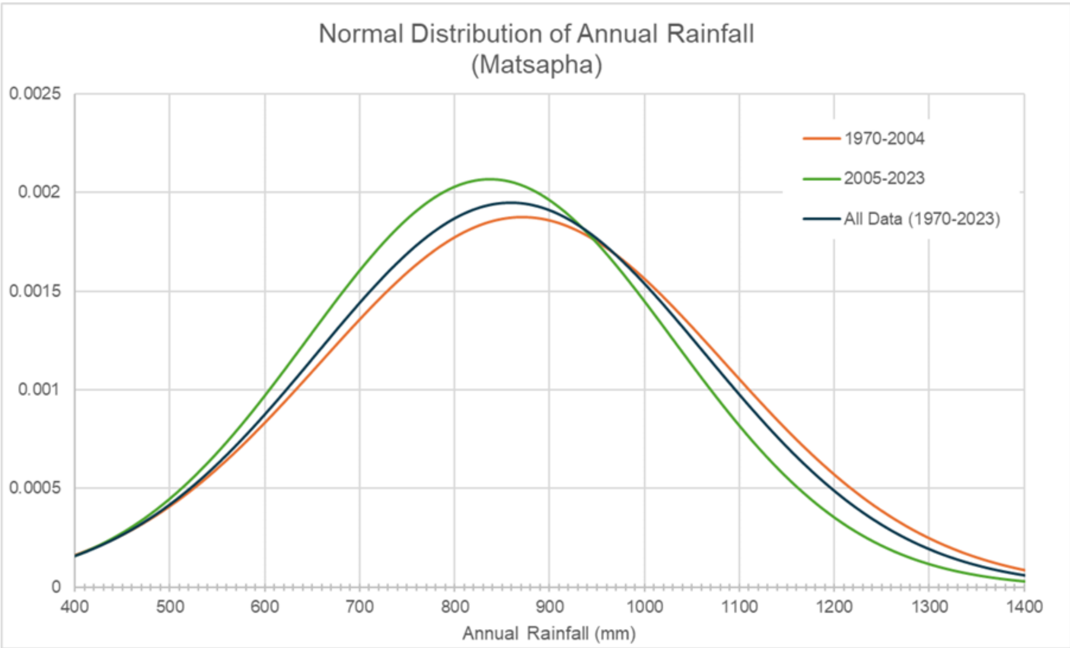

Figure 8 Normal Distribution of Annual Rainfall for Matsapha Station

This trend indicates that the overall rainfall amount has not changed for the past 20 years especially. This therefore indicates that the impact of climate change on the overall rainfall is not significant. Several other studies which modelled the future, e.g. the DWA (2014) Climate Vulnerability Assessment Study projects a similar finding. The amount of rainfall received in the catchment is expected to remain constant going towards the end of the century. Other analyses contained in the Second National Communication predicts that Eswatini can expect an increase in rainfall in all seasons, although the increase will be more pronounced towards the East. Some disagreement exists between different downscaled projections with regards to the mid-century increases, but the general trend remains upwards (Eswatini, 2012). Any negative potential changes in streamflow's of the Usuthu River may be caused by other factors such as changes in land-use as opposed to changes in rainfall. There is however a caution when we consider the year-to-year variations. There will be likely increase in rainfall variability, with some years receiving a lot and some years with droughts. To manage these potential variations, storage will play a significant role.

3.1.2 Temperature

For temperature, the climate change models are in agreement, all predicting increase in the future temperature across the country and in particular in the Usuthu Basin. Over the past period (1901 to 2009) the average temperature in the Usuthu Basin has increased by 1.5°C and projections in the 2050 to 2100's indicates an average increase in the range of +1.5 to +3.5°C. For the near, middle and far (end of century) future, projections show general rising temperatures that are outside of the natural patters of variability. Under the worst-case scenario (the so-called A2 or RCP8.5 scenario sketched by the IPCC, based on very little global mitigation of climate change) the average annual temperature will rise at least 3°C, but possibly even 5°C by the end of the century (South Africa, 2013a). Near future (2015 2035) increases are projected to rise 1-2 degrees above historic values (South Africa, 2013a). Under less extreme scenarios, temperature increases will be limited to less than 3°C by the end of the century (South Africa, 2013a).

3.1.2 Extreme weather events

3.1.2.1 Drought and Floods

Eswatini is prone to extreme weather events such as droughts and floods, in the year 2015/16, the country experienced a severe El 'Nino induced drought ever experienced in 30 years which led to total crop failure and over 80,000 cattle dying. During the last drought of 2015-16, the hydroelectric power generation capacity drastically reduced. Table 3 below shows the recent drought and flood events that have been experienced in the Usuthu Basin in the past 55 years.

Table 3 Recent drought and flood events across the Usuthu Basin

River basin	Recent drought events	Recent flood events
Usuthu	1971-72; 1974-75; 1982-83; 1991-92; 1994-95, 2015-16	1999-2000; 1975-76

According to the (DWA, 2014) the severe drought and flood risk for the Usuthu Basin is projected at 16% and 12%, respectively, in the 2050's and the frequency is projected to increase. Figures 3 and 4 below show drought and flood risks in the country (Source: Dlamini, 2021).

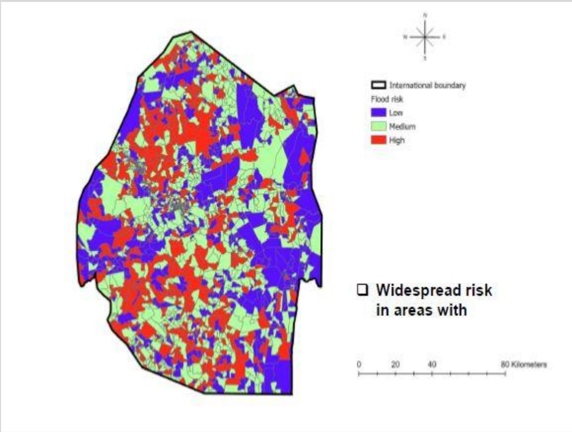

Figure 9 Eswatini Flood Risk

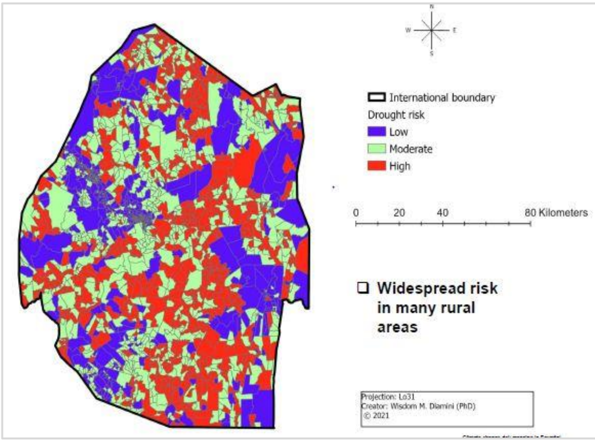

Figure 10 Eswatini Drought Risk

3.1.2.2 3.1.3.1 Storms and Cyclones

Tropical cyclones (tropical storms, hurricanes, and typhoons) associated with very strong and destructive winds are likely to increase with climate change. Warming of the surface ocean from anthropogenic (human-induced) climate change is likely fuelling more powerful Tropical Cyclones. An article published by (NOAA, 2021) indicates that the proportion of severe TCs (category 4 & 5) has increased, possibly due to anthropogenic climate change. This proportion of intense TCs is projected to increase further, bringing a greater proportion of storms having more damaging wind speeds, higher storm surges, and more extreme rainfall rates. Hydroelectric generation and electricity transmission infrastructure remains at risks due to damage by strong wind as a result of tropical cyclones.

3.1.4 Increased lightning

If the difference in electric charge between the ground and the thundercloud becomes large enough, electric current will arc between them as lightning. Because hotter air temperatures produce more water vapor, climate scientists agree that lightning activity will probably increase as the planet warms. Predictions of the extent of this increase have ranged from 5% to well over 100% per each degree in warming[14]. Even though scientific studies have not been conducted in Eswatini, it is a general observation that the frequency and severity of lightning has increased. The lightning strike injects a current into the power system when it hits a transmission line. The magnitude of the generated voltages depends on the current waveform and the impedances through which it flows. The steepness of the voltage wave governs the insulation flashover. Under climate change projects such as Lower Maguduza are likely to experience these effects which may also result to increased claims from clients whose electronic equipment is damaged by high voltage.

[14] Sumner, T. (2014), Lightning strikes will surge with climate change

3.1.5 Wildfires

New research has found that increased spells of severe drought and low humidity are extending the length of the "fire weather" season - at a much faster rate than climate models have predicted. The overall dying of the grass and vegetation increases fire incidences. Eswatini is heavily impacted by wildfires. Figure 5 below indicate the active and burnt area risk prone areas of Eswatini. The proposed project is likely to be affected by the increase in severity and frequency of fire. Hence the project must be careful in its choice of the materials used especially on the transmission lines. This also means that maintenance costs for transmission lines to protect against fire such as bush clearing are likely to increase

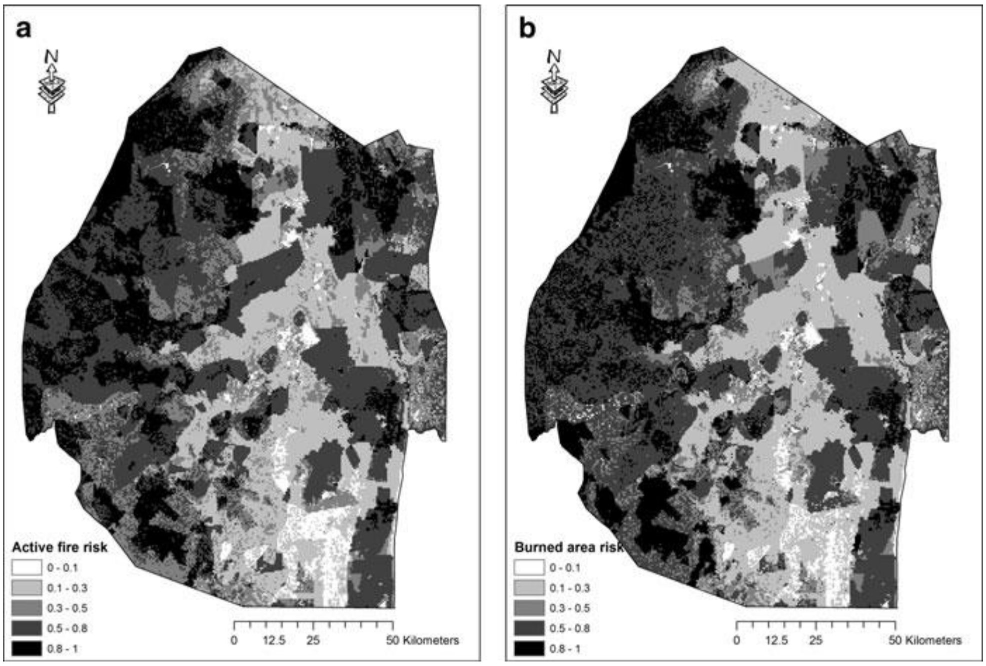

Figure 11 The fire risk maps derived from the MODIS active fire and burned area data *(Source: Wisdom Dlamini)*

From the analysis it is evident that the proposed hydropower generation project is in areas with a high fire risk potential and mitigation measures must be taken into consideration.

3.2 Anticipated Positive Impacts of Climate Change of the LMHP Project

Investing into hydropower project comes with several benefits in curbing climate change.

- Firstly, hydropower is regarded as a clean renewable energy and investing in such projects helps in reducing GHG emissions. The kingdom of Eswatini is importing about 70% of its electricity supply from thermal/coal generation plants in South Africa. This means that about 70% of the electricity consumed in Eswatini is not clean and the carbon footprint is transferred to Eswatini. Investing in the LMHP project will reduce the import of the unsustainable power from South Africa and will contribute in reduce/avoidance of GHG emissions hence reducing the carbon footprint of Eswatini from the Energy sector.
- The LMHP project is benefiting from existing infrastructure such as the Mkhinkomo and Luphohlo dams. This therefore means that the project will have minimal activities

that accelerate climate change e.g. less vegetation removal and led deforestation. Since there will be no new dams constructed, the project is therefore avoiding potential GHG emission generation.

- Impacts confined to a small area; often operated outside the river basin as a separate system that only exchanges the water from a nearby river from time to time.
- Hydropower plants do not emit the waste heat and gases which is common with fossil fuels driven systems. In hydropower systems there is no need for mining and drilling required to access fossil fuels hence the ability for environmental pollution is limited.

3.3 Anticipated Negative Impacts of Climate Change to the LMHP Project

Some of the key negative impacts on climate change on the LMHPS are summarises below:

- Flooding leading to high runoff causing increased sedimentation and increasing costs for dredging in storage and canal systems.
- High temperatures – increasing evaporation from storage dams.
- Flooding that may also lead to dam failure upstream leading to risks flooding the hydropower generation infrastructure/ equipment downstream.
- Droughts, causing low river flows and low water storage which will limit the generation of enough electricity as per designs.
- High temperatures as a result of the changing climate will lead to more evaporation of stored water in upstream reservoir, reducing the potential for power generation.
- Increase incidences of tropical cyclones causing strong winds which will likely damage transmission lines and infrastructure.
- Flooding may cause low lying bridges leading to the power station/generation inaccessible by staff during operation.
- Lightning may induce a high voltage surge leading to damage of client's properties and equipment. This may increase claims from EEC during operations.

3.4 Climate Change Vulnerabilities

The key factors that make the LMHPS project vulnerable to climate change are summarised below:

- **No dedicated water allocation for hydropower generation** – By nature hydropower is a non-consumptive use of water, hence most often not allocated a share in the water resource. This exposes the system especially during droughts where there are low flows in the Usuthu river. This requires storage reservoirs or dams to manage the variability. Since there are the Luphohlo and Mkhinkomo dams upstream, this vulnerability will be addressed.
- **The existing transboundary water sharing agreements** allocates certain quantities of water Eswatini. Presently, the Republic of South Africa is not using its entire share according to the agreements. Adverse weather (such as drought) conditions may lead to South Africa deciding to take its entire share, which will reduce inflows to Luphohlo and

Mkhinkomo dams and subsequent result to rationing and directly limiting the proposed project to generate electricity.

3.5 Anticipated Climate Change Risks for the LMHPS Project

The risk associated with the project sits at the intersect of Hazards, Vulnerability and Exposure elements. Risks are the heart of this intersect as depicted in the diagram below.

The anticipated risks associated with this project due to the climate change impacts and vulnerabilities are as follows:

- **Loss of Income** – this may be due to drought leading to an inability to generate electricity.
- **Increased maintenance and operational costs**- The risks of fire destroying infrastructure, Floods- destroying infrastructure will require more funds reserves for maintenance
- **Increased claims** from clients due to power outages and high voltages that damage client's equipment and infrastructure. This will reduce profits.
- **High investment costs** – may be required to invest into more climate resilient materials for generation and transmission infrastructure.

4. GHG EMMISSIONS AND THE LOWER MAGUDUZA HYDROPOWER GENERATION PROJECT.

According to Principle 2 of the Equator Principles Guidelines (2023), a project is expected to quantify the amount of GHG emissions that are likely to be produced by the project. It is expected that a project reaching above the set threshold of 25,000 tonnes of CO_2-equivalent annually, develops a GHG emissions management/ reduction plan. This section of the report outlines the findings/position of the LMHPs in regard to the threshold.

4.1 Estimation of GHG Emissions for the LMHP Project

One of the expected outputs of this study is to assess the greenhouse gases (GHG) emissions this proposed project will produce annually. According to Principle 2 of the equator principles guidelines, Projects that are expected to produce more than 25,000 tonnes of CO_2-equivalent annually, the Client is expected to quantify "direct emissions from the facilities as well as indirect emissions associated with the off-site production of energy used by the project". It is therefore important to check if the GHG emissions that this project will have exceed the proposed level.

Hydropower is regarded as a clean, renewable, and environmentally friendly source of energy. Renewable energy technologies, such as hydropower, contribute significantly to the reduction of GHG emissions and to the security of the energy supply. In comparison with conventional coal power plants, hydropower prevents the emission of about 3 GT CO_2 per year, or about 9% of global annual CO_2 emissions[15].

In general, hydropower is a source of energy that produces little GHG emissions. According to Alialey et. al (2023), CO_2 emissions per GWh are 3–4 t for hydropower run-of the river, and 10–33 t for hydropower with a reservoir; these values are about 100 times less than the emissions from traditional thermal power. Hydropower creates no direct atmospheric pollutants or waste during operation, and GHG emissions associated with most lifecycle stages are minor. The IPCC states that hydropower has a median greenhouse gas (GHG) emission intensity of 24 gCO_2-eq/kWh - this is the grams of carbon dioxide equivalent per kilowatt-hour of electricity generated allocated over its life cycle. Given the above estimates, the LMHP project is expected to generate 1572 tCO_2-eq per annum. This is very insignificant, and it demonstrates the beneficial effect of hydropower versus thermal power. This project therefore is within the limits of the guidelines and according to the principles there is no need to develop plans to manage GHG emissions.

4.2 Ways in which the LMHP project will reduce GHG emissions

[15] Berga (2016) The Role of Hydropower in Climate Change Mitigation and Adaptation: A Review

The following are ways that this project will likely reduce GHG emissions:

- The project will target to use newer and energy efficient equipment during construction and operation. This would likely reduce the overall GHG emitted by the project.
- Minimum clearance of trees and vegetation to pave way for construction. The LMHP project will have very minimal vegetation clearance during construction. The project is building existing dams for water storage and a weir to control the flows which reduces the risks of inundating new land with vegetation which then releases GHG emissions. The area inundated by the weir will be cleared with trees acceptable to inundation kept in place thereby reducing the amount of GHG from decomposing vegetation die the upstream flooding of the weir. During the construction phase there will be minimum cutting of trees and using designs that are sensitive to the ecosystem around the project area. This may also mean that the number of trees that are cut are replaced through replanting programme to maintain an increase of carbon dioxide sinks.
- Use of company climate friendly company vehicles and equipment during operations leads to reduced emissions. By replacing dirty coal generated electricity by clean green hydro electricity

5. PROPOSED MITIGATION MEASURES

The proposed Climate Change Mitigation Measures for the LMHPS are summarized in Table 4 below. This takes into consideration the potential risks, vulnerabilities and opportunities. The mitigation measures are analyzed and organized as per the various project development stages (i.e. the Planning, Design, Tendering, Implementation, Construction and Decommission stage).

Table 4 Proposed Climate Change Mitigation Measures

Climate change risk activity	**Proposed Climate Change Mitigation Measures**	**Stage of project intervention**	**Evaluation of Environmental Impact**						**Responsibility**
			Likelihood of an impact actually occurring	Extent of the impact	Magnitude of the Impact	Duration of the Impact	Reversibility of the impact	Significance of the impact	
Mitigation measures for project activities that will likely contribute or accelerate climate change									
Cutting of trees for construction purposes	Site clearance designs must ensure minimal cutting of trees	Planning and design stage	5	1	4	4	5	Medium - high	MLH Architects and project designers
	Conduct an inventory of the type and number of trees that will be affected to inform a replanting programme	Pre-construction							Construction Contractors
	All construction companies' staff must be trained by environmental specialists on	Construction planning stage							MLH environment Office/ hired consultants

	tree conservation as per the Construction EMP								
	Develop and implement a plant replanting programme linked to the Construction EMP	Decommissioning stage							Construction Contractors
	EEC should account for these emissions in their GHG emissions inventories.	Implementation stage Decommissioning							
Use of equipment that uses fossil fuels and emits GHG into the atmosphere during construction phase and operational phases.	It is proposed that contractors that tender for work should largely use newer equipment with less emissions. The tendering processes and asset inventories submitted as part of the tender should solicit information regarding the condition of the construction company's equipment.	Tendering and implementation stage	5	2	2	3	4	High	Tender committee, Contractor and Project Managers
	The construction companies should also have a clear plan for minimizing pollution during construction. Equipment used to include heavy machinery should thrive to be less GHG emission and where possible	Construction Phase							Project Managers

	cleaner energy sources such as solar be used.								
	As a long-term investment option, the operating company should consider transforming their vehicle fleet from using fossil fuels to electric vehicles or blended vehicles. It should be noted though that the technology is still at rudimental stage in Eswatini and might not be appropriate in the project, hence this should be considered as a long-term strategy of EEC.	Implementation Phase							Procurement Team
Proposed mitigation measures for impacts of climate change on the Project									
Increased Floods that may cause dam failure and damage to infrastructure	The designs should consider storage weir that is capable of capturing maximum possible water to manage floods, droughts and rainfall variability.	Design stage	2	3	4	1	2	Medium to high	Project design team
Increased Rainfall Variability affecting amount of water availability for power generation			5	3	4	3	2	Medium to high	Operations Department

Increased Droughts leading to less water availability for power generation	Develop early drought preparedness plans for managing power generation during periods of droughts with low streamflow has and low dam level storage.	Implementation stage							Operations Department
Increased Flooding affecting road networks and crossings impeding access to project site	Consider the graveling of roads that lead to the project sites.	Construction stage	5	2	2	1	1	Low	Operations Department
Floods leading to high levels of sedimentation in storage infrastructure	Consider sedimentation removal technologies in the construction and operational designs	Design and operational stage	5	1	3	4	2	Medium	Operations Department
High incidences floods that can potentially cause dam breaks and destroying of the power generation infrastructure downstream	Consider the construction of new infrastructure away from flooding zones as much as possible.	Design stage	2	3	4	4	5	Extreme	Project Designers
	Disaster Preparedness and Management Plans for the project	Planning stage							MLH Environmental Management Office

	Consider taking insurance cover for all downstream power generation infrastructure that is at risk.	Post Project implementation							MLH Management
Increased evaporation from surface storage dams reducing water availability for power generation	The designs of the canals should be in such a way that they allow minimal evaporation. Normally deep and narrow storage dams allow less evaporation	Design Stage	5	2	2	2	1	Low	Project design team and architects
Increase incidences of Fires that can destroy electricity transmission infrastructure	Fire management programme by ensuring adequate allocation of resources for bush clearing	Implementation stage	5	3	4	1	1	Low	MLH Finance and infrastructure maintenance team
	Establish an awareness programme that will train and build awareness of the associated communities on the impacts of fire to the electricity transmission infrastructure	Implementation stage							MLH Project Implementation Team and Environmental Management Office

Increased frequency and incidences of damaging lightning	Ensure the construction follows all safety standards Consider taking insurance cover for major risks and claims from clients	Construction Implementation	5	5	4	1	1	High	Contractors and MLH project managers
Strong winds and Hurricanes that can potentially destroy power transmission infrastructure and buildings	Consider using steel transmission lines posts that are not easily susceptible to breaking due to strong winds and use housing designs that are resilient to adverse weather impacts	Design and construction phase	5	1	3	2	1	Medium	Project design team and Contractors

Score -1 (low) - 5 (high)

6. CONCLUSIONS

Hydropower is considered as one of the cleaner energy sources that has minute GHG emission. Compared to fossil fuel driven systems, hydropower remains the best renewable energy option. The Lower Maguduza Hydro-Power Scheme is one of such projects that has negligible GHG emissions that contribute to climate change. Since this project will not construct any water storage as part of the system but benefit from existing water storage facilities, it is expected that the LMHP project will not contribute much to accelerating GHG emissions. Instead investing in such a project will positively contribute significantly in the lowering of GHG emissions of Eswatini by reducing the importation of coal generates electricity from South Africa and therefore reducing the national carbon footprint. The benefits of investing in this project far outweigh the negative effects.

Climate change is already happening and will likely intensify in the future. The Kingdom of Eswatini is not spared from the catastrophic effects of climate change. The Lower Maguduza Hydro-Power Scheme is likely to experience negative impacts of climate change. Climate induced hazards such as droughts, floods, tropical cyclones, increased intensity and severity of lightning, increased fire incidences are likely to continue and affect the proposed development project. Most effects are going to be as a result of high rainfall variability.

The evidence from all the studies and climate models predicts positive increase trend in temperature. This therefore means that the Usuthu Basin will get warmer. The rainfall component is inconclusive. Historic data from the hydrology study for this project does not reflect changes in the past rainfall trends. Conclusions can be drawn that based on the current trends; the future rainfall might not change. Other factors such as land use may however alter this hydrology, and such must be kept on check. Climate change variability in form of droughts will continue to affect the water availability in the Usuthu Basin, hence managing appropriately the water release from storage is critical for sustaining this project.

Other impacts such as cyclones with strong winds and lightning will likely increase and potentially affect the transmission infrastructure. The project should consider using weather resilient infrastructure such as steel posts that are not susceptible to damage by strong winds. Evidence indicates that wild fires are becoming prominent in Eswatini. This risk possess danger to electricity transmission lines which most often get damaged by wild fires. The infrastructure maintenance plan should include budget for bush clearing measures especially under the transmission lines.

Overall, the assessment indicates that the LMHPS is less susceptible to climate change especially from the water availability point of view as backed by the hydrology study. In addition, the assessment concludes that the project has very minimal contribution to GHG emissions that could potentially exacerbate climate change.

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ANNEX A: IMPACT ASSESSMENT DESCRIPTIVE CRITERIA
Probability, Extent, Magnitude and Reversibility Evaluation

Probability	***Categories 1 – 5***		
Likelihood of an impact actually occurring	Improbable	1	Estimated less than 5 % chance of the impact occurring
	Probable	2	Estimated 5 to 24 % chance of the impact occurring
	Likely	3	Estimated 25 to 54 % chance of the impact occurring
	Very Likely	4	Estimated 55 to 94 % chance of the impact occurring
	Definite	5	Estimated greater than 95 % chance of the impact occurring
Extent	*Categories 1 – 5*		
The area over which the impact will be expressed	Site	1	On site
	Local	2	Within a 20 km radius of the site
	Regional	3	Beyond a 20 km radius of the site
	National	4	Whole country
	International	5	Trans-boundary
Magnitude	*Categories 1 – 5*		
Describes whether an impact is destructive or benign	Very low	1	Natural and/ or social functions and/ or processes are not affected
	Low	2	Natural and/ or social functions and/ or processes are slightly affected
	Medium	3	Natural and/ or social functions and/ or processes continue but in a modified manner
	Medium-high	4	Natural and/ or social functions and/ or processes are disturbed so that they cease to occur temporarily
	High	5	Natural and/ or social functions and/ or processes are disturbed so that they cease to occur permanently
Duration	*Categories 1 – 5*		
Indicates what the lifetime of the impact will be	Very short term	1	1-30 days
	Short-term	2	1-3 months
	Medium	2	3-12 months
	Long-term	3	1 to 2 years
	Permanent	4	Project lifespan
Reversibility	*Categories 1-5*		

Indicate if ease of reversing the impact	Easy	1	Easy to completely restore to original state
	Somewhat difficult	2	Possible to be naturally original state
	Difficult	3	Difficult to go back to its original state
	Very difficult	4	Very difficult to go back its natural state
	Impossible	5	Not possible to reverse

Impact Significance Evaluation

The **SIGNIFICANCE** of an impact is derived by the duration, spatial extent and magnitude. The sum of these is then multiplied by the probability rating.
Significance = Probability x (Extent + Magnitude + Duration)
A colour code is then applied for the number obtained from adding all the criteria in order to provide a significance for each impact.
The table below shows the impact significance ratings

Impact Significance Ratings

IMPACT SIGNIFICANCE			
Significance	*Minimum value of 5, maximum of 20*		
The significance of an impact is derived by taking into account the temporal and spatial scales and magnitude.	Low	20 and below	Low consequence, improbable, minimal mitigation may be required if impact is negative
	Medium	21-40	Medium consequence, probably, mitigation is advised / preferred if impact is negative
	Medium-high	41-60	Medium to high consequence, likely, mitigation is necessary if impact is negative
	High	61-80	High consequence, very likely, mitigation is essential as impact is negative
	Extreme	81-100	Extreme consequences, definite, mitigation is essential as impact is negative