



Eswatini 4th National Communication



Table of Contents

Table of Contents	i
List of Tables	vii
Table of Figures	ix
List of Acronyms	xiii
Acknowledgements	xiv
Executive Summary	xv
1 INTRODUCTION.....	1
1.1 BACKGROUND	1
1.2 CHAPTER OUTLINE	2
2 NATIONAL CIRCUMSTANCES	3
2.1 INTRODUCTION	3
2.2 GEOGRAPHICAL PROFILE	3
2.3 POLITICAL SETUP	4
2.4 ADMINISTRATIVE	4
2.5 WEATHER AND CLIMATE	4
2.6 CLIMATE CHANGE IN ESWATINI	7
2.7 DEMOGRAPHY: POPULATION AND HUMAN DEVELOPMENT INDICATORS	8
2.8 GENDER DYNAMICS AND CLIMATE CHANGE	9
2.8.1 WOMEN IN THE LABOUR FORCE.....	9
2.8.2 PARTICIPATION OF WOMEN IN THE ECONOMY	10
2.9 ECONOMIC OUTLOOK AND DEVELOPMENT	13
2.9.1 ECONOMIC SECTORS	14
2.9.1.1 AGRICULTURE AND FOOD SECURITY	14
2.9.1.2 RAINFED CROP PRODUCTION.....	15
2.9.1.3 SUGAR INDUSTRY	16
2.9.1.4 LIVESTOCK FARMING	17
2.9.2 ENVIRONMENT	17
2.9.2.1 ENVIRONMENTAL ISSUES.....	19
2.9.2.2 LAND DEGRADATION AND HABITAT TRANSFORMATION	20
2.9.2.3 WATER POLLUTION.....	20
2.9.2.4 WASTE DISPOSAL	20
2.9.2.5 INVASIVE SPECIES.....	20
2.9.2.6 UNSUSTAINABLE HARVESTING OF NATURAL RESOURCES.....	20

2.9.3	ENERGY.....	21
2.9.4	INFRASTRUCTURE AND BUILT ENVIRONMENT	23
2.9.5	INFORMATION AND COMMUNICATION TECHNOLOGY	24
2.9.6	TOURISM	24
2.9.6.1	TRAVEL AND ACCOMMODATION TRENDS	26
2.9.6.2	RESERVES AND CULTURAL EVENTS.....	27
2.9.7	WATER AND SANITATION.....	28
2.9.7.1	RIVER AND DAM LEVELS.....	30
2.9.7.2	TRANSBOUNDARY WATER RESOURCES.....	31
2.9.8	HEALTH.....	32
2.9.8.1	NUTRITION AND FOOD SECURITY.....	36
2.9.8.2	WATER AND SANITATION	37
2.9.8.3	HEALTH AND SERVICE DELIVERY	38
2.9.8.4	HEALTH AND EMERGENCIES	39
2.10	INSTITUTIONAL FRAMEWORK ON CLIMATE CHANGE	39
2.11	POLICIES AND STRATEGIES THAT ADDRESS CLIMATE CHANGE	40
2.11.1	ADAPTATION	41
2.11.2	MITIGATION.....	42
2.11.3	PROGRESS ON THE IMPLEMENTATION OF THE NATIONALLY DETERMINED CONTRIBUTIONS (NDC) AND SUSTAINABLE DEVELOPMENT GOALS (SDGs)	44
2.11.4	INTEGRATION OF CLIMATE CHANGE-RELATED POLICIES AND STRATEGIES	46
3	NATIONAL GREENHOUSE GAS INVENTORY.....	47
3.1	NATIONAL GHG INVENTORY METHODOLOGY	48
3.2	QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)	49
3.3	INSTITUTIONAL ARRANGEMENTS.....	50
3.4	KEY CATEGORY ANALYSIS	53
3.5	NATIONAL 2018 GHG INVENTORY SUMMARY.....	54
3.5.1	2018 EMISSIONS BY GAS.....	54
3.5.2	2018 GHG INVENTORY BY SECTOR.....	55
3.5.3	INDIRECT GHG EMISSIONS	57
3.6	ENERGY.....	57
3.6.1	GHG TRENDS.....	58
3.6.2	COMPARISON OF REFERENCE APPROACH AND SECTORAL APPROACH.....	60
3.6.3	RE-CALCULATIONS	61

3.6.4	IMPROVEMENTS SINCE THE 2010 GHG INVENTORY	61
3.6.4.1	SCOPE FOR IMPROVEMENTS.....	61
3.7	IPPU	62
3.7.1	GHG trends	64
3.7.2	RE-CALCULATIONS	65
3.7.3	IMPROVEMENTS SINCE THE 2010 GHG INVENTORY	67
3.7.4	SCOPE FOR IMPROVEMENTS.....	67
3.8	AFOLU.....	68
3.8.1	GHG TRENDS	69
3.8.2	RE-CALCULATIONS	71
3.8.3	IMPROVEMENTS SINCE THE 2010 GHG INVENTORY	72
3.8.4	SCOPE FOR IMPROVEMENTS.....	73
3.9	WASTE.....	73
3.9.1	GHG TRENDS	75
3.9.2	RE-CALCULATIONS.....	77
3.9.3	IMPROVEMENTS SINCE THE 2010 GHG INVENTORY	77
3.9.4	SCOPE FOR IMPROVEMENTS.....	78
3.9.5	NATIONAL GHG INVENTORY TRENDS 1990-2018.....	78
4	GENERAL DESCRIPTION OF STEPS TAKEN OR ENVISAGED TO IMPLEMENT THE CONVENTION.....	80
4.1	PROGRAMMES CONTAINING MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE	80
4.1.1	GENERAL METHODOLOGY	81
4.1.2	CLIMATE CHANGE SCENARIOS.....	83
4.1.2.1	CURRENT CLIMATE AND PROJECTED CHANGES	83
4.1.2.1.1	A SPATIAL PATTERN OF BASELINE TEMPERATURE OVER ESWATINI.....	83
4.1.2.1.2	A SPATIAL PATTERN OF BASELINE PRECIPITATION OVER ESWATINI	84
4.1.2.1.3	STORMS AND LIGHTNING	86
4.1.2.2	PROJECTED ANNUAL AND SEASONAL CLIMATE FUTURES FOR ESWATINI....	87
4.1.2.2.1	TEMPERATURE ANOMALIES.....	87
4.1.2.2.2	PRECIPITATION ANOMALIES	88
4.1.2.2.2.1	PRECIPITATION PERCENTAGE CHANGE	88
4.1.2.3	CLIMATE EXTREME INDICES AND THEIR PROJECTIONS ACCORDING TO ECOLOGICAL ZONES	89
4.1.2.3.1	HEAT EXTREMES	89
4.1.2.3.2	HEAT WAVES	90
4.1.2.3.3	WET EXTREMES.....	91
4.1.2.3.4	DROUGHT	94
4.1.3	SECTORAL ANALYSIS	95
4.1.3.1	INFRASTRUCTURE AND THE BUILT ENVIRONMENT	95
4.1.3.1.1	INFRASTRUCTURE AND CHANGES IN THE CLIMATE SYSTEM.....	95

4.1.3.1.2	POLICIES, STRATEGIES AND LEGAL FRAMEWORKS	96
4.1.3.1.3	VULNERABILITY AND RISK ASSESSMENT	96
4.1.3.1.3.1	INTERGRATED INFRASTRUCTURE VULNERABILITY AND RISK	96
4.1.3.1.3.2	ENERGY SECTOR VULNERABILITY RISK	97
4.1.3.1.3.3	TRANSPORT SECTOR VULNERABILITY ASSESSMENT	98
4.1.3.1.3.4	WATER SECTOR VULNERABILITY AND RISK	99
4.1.3.1.3.5	PUBLIC INFRASTRUCTURE VULNERABILITIES AND RISK	100
4.1.3.1.3.6	INFORMATION AND COMMUNICATION TECHNOLOGY VULNERABILITIES AND RISKS 101	
4.1.3.1.4	PRIORITISED ADAPTATION ACTIONS.....	101
4.1.3.1.5	GENDER AND CLIMATE RESILIENT INFRASTRUCTURE	103
4.1.3.1.6	SUMMARY OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE BUILT ENVIRONMENT	104
4.1.3.1.7	BARRIERS	105
4.1.3.1.8	CONCLUSION	106
4.1.3.2	HEALTH.....	106
4.1.3.2.1	HEALTH AND CHANGES IN THE CLIMATE SYSTEM	106
4.1.3.2.2	HEALTH POLICIES, STRATEGIES AND LEGAL FRAMEWORKS	107
4.1.3.2.3	VULNERABILITY AND RISK ASSESSMENT FOR HEALTH SECTOR	108
4.1.3.2.4	HEALTH SECTOR EXPOSURE TO CLIMATE HAZARDS.....	108
4.1.3.2.4.1	BASELINE EXPOSURE	109
4.1.3.2.4.2	PROJECTED CLIMATE EXPOSURE	112
4.1.3.2.5	POPULATION AND HEALTH INFRASTRUCTURE VULNERABILITY	115
4.1.3.2.5.1	SENSITIVITY	115
4.1.3.2.5.2	COPING /ADAPTIVE CAPACITY	116
4.1.3.2.6	MATRIX OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE HEALTH SECTOR	120
4.1.3.2.7	ADAPTATION MEASURES HEALTH SECTOR	121
4.1.3.2.8	PRIORITISED ADAPTATION ACTIONS FOR HEALTH SECTOR	130
4.1.3.2.9	DIFFICULTIES AND BARRIERS TO, AND ASSOCIATED NEEDS FOR ADAPTATION FOR THE HEALTH SECTOR	131
4.1.3.3	TOURISM	133
4.1.3.3.1	TOURISM AND CHANGES IN THE CLIMATE SYSTEM	133
4.1.3.3.2	POLICIES, STRATEGIES AND LEGAL FRAMEWORKS FOR TOURISM SECTOR.....	134
4.1.3.3.3	VULNERABILITY AND RISK ASSESSMENT FOR TOURISM SECTOR	135
4.1.3.3.3.1	HOSPITALITY INDUSTRY AND TOUR TRANSPORT OPERATORS	137
4.1.3.3.3.2	CULTURAL EVENTS	138
4.1.3.3.3.3	HERITAGE SITES	139
4.1.3.3.3.4	NATURE RESERVES AND GAME RESERVES	140
4.1.3.3.3.5	SPORTS AND ADVENTURE	141
4.1.3.3.4	ADAPTATION MEASURES FOR TOURISM SECTOR	142
4.1.3.3.4.1	HOSPITALITY INDUSTRY AND TOUR TRANSPORT OPERATORS	142
4.1.3.3.4.2	CULTURAL EVENTS	143
4.1.3.3.4.3	HERITAGE SITES	143
4.1.3.3.4.4	NATURE AND GAME RESERVES	143
4.1.3.3.4.5	SPORTS AND ADVENTURE	144
4.1.3.3.5	MATRIX OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE TOURISM SECTOR	144
4.1.3.3.6	BARRIERS, CHALLENGES AND ASSOCIATED NEEDS FOR ADAPTATION IN THE TOURISM SECTOR.....	146
4.1.3.3.7	OPPORTUNITIES FOR ADAPTATION BY KEY TOURISM ACTORS	146
4.1.3.3.8	CONCLUSION FOR THE TOURISM SECTOR	148
4.1.4	ADAPTATION CHALLENGES, NEEDS AND OPPORTUNITIES	149

4.2	PROGRAMMES CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE	151
4.2.1	BASELINE.....	151
4.2.1.1	BASELINE EMISSIONS	152
4.2.2	SECTORAL ANALYSIS	153
4.2.2.1	ENERGY	153
4.2.2.1.1	COMMERCIALISATION OF A 10% ETHANOL BLEND	154
4.2.2.1.2	CONDUCTING STUDIES TO ASSESS ADOPTION OF ELECTRIC MOBILITY OPTIONS 154	
4.2.2.1.3	ELECTRICITY PRODUCTION AND SUPPLY	154
4.2.2.1.4	ENERGY FOR INDUSTRIAL PROCESSES, COMMERCIAL, AGRICULTURE AND RESIDENTIAL ACTIVITIES.....	156
4.2.2.1.5	ENERGY FOR RESIDENTIAL USAGE	156
4.2.2.1.6	GHG EMISSION REDUCTIONS RELATED TO ENERGY EFFICIENCY	156
4.2.2.1.7	METHODOLOGY APPLIED TO QUANTIFY GHG EMISSION REDUCTIONS	157
4.2.2.2	IPPU.....	157
4.2.2.3	WASTE	159
4.2.2.3.1	AVOIDING, MINIMISING AND RECYCLING SOLID WASTE	160
4.2.2.3.2	IMPROVING WASTEWATER TREATMENT AND CONTROL THROUGH EXPANDING SANITATION COVERAGE.....	161
4.2.2.3.3	METHODOLOGY USED TO QUANTIFY GHG EMISSION REDUCTIONS	162
4.2.2.4	AFOLU	163
4.2.2.4.1	CLIMATE SMART AGRICULTURE	164
4.2.2.4.2	FOREST AND GRASSLAND RESTORATION	165
4.2.2.4.3	GHG EMISSIONS REDUCTIONS RELATED TO MITIGATION MEASURES IN AFOLU	166
4.2.2.4.4	METHODOLOGY USED TO QUANTIFY GHG EMISSION REDUCTIONS	167
4.2.3	IMPLEMENTATION CONSIDERATIONS AND IMPROVEMENTS.....	167
5	OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION.....	168
5.1	TRANSFER OF TECHNOLOGIES.....	168
5.1.1	IMPLEMENTATION.....	169
5.1.2	RECOMMENDATIONS.....	171
5.2	RESEARCH AND SYSTEMATIC OBSERVATION	172
5.2.1	SURFACE BASED OBSERVATIONS.....	172
5.2.1.1	STATION NETWORK	172
5.2.1.2	OBSERVED DATA	173
5.2.1.3	CHALLENGES AND GAPS	174
5.2.2	DATA MANAGEMENT	174
5.2.2.1	CHALLENGES	174
5.3	EDUCATION, TRAINING AND PUBLIC AWARENESS.....	175
5.3.1	EDUCATION	175
5.3.2	PRIMARY SCHOOL CURRICULUM AUDIT	175
5.3.3	UNIVERSITY MASTER'S PROGRAMME	176
5.3.4	CHALLENGES	176

5.3.5	AWARENESS RAISING	177
5.4	CAPACITY BUILDING	177
5.5	INFORMATION AND NETWORKING	181
6	CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS	182
6.1	Barriers, measures, and support needed toward climate change adaptation in Eswatini.....	182
6.2	Technical or capacity support needs.....	186
7	References	190
8	Appendices	202

List of Tables

Table 2-1: Summary of economic features including the reference year.	13
Table 2-2: Types of handicrafts produced using different plants species in Eswatini. Source: Pullanikkatil et al., 2021	25
Table 2-3. Number of water service connections and water consumption in Eswatini (Eswatini Water Services Corporation (EWSC), 2021).	29
Table 2-4. The five major dams in Eswatini with the associated river source and storage capacity	30
Table 2-5: The top 10 causes of morbidity and mortality in Eswatini.....	33
Table 2-6. Proportion of population living below the poverty line (Source: National Health Sector Strategic Plan (2019-2023))	35
Table 2-7. Service delivery capacity, by Region (Swaziland NTD Plan, 2015-2020).....	38
Table 2-8. Indicators of health emergency preparedness (NHHSP 2019-2023)	39
Table 2-9. Initiatives implemented by public organisations as per the initial Nationally Determined Contribution (NDC) to the Convention on Climate Change/ Climate Change Policy (Source: ESEPARC (2021))......	44
Table 2-10. Initiatives implemented by organisations in the private sector as per the Intended Nationally Determined Contribution (INDC) to the Convention on Climate Change/ Climate Change Policy (Source: ESEPARC (2021))......	45
Table 3-1: Global warming potential (GWP) values applied in the inventory (IPCC SAR, 1995)......	48
Table 3-2: Summary of the key categories in the inventory, highlighting the absolute value in 1990 and 2018, as well as the percentage contribution over the assessment period.	53
Table 3-3. Summary of GHG Emissions/Removals for Eswatini, 2018 GHG Emissions (Gg CO ₂ e).....	55
Table 3-4. 2018 GHG Inventory Summary.....	56
Table 3-5. Indirect GHG emissions 2018 (Gg).	57
Table 3-6. Summary table of sub-category GHG emissions in the energy sector for 2018.	58
Table 3-7. Summary table of sub-category GHG emissions in the IPPU sector for 2018..	63
Table 3-8. Comparison of emission estimates between the previous inventory of TNC and the current inventory.	67
Table 3-9. Summary table of sub-category GHG emissions in the AFOLU sector for 2018.	69
Table 3-10. Summary table for sub-category emissions in the waste sector for 2018.	74
Table 4-1: ETCCDI extreme climate indices used for the NC4.	82
Table 4-2: Climate Hazards, Associated Risks, and Adaptation Strategies for Communication and Information Infrastructure in the Built Environment	104
Table 4-3: Climate Hazards, Risks, and Adaptation Options for Transport Infrastructure in the Built Environment.....	104
Table 4-4: Climate Hazards, Risks, and Adaptation Options for Water Supply and Sanitation Infrastructure	104
Table 4-5: Climate Hazards, Risks, and Adaptation Options for Public Facilities and Buildings	105
Table 4-6: Natural hazards reported in the EMDAT database for Eswatini (1981 to 2021) and reported in the DisInventar database for Eswatini (2011 to 2020) (source: Dlamini,	

2021).	108
Table 4-7: Health facilities with the highest projected 5-rainfall days, 2071-2100.	112
Table 4-8: Health facilities with exposure to the highest number of projected hot days (2071-2100).	113
Table 4-9: Health facility location with the highest projected annual maximum length of dry spell days (2071-2100).	114
Table 4-10: Climate Hazards, Risks, and Adaptation Options for Health Facilities and Human Health.	120
Table 4-11: Comparison of adaptation measures identified by the NC3TNC, NDC and some strategies and priorities in the NHSSP 2019-23.	124
Table 4-12: Climate Hazards, Risks, and Adaptation Options for the Tourism Sector.	144
Table 4-13: Opportunities for Climate Change Adaptation by Key Tourism Sector Actors	147
Table 4-14: GHG Sources and Sinks GHG emissions totals in 2010.	151
Table 4-15: Aggregated business as usual (BAU) baseline from all sectors (Gg CO ₂ e).	152
Table 4-16: Annual GHG emission reductions from the ex-post assessment of renewable electricity generation compared to the GHG emissions in the 'with policy scenario'.	155
Table 4-17: Annual GHG emission reductions from the ex-post assessment of energy efficiency compared to the GHG emissions in the 'with policy scenario'.	157
Table 4-18: . Annual GHG emission reductions from the ex-post assessment of food waste composting, paper recycling and wood-waste reclamation compared to the GHG emissions in the 'with policy scenario'.	161
Table 4-19: Annual GHG emission reductions from the ex-post assessment of improving sanitation coverage in wastewater handling compared to the GHG emissions in the 'with policy scenario'.	161
Table 4-20: Annual GHG emission reductions from the ex-post assessment of AFOLU mitigation measures compared to the GHG emissions in the 'with policy scenario'.	167
Table 5-1: Priority Climate Adaptation Technologies by Sector	168
Table 5-2: Priority Climate Mitigation Technologies by Sector	168
Table 5-3: Challenges Facing Manual and Automatic Weather Stations (AWS) in Eswatini	174
Table 5-4: Climate-Related Training and Capacity-Building Initiatives by Development Partners	178
Table 6-1: Barriers, measures, and support needed toward climate change adaptation in Eswatini.	183
Table 6-2. Technical and capacity building needs for adaptation	187
Table 6-3. Technical and capacity building needs for mitigation.	187
Table 8-1: The highest ranges found for vulnerability indicators.	205

Table of Figures

Figure 2-1: Map of Eswatini agro-ecological zone and the associated elevation (Rommelzwaal, 1993; Dlamini, 2017).....	3
Figure 2-2: Eswatini administrative boundaries	4
Figure 2-3: Annual temperature anomalies relative to 1961-1990 baseline period calculated from observed, historical data produced by the Climatic Research Unit (CRU) of University of East Anglia.....	5
Figure 2-4: The total average annual rainfall in Eswatini (Source: Meteorology (2021))	6
Figure 2-5: Decline in rainfall over the country (Meteorology Department, 2021).....	6
Figure 2-6: Demographics of Eswatini, Data of UNDESA (Population Division).....	8
Figure 2-7: Urban and b) rural population distribution (source: CSO, 2017)	8
Figure 2-8: National Unemployment by gender (Central Statistics Office, 2020)	10
Figure 2-9: Share of Jobs by Sector by gender, (Central Statistics Office, 2020)	10
Figure 2-10: Number of Maize Farmers in 2014 - 2016 (Ministry of Agriculture, 2020)	11
Figure 2-11: Perceptions on whether climate change affects men and women equally ..	12
Figure 2-12: . Eswatini projection update map for food insecurity phase classification (December 2021 March 2022) (IPC, 2022).....	15
Figure 2-13: Maize Production (Area planted, MT Produced and Yield) 2012 – 2022. Source: Eswatini Ministry of Agriculture, 2022	16
Figure 2-14: Sugar Production (2014-2021) in metric tonnes. Eswatini Sugar Association, 2022.....	16
Figure 2-15: A graphical presentation of the number of red meat livestock in Eswatini from 2011-2018 (Source: Dlamini and Huang, 2019).....	17
Figure 2-16: Vegetation types of Eswatini	18
Figure 2-17: Main River systems of Eswatini.....	19
Figure 2-18: Household access to electricity as a percentage of the total population.....	21
Figure 2-19: Eswatini power plants and electricity transmission network.....	22
Figure 2-20: Total primary energy supply in Eswatini in 2014 (Kingdom of Eswatini, 2018)	23
Figure 2-21: Eswatini transport infrastructure showing roads, railways, and airports	24
Figure 2-22: Geological overview map of Eswatini (modified after Schlüter, 2008). The numbers indicate the following geo-sites: 1: Mahamba Gorge; 2: Sibebe Monolith; 3: Gobholo Cave; 4: Pigg's Peak gneisses; 5: Nsangwini rock paintings; 6: Sandlane rock shelter and paintings; 7: Hholoshini rock shelter and paintings; 8: Forbes former gold mining deposit; 9: Ngwenya iron ore deposit; 10: Bulembu former asbestos mine.....	25
Figure 2-23: Map of accommodation facilities, roads and different ports of entry in Eswatini.....	26
Figure 2-24: : Map of Eswatini's conservation areas and their conservation statuses (a) and a map of the types of ecosystem habits per agro-ecological zones (b). Source: Dlamini (2012)	27
Figure 2-25: Map of Eswatini's protected and protection-worthy areas	28
Figure 2-26: Eswatini's population with access to safe drinking water (source: Department of Water Affairs, 2020)	28
Figure 2-27: Proportion of population using safely treated water between 2012 and 2018	29
Figure 2-28: The location of major dams in Eswatini and their storage capacities ($\times 10^6$ m ³).	30

Figure 2-29: Eswatini River Capacity. 2010 –2018	31
Figure 2-30: Overall dependency ratio by Tinkhundla (Source: CSO, 2017)	35
Figure 2-31: The distribution of the food insecure population by Inkhundla in relation to health facilities (source: VAC, 2022).	37
Figure 2-32 a and b. Eswatini population size (2017) and health facility coverage	38
Figure 2-33. Institutional Arrangements for Compiling the Fourth National Communication.	40
Figure 3-1: Institutional arrangements for the compilation of the GHG emissions inventory (MTEA, 2020).	51
Figure 3-2: 2018 GHG inventory by gas (direct GHG emissions).....	54
Figure 3-3: GHG per sector in the 2018 GHG inventory.	55
Figure 3-4. National GHG emission shares in the energy sector shown by a) sub-category and b) gas for 2018.....	58
Figure 3-5. Energy Sector Emissions by Category.	59
Figure 3-6. Energy Sector Emissions by Gas for the 1990 to 2018 period.	60
Figure 3-7: Energy sector emissions estimated using the reference approach compared to sectoral approach.	61
Figure 3-8: Timeseries of IPPU sector emissions from 1990 to 2018.....	64
Figure 3-9: Direct GHG emissions of IPPU sector by gas in Gg CO ₂ equivalent.....	65
Figure 3-10: Indirect GHG emissions of IPPU sector by gas in Gg.	65
Figure 3-11. National GHG emission shares in the AFOLU sector shown by a) sub-category and b) gas for 2018.	68
Figure 3-12. Land category emissions by land use type from 1990 to 2018.	70
Figure 3-13: AFOLU Sector emissions by Gas from 1990 to 2018.	71
Figure 3-14. AFOLU Sector emissions by Category from 1990 to 2018.....	71
Figure 3-15. National GHG emission shares in the waste sector shown by a) sub-category and b) gas for 2018.....	74
Figure 3-16: Total Waste Emissions by Category 1990-2018 (Gg CO ₂ e).	75
Figure 3-17 : Total Waste Emissions by gas 1990-2018 (Gg CO ₂ e).....	76
Figure 3-18: Comparison of estimated GHG emissions for 2000 and 2010 estimated in the 2010 inventory and the 2018 inventory.	77
Figure 3-19: Time-series of total GHG emissions from 1990 to 2018 including FOLU and excluding FOLU.	79
Figure 4-1: Risk emerges from the overlap of climate hazards, vulnerability, and exposure.....	80
Figure 4-2: CCAM dynamically down-scaled baseline period (1961-1990) OND, JFM and JJA mean maximum temperature (°C) under RCP 8.5.....	84
Figure 4-3: Downscaled baseline period (1961-1990) projected changes in mean annual precipitation totals (mm) under RCP 8.5.	85
Figure 4-4: Rainy seasons (OND and JFM) baseline period ensemble percentiles of CCAM downscaled mean annual total precipitation (mm) under RCP 8.5.	86
Figure 4-5: The ensemble percentiles of CCAM downscaled annual maximum temperature (°C) under RCP8.5 for the periods 2041-2070 and 2071-2100	87
Figure 4-6: The ensemble percentiles of CCAM downscaled annual mean maximum temperature (°C) under RCP8.5 for the periods 2041-2070 and 2071-2100.	88

Figure 4-7: The ensemble percentiles of CCAM downscaled projected changes in annual precipitation total (%) under RCP8.5 for the periods 2041-2070 and 2071-2100 relative to the baseline.	89
Figure 4-8: Downscaled annual mean of the maximum of maximum temperature (°C) (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.	90
Figure 4-9: Downscaled annual mean of the count of heatwave days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.	91
Figure 4-10: Downscaled annual mean of moderate to heavy precipitation days.....	92
Figure 4-11: Downscaled annual mean of the count of consecutive wet days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.....	93
Figure 4-12: Downscaled annual mean of the highest five-day rainfall per year (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.	94
Figure 4-13: Downscaled annual mean of the count of consecutive dry days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.....	95
Figure 4-14: Risk of built environment infrastructure susceptibility to future climate change at Inkhundla level.....	97
Figure 4-15: Variability in altitude and health facility coverage.....	109
Figure 4-16: Health facility location in relation to baseline for a) the annual number of days with moderate to high rainfall and b) the highest five rainfall days per year.	110
Figure 4-17: Baseline exposure of health facilities to a) hot days, b) extreme heat and c) heatwaves.	111
Figure 4-18: Health facility location in relation to the baseline for the annual maximum length of dry spell days.....	111
Figure 4-19: Health facility location in relation to projected precipitation, showing the highest annual five rainfall days for a) 2041-2070 and b) 2071-2100.....	112
Figure 4-20: Exposure of health facilities to projected hot days, a) 2041-2071 and b) 2071-2100.	113
Figure 4-21: Health facility location in relation to the projected annual maximum length of dry spell days, for a) 2041-2070 and b) 2071-2100.	114
Figure 4-22: Trend of Eswatini international tourist visitations by month between 2012 and 2021.	134
Figure 4-23: Diagram showing the methodology used for the vulnerability and risk assessment.	137
Figure 4-24: Most visited towns and tourism attractions plotted against, a) the baseline (1961-1990) and, projected b and c) (2041-2070 and 2071-2100) dry spells	139
Figure 4-25: Most visited towns and tourism attractions plotted against annual percentage of hot days for a) the baseline (1961-1990) and projected change in b) 2041-2070 and c) 2071-2100).....	140
Figure 4-26: Most visited towns and tourism attractions plotted against the annual percentage of hot nights for, a) the baseline (1961-1990) and projected anomalies of b) 2041-2070 and c) 2071-2100).....	141
Figure 4-27: Most visited towns and tourism attractions plotted against, a) the baseline (1961-1990) and, b and c) projected (2041-2070 and 2071-2100) extreme precipitation.	142

Figure 4-28: Annual GHG emission in the ex-post 'with policy' scenario of energy mitigation measures compared to the GHG emissions in the 'with policy scenario' and 'without policy' scenario of the NDC.	154
Figure 5-1: Manual Stations and AWS	173
Figure 8-1. Health facilities by a) areas with the most people and b) areas with the most vulnerable population (source: VAC, 2022).	202
Figure 8-2: Distribution of social vulnerability among Tinkhundla	204

List of Acronyms

AFOLU	Agriculture, Forestry and Other Land Use
Annex I	Parties included in Annex I to the United Nations Framework Convention on Climate Change
BUR	Biennial Update Report
CAEP	Climate Action Enhancement Package
CBIT	Capacity Building Initiative for Transparency
CO ₂	Carbon Dioxide
CH ₄	Methane
COMESA	Common Market for Eastern and Southern Africa
CPEIR	Climate Public Expenditure and Institutional Review
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of Southern Africa
EEA	Eswatini Environment Authority
ERA	Eswatini Revenue Authority
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HDI	Human Development Index
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
MSW	Municipal Solid Waste
MHUD	Ministry of Housing and Urban Development
MNRE	Ministry of Natural Resources and Energy
MoA	Ministry of Agriculture
MRV	Measurement, Reporting and Verification
MTEA	Ministry of Tourism and Environmental Affairs
NAMA	Nationally Appropriate Mitigation Action
NA	Not Available
NC	National Communication
NCCC	National Climate Change Committee
NDC	Nationally Determined Contribution
NDMA	National Disaster Management Agency
NE	Not Estimated
NIR	National Inventory Report
NO	Not Occurring
N ₂ O	Nitrous Oxide
QA/QC	Quality Assurance and Quality Control
SEA	Swaziland Environmental Authority
SF ₆	Sulphur Hexafluoride

Acknowledgements

The preparation and submission of the Fourth National Communication (NC4) of the Kingdom of Eswatini to the United Nations Framework Convention on Climate Change (UNFCCC) was a collaborative effort that involved the participation and contribution of various stakeholders from different sectors and institutions.

Sincere gratitude and appreciation to all those who supported and facilitated this process, including:

- The Global Environment Facility (GEF) for providing the financial resources for the NC4 project through the United Nations Environment Programme (UNEP), UNEP for providing the technical assistance and guidance for the implementation of the NC4 project, as well as the quality assurance and review of the reports.
- The Ministry of Tourism and Environmental Affairs for coordinating and overseeing the NC4 project, as well as providing policy direction and institutional support.
- The National Climate Change Committee (NCCC) for providing strategic oversight and stakeholder engagement for the NC4 and BUR1 projects, as well as endorsing the reports.
- The Department of Meteorology for providing the operational management and technical support for the NC4 project, as well as compiling and editing the reports.
- The national consultants and experts who have conducted the studies, analyses, and assessments for the different components of the NC4, as well as contributed to the writing of the reports.
- The government ministries and departments, non-governmental organizations, private sector, academia, research institutions, media and civil society who have provided the data, information, feedback, and inputs for the NC4, as well as participated in the workshops, consultations, and validation meetings.

Executive Summary

INTRODUCTION

This chapter is dedicated to the introduction of the Fourth National Communication (NC4). Specifically, it highlights that the Government of Eswatini, through the Ministry of Tourism and Environmental Affairs (MTEA), submitted the Initial National Communication (2002), Second National Communication (2012) and Third National Communication (2016) to the United Nations Framework Convention on Climate Change (UNFCCC). The chapter highlights various reports on which the NC4 has been based. These include:

1. Eswatini National Circumstances on Climate Change (2021);
2. Anthropogenic Greenhouse Gas (GHG) inventories of emissions and removal of sinks and measures to mitigate GHG emissions by addressing emissions and removals;
3. Vulnerability and adaptation assessments and other information derived from relevant research initiatives and programs and systematic observations.

NATIONAL CIRCUMSTANCES

Since publishing its First National Communication in 2002, several activities which focused on addressing climate change have been undertaken. These include the establishment of a National Climate Change Committee (NCCC) and other Climate Change Adaptation (CCA) coordination structures. Due to the cross-cutting nature of issues related to climate change, there are several ministries and other national institutions which have been mandated and assigned lead roles important for aligning sectoral policies with requirements for climate action and strengthening stakeholder capacity.

An enabling policy environment has been created that responds to climate change adaptation and disaster risk reduction. The country developed the National Climate Change Policy and Strategy (2016) and the National Climate Change Strategy and Action Plan (2015-2020). In addition, the National Disaster Risk Reduction Policy and National Resilience Strategy and Disaster Risk Reduction Plan of Action (2017- 2021) were developed. Key assessments conducted in the country in the last five years which have highlighted the impacts of climate change at regional and sectoral levels include the annual Vulnerability Assessment and Analysis Report (VAC, 2019), State of the Environment Report (SOER, 2020), Technology Needs Assessment (TNA, 2016- 2018), and two additional National Communication reports to the UNFCCC (Second and Third communications in 2012 and 2016, respectively).

Economic growth in Eswatini over the last decade has been slow due to a combination of many factors. One of the major contributors to low economic production and the much-felt socio-economic hardship is the 2015/2016 drought associated with El Niño. As per the National Disaster Management Agency (NDMA), the drought affected about 50% of the Eswatini population through food security-linked challenges, emanating from livestock loss and crop failure. Despite the country not being a coastal country, it regularly experiences natural disasters such as floods linked to cyclones and major storms coming from the Indian Ocean through the Mozambique Channel. The study confirms that the frequency, severity, and uncertainty of these extreme events are likely to be amplified by climate change. This is in addition to prolonged dry spells. The COVID-19 pandemic also led to a significant downturn in the economy, with the tourism sector, which accounts for 1.2% of the Gross Domestic Product (GDP), having gone through a complete shutdown in response to restricted border movement. The hospitality industry especially suffered, affecting both urban and rural populations through job losses.

While the country needs to explore short-term economic recovery through its fiscal plans, existing climate mitigation and adaptation priorities need not stall. The country could benefit from access to initiatives that implement green recovery models, integrating socio-economic revival and development with long-term technological balance and environmental sustainability.

Agriculture forms the basis of Eswatini's economy and is very susceptible to climate-change-linked shifts in precipitation and temperature patterns, including those of the associated extremes. In the recent past, the performance of sectors such as health and tourism suffered knock-on effects from the highlighted natural disasters that disrupted seasonal climate patterns.

The widescale degradation of wetlands in urban areas of Eswatini is further contributing to water quality and flooding issues. Wetlands play an important role in maintaining local water quality, flood control, and providing fish and wildlife habitats. Shortcomings in legislation impede the EEA prosecution power to litigate cases of wetland destruction and needs urgent action to strengthen regulations to control future urban developments. As precipitation has declined over the past decade, the quantity of water in major rivers has also seen an overall decline. With the projected changes in temperature and precipitation, the country is anticipated to see a 40% decline in streamflow by 2050. This poses a major threat to the increasing demand of water for industries, agriculture, and domestic consumption. Presently, agriculture accounts for 96.6% of the available supply. The decline in streamflow, together with climate change, means that trans-boundary water agreements between South Africa

(upstream) and Mozambique (downstream) are likely to be put under massive pressure.

Eswatini imports most (about 80% in 2018) of her electricity from South Africa. During the major droughts of 2015/16 in Eswatini, internal generation declined from about 25.1% (in 2014) to 9.8% (in 2016), reflecting a significant sensitivity to climate change attributable to mega-droughts. The Eswatini Energy Masterplan 2034 outlined the key strategies to move towards greater energy independence, given the expiration of existing energy agreements with South Africa in 2025. The health sector in Eswatini is traditionally allocated the third-highest budget by the government, with Education and General Public Service receiving the first and second-highest annual allocation, respectively. The significant investment in health over the last decade has improved life for many, but significant challenges remain. According to the UNICEF-Eswatini Report of 2018, 90% of the health sector budget in recent years is consumed by recurrent spending such as administration and salaries, leaving no funding for infrastructure. The fact that donor and government development budgets are not currently integrated reflects a major limitation in informing policy implementation and planning. Despite these challenges, life expectancy for men has increased from 45.3 years (in 2012) to 55.1 years (in 2018). The average life expectancy for both men and women is 57.7 years.

The Ministry of Health, NGOs, and some donor-funded organizations operate major hospitals and satellite clinics spread throughout the country. A four-tier system of service provision is used by the formal sector (Swaziland NTD Plan, 2015-2020). This consists of Tier-1 services (operating at community level); 274 Tier-2 facilities and services consisting of clinics, with rural clinics forming the backbone of primary health care infrastructure; 10 Tier-3 (health centres and regional referrals), and three Tier-4 (national referrals) hospitals. In summary, as of 2018, there were 2.6 facilities per 10,000 population in the country.

ESWATINI GREENHOUSE GAS INVENTORY

The GHG emissions inventory presented in this report covers the period 1990-2018 and includes the Energy, Industrial Process and Product Use (IPPU), Waste and Agriculture, Forestry and Other Land Use (AFOLU) sectors. The total GHG emissions have been steadily increasing since 1990. This is found to be the case with the AFOLU sector included. The increasing emissions in the AFOLU sector are due to the deforestation of indigenous forests and dam infrastructure development.

The inventory was compiled by a team of national experts and international consultants. Quality control and assurance activities occurred throughout the compilation of the inventory, based on the UNFCCC Annex I Review Handbook 6 and input from the national and international experts. All calculations were checked by multiple individuals using a transparent

documentation and commenting system. Additionally, all data sources and calculations were archived on an online archiving site, set-up for Eswatini's GHG inventory. All processes of the calculations and estimations were archived for document integrity, and the data was obtained and cross-checked. The development of the online archiving site represents a key improvement to facilitate the updating and continuous reporting of the country's GHG emissions.

Figure ES 1 shows that 48% of emissions in 2018 were attributed to the AFOLU sector, 40% to Energy, 11% to Waste, and IPPU provides the remaining 1%. Total GHG emissions peaked in 2015, dipped in 2016, before increasing again over the last two years of the time series. The drop in emissions is driven by an increase in the carbon sinks in 3.B.1 Forest Land due to an increase in plantations following a period of prolonged drought. The trend seen in the AFOLU sector is predominantly from emissions and removals from 3.B Land, which are driven by land use change. The Harvested Wood Products category showed a downward trend from 1990, with the sink declining over the time series. In terms of total GHG emissions by gas, the 2018 inventory emissions show that CO₂ is responsible for 52% of emissions, followed by CH₄ at 26%, N₂O at 22% and the F-gases contribute less than 1%.

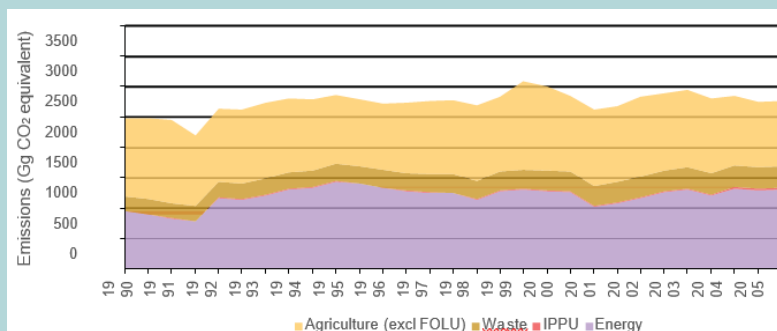


Figure ES 1: Time-series of total sectoral GHG emissions from 1990 to 2018 excluding FOLU.

The GHG inventory was mainly compiled at Tier-1 level with sectoral improvements. In the Energy sector, all emission estimates for this sector were recalculated. A comparison between total emissions in each sub-category of the previous inventory and the current inventory indicates that estimates were similar. The methodology to quantify CH₄ and N₂O emissions in road transportation was moved to Tier-2. Improvements were also made to the IPPU, where recalculations showed that the sector is no longer a key category in the country. This was primarily linked to the previous data used for the TNC to estimate emissions from Refrigeration and Air-Conditioning, being associated with uncertainties. There is a 4.82% reduction in the total emissions from IPPU due to recalculations completed for the 2018 inventory. For the AFOLU sector, category 3B emissions and removals from land were estimated to be lower than reported in the TNC due to the

inclusion of consistent land change maps between 1990 and 2015. This allowed for estimates of emissions and removals from all 6 land classes as well as the conversion between land categories. In addition, carbon stock and biomass data were updated with the incorporation of regional data. For the waste sector, changes to the data used to estimate clinical waste incineration were made. Tier-1 was used in the current waste sector inventory, and the increase in emissions observed relative to the TNC was linked to the increase in population rather than a change in data sources.

VULNERABILITIES AND ADAPTATION

This chapter looks at the analysis shifts in the annual-based extreme climate indices, annual and seasonal precipitation, and maximum and minimum temperature using an approach that is consistent with a multi-model ensemble climate change simulation under RCP8.5 scenarios. High-resolution (8km) climate model downscaling of simulation experiments have been forced with sea-ice and sea-surface temperature forcings from six different General Circulation Models (GCMs).

The chapter also assesses the vulnerability and adaptation to climate change for built infrastructure, health, and tourism sectors. Where relevant, chapter's reflections on sector-specific climate change issues, gender, and youth are also summarized. Each section includes a discussion of present vulnerability and future climate impacts assessment, and concludes with a summary of adaptation options to offset the adverse impacts of climate change and to address the challenge associated with adaptation in Eswatini.

The results suggest that there has been a warming trend over Eswatini during the baseline period 1961-1990. The trend is projected to continue for the studied future periods (2041-2070, 2071-2100). The warming signal in day-time and night-time temperatures in future periods is reflected over all seasons of the year. The observed and simulated declining trend in mean annual total precipitation over the baseline period is mostly weak and not statistically significant. Like most countries in the south-eastern part of Africa, Eswatini is projected to an increased frequency of dry spells, and droughts of increased intensity. Environmental degradation leading to the siltation of dams compounded by increased evapotranspiration has the potential to amplify the hydrological loss and the cost of dam maintenance, with dire implications for water quantity and quality. The country's geographic characteristics and socio-economic conditions contribute to some of the identified vulnerabilities to climate change.

BUILT INFRASTRUCTURE

Eswatini has well-developed built infrastructure which includes an effective road and rail network as well as a reliable supply of electricity and a robust telecommunications system. The country's telecommunications

infrastructure consists of radio, television, fixed and mobile telephones, and the internet. Most of Eswatini's electricity (80%) is imported from South Africa and Mozambique. Domestic energy production in Eswatini is mainly provided by four hydropower plants and sugarcane-based co-generation plants. Solar power has only recently found its way into energy plants and in 2021 a new 10 MW solar plant was developed near Lavumisa. Road transport and road infrastructure together form the largest part of the transport sector in Eswatini. The total length of the road network is 4 879km, 1 117km of which is paved and 3 761 km is unpaved. Eswatini has one public airport, King Mswati III International Airport (KM III) which connects Eswatini directly with the world. The Eswatini Water Services Corporation manages the provision of potable water and wastewater management. There are several dams and water treatment plants which provide potable water for the country, with the five most important dams delivering around 690 million cubic meters. The Nondvo multipurpose dam is planned and under construction. There are several settlements scattered across the country with the only city with a population size over 100 000 being Manzini. The next largest city is Mbabane with 76 000 which is the capital city of Eswatini. Public health infrastructure in Eswatini is made up of government, mission, and private health facilities.

Changes in the climate system will cause new risks to vital infrastructure for energy supply, water supply, transportation system, public infrastructure, and communication systems/ ICT. Climate change will affect infrastructure provision and operation, lifespan, effectiveness, and operating costs. Climate change impacts on built infrastructure depend upon trends in economic development, population changes, and technological changes.

Urban population growth in Eswatini will increase the need for urban infrastructure such as housing, water, energy, sanitation, healthcare, education facilities, and public transport. Some of the existing infrastructure in Eswatini has been deteriorating over the past decade especially in the transport, energy, and water sectors, contributing to their vulnerability to climate change. Land degradation, especially the destruction of wetlands, wide-spread deforestation, soil erosion and proliferation of alien invasive species in Eswatini further increases the vulnerability of built infrastructure by increasing the risk of flooding, landslides, and fire. Land use change through increasing development activities in major centres of Eswatini leads to more impervious surfaces, which also compounds climate impacts on built infrastructure. Although mean annual rainfall is projected to decline over Eswatini, an increase in the intensity of high-rainfall events is projected to occur. This is also amplified by insufficient drainage systems in the urban areas of Eswatini. Poorly maintained roads and bridges that are exposed to more extreme precipitation events can be washed away or rendered impassable. This is especially the case in Manzini, where there is serious road degradation in both rural and urban areas.

The Tinkhundla of Ludzeludze and Lobamba are at the highest risk from climate change due to the density and amount of infrastructure, high population concentration and risk of flooding and land degradation. Other areas of concern are in the north-eastern Highveld region and the Tinkhundla of Ngwempisi, Mahlangatja, as well as areas around Hluti and Hlatikulu. These areas are at higher risk mainly due to land degradation, unpaved roads, and the risk of flooding. A particularly important risk factor for fires is the expansion of the wildland/urban interface in settlements.

Adaptation interventions for the built infrastructure sector in Eswatini can be divided into hard adaptation options, such as the raising of dam walls, building new power generation facilities, reinforcing infrastructure, relocating critical infrastructure, and structural modification of systems. Non-structural or soft adaptation refers to the spatial planning, monitoring and maintenance of infrastructure, as well as maintaining and rehabilitating ecological infrastructure. Many impacts on infrastructure can be mediated by adaptation interventions aimed at restoring biodiversity, catchments, and wetlands through ecosystems-based adaptation. Specific soft adaptation options of importance in Eswatini are the development of climate-sensitive policies, legislation, and development plans that reference resilience to protect infrastructure from known and anticipated climate risks. Other soft adaptation options include developing appropriate monitoring and evaluation systems to assess the effectiveness of adaptation measures, improved weather forecasting capability and implementation of multi-hazard early warning systems, as well as more frequent and enhanced inspection of affected sites.

HEALTH

The health sector, which is already under strain, has been adversely affected by the recent weather and climate extremes in the country and neighbouring countries. Specifically, residents living in informal settlements and rural areas with poor access to treated water are subject to vector-borne diseases such as malaria, which could be linked to significant shifts in temperature and precipitation. This could compromise a decade of progress in malaria eradication should mosquito populations migrate to high-lying areas. The drying of rivers (leading to 40% in stream flow reduction by 2050) and lack of clean drinking water for rural areas could exacerbate the risk of water-borne diseases.

The resilience and subsequent health status of communities is influenced by several factors including:

1. income levels,
2. housing standards,
3. types of labour,
4. exposure to biophysical factors (which include weather and climate conditions),

5. appropriate health service delivery infrastructure and equipment including transport,
6. adequate financing for critical interventions (NHSS, 2019).

The impact associated with climate change is likely to amplify the pressure on the health sector in Eswatini. Challenges in financial governance in the health sector include inadequate tracking of financial resources and expenditure, insufficient accountability, inefficient allocation and use of resources, service expenditure with a curative rather than preventative focus, resources not allocated in an equitable manner, and some critical areas relying on donor funding, which is not sustainable (National Health Sector Strategic Plan (NHSSP), 2019). In 2018, for example, health expenditure only comprised 9.1% of total government expenditure, with a total health expenditure per capita of \$259. The expenditure is anticipated to reach about 15% with a health expenditure per capita of \$310 by 2023 (NHSSP, 2019).

Community health resilience in the face of large-scale changes such as climate change is built on functioning health care systems and capabilities that support physically, mentally, and socially healthy individuals and communities (Wulff et al., 2015).

TOURISM

Tourism is one of the sectors that has seen the negative impacts of climate change. One of the major contributing factors is the heavy reliance of the sector on outdoor activities such as cultural ceremonies, leisure activities, and climate-sensitive ecological resources. However, the potential of the tourism sector to boost the country's economy remains high even under the present climate-change related risks.

The projected changes in extreme precipitation and temperature under climate change have the potential to compound the existing threats experienced by the social, economic, and cultural activities associated with the tourism sector. Specifically, the projected increased frequency or intensity of extreme heat events such as heatwaves may require rethinking of the timing, duration, and financial costs for safely hosting (by tourism operators) or for attending the events (by local, national, and international tourists). The vulnerability assessment reveals that the tourism sectors' climate-change induced risks are strongly linked to the built infrastructure as an enabler of swift, positive tourism experiences. The coping capacity of the sector to enable it to deal with heat and precipitation extremes is critical as it drives perceptions around safety. Investment in the strengthening of early warning systems, relevant climate change response, education, and awareness are thus essential elements to bolster extreme preparedness for the sector.

The Eswatini Government and communities have been innovative in creating an enabling environment, creating visibility, and supporting the economic resilience of the tourism sector over the past decade. Despite these efforts, there is a need for more multi-disciplinary research to evaluate the knock-on effects on the tourism sector of climate impacts in other sectors such as energy, health, water, biodiversity, and agriculture. This is, however, outside the scope of the current assessment.

MITIGATION MEASURES

The Kingdom of Eswatini's National Climate Change Policy (2016) sets the basis for the country's response to climate change and the need to advance mitigation measures. The intent and ambition of these mitigation goals are outlined in the updated Nationally Determined Contributions (NDC) of the country, which sets an economy-wide target of reducing GHG emissions by 5% by 2030, compared to the baseline year of 2010. This chapter reports on the current status of the mitigation measures mentioned in the country's NDC.

Since 2010, when the TNC was submitted, the GHG emissions of Eswatini have increased by 51.9% between 2010 and 2018. Sectoral emission reduction contributions for the 2010-2020 period are 73% from the AFOLU sector, 26% from the energy sector and 0.7% from the waste sector. While the emissions are increasing, the total GHG emission reductions have been steadily increasing due to increased forest and grassland restoration and conversions. These emission reductions were estimated from implemented mitigation measures using an ex-post assessment approach.

In the energy sector, the ex-post assessment of mitigation measures for 2010-2020 indicates that both renewable energy generation and energy efficiency measures were important for mitigation, contributing 59% and 41% of the total energy sector emission reductions, respectively. The total annual emission reductions from biomass, solar, and biomass renewable energy sources increased from 2010 to 2020 due to the increasing electricity generation capacity from biomass. The decline in emission savings from energy efficiency is due to increasing GHG emissions from fuel combustion. Implementation of energy efficiency measures would need to be intensified for this to offset GHG emissions from fuel combustion activities.

In the waste sector, by 2030, Eswatini aims to reduce waste generation through prevention, reduction, recycling, and reuse which is currently achieved through food waste composting and paper and wood recycling. GHG emission reductions from food waste composting and paper recycling, and wood-waste reclamation are observed to pick up from 2018 onwards. Food waste composting emission reductions increased from 0.08 Gg CO₂e in 2018 to 0.43 Gg CO₂e in 2020. Paper recycling and wood-waste reclamation emission reductions increased from 0.10 Gg CO₂e in 2018 to 0.61 Gg CO₂e in 2020. The annual emission reductions from sanitation

improvement declined from 2010 to 2020 as household access to flush toilets with treated sewerage drops over this period.

In the AFOLU sector, mitigation activities in forestland and grassland categories contribute the most to GHG emission reductions in AFOLU, particularly from afforestation and grassland conversion from other land uses. The total annual emissions reductions from forest and grassland restoration actions increased from 584 Gg CO₂e in 2010 to 1367 Gg CO₂e in 2020. The total annual emissions reductions from climate-smart agriculture actions increased from 1.20 Gg CO₂e in 2010 to 1.58 Gg CO₂e in 2020.

FINANCE, TECHNOLOGY AND CAPACITY BUILDING SUPPORT GAPS

Adequate domestic and international financial support is needed to undertake a range of sectoral activities, including technical, capacity building, and project management for the implementation of climate action outlined in the country's Nationally Determined Contribution (NDC) (GoE-MTEA, 2021). Financing required for implementing the climate actions proposed in the Eswatini's NDC was estimated between USD950 million to USD1.5 billion, as outlined in the country's assessment of cost benefit and macro-economic impacts of climate change in Eswatini. The assessment further provides the total cost and breakdown per sector for financing requirements for adaptation and mitigation measures.

Eswatini emphasises an integrative cross-sectoral approach to build climate-resilience through technology adoption and institutional capacity building across sectors. In terms of capacity building and technical support needs, the country faces various barriers and gaps to effective planning and implementation of climate action, such as technology transfer and diffusion, technical knowledge and skills, institutional capacity, access to finance, effective monitoring, reporting and verification (MRV), among others.

The country's TNA identified technology priorities for adaptation and mitigation, alongside delineating the capacity building requirements. Building on these priorities, the country also identified and highlighted specific needs on technology and capacity building for adaptation and mitigation in its revised NDC.

1 INTRODUCTION

1.1 BACKGROUND

The United Nations Framework Convention on Climate Change (UNFCCC) has been instrumental in supporting the global response to the threat of climate change since it entered into force in 1994. The Convention's key focus is to co-operatively combat climate change by limiting average global temperature increases and the resulting climate change, and addressing current and future climate change challenges. In its mandate, the convention contributes to the attainment of sustainable development aspirations to improve the quality of life without amplifying environmental degradation and compromising the resources needed by upcoming generations.

The Kingdom of Eswatini ratified the UNFCCC in March 1995, adopted the Kyoto Protocol in 1997, and accepted the Paris Agreement in September 2016. By ratifying the Kyoto Protocol, the Kingdom of Eswatini demonstrated commitment to seeking global solutions and making local efforts to reduce greenhouse gas emissions and address climate change impacts in pursuance of its national sustainable development. In accordance with Article 4, Paragraph 1, and Article 12, Paragraph 1 of the convention, the country is obliged to prepare, publish, and report its national communication to the Conference of the Parties (COP) to the UNFCCC.

The Government of Eswatini submitted the First National Communication (2002), Second National Communication (2012), and the Third National Communication (2016). The Fourth National Communication builds on work done during the previous communications, and presents updates. This is achieved by contributing content that has not been covered in previous communications and by reporting new developments and changes that must take place in areas that have been covered in preceding national communications.

The Eswatini Fourth National Communication (NC4), under the UNFCCC, has been developed through the Department of Meteorology within the Ministry of Tourism and Environmental Affairs. The project is funded by the Global Environment Facility (GEF) through the United Nations Environment Programme. For the Kingdom of Eswatini, the NC4 is considered as a key tool for awareness creation and knowledge sharing at a national level; an information base for participation in different mechanisms directed towards GHG reduction and adaptation; a recourse for informing policy development, as well as integration of climate change adaptation and mitigation actions into broader national development imperatives. The process towards compilation of the NC4 has strengthened the national capacity to assess GHG emissions and climate change impacts.

The report follows the guideline for preparing the National Communications from parties not included in Annex 1 to the Convention (17/CP.8). To this effect, the NC4 presents a summary of the following reports:

- National Circumstances;
- National Inventories of GHG emissions and removals by

- sinks;
- Vulnerability and adaptation assessments;
- Measures to mitigate GHG emissions by addressing emission and removals;
- Other information in connection with gaps and constraints;
- Financial, technical, and capacity needs.

1.2 CHAPTER OUTLINE

Chapter 1: Introduction: provides the background and highlights the focus of the report.

Chapter 2: National Circumstances: presents an overview of the national circumstances from the perspective of its geography, environment, climate, and socio-economic profile.

Chapter 3: National Greenhouse Gas Inventory: presents the National Greenhouse Gas Inventory for the years 2000-2018.

Chapter 4: General Description of Steps Taken or Envisaged to Implement the Convention: describes the steps taken or planned to implement the convention.

Chapter 5: Other Information Considered Relevant to the Achievement of the Objective of the Convention: provides additional information relevant to achieving the convention's objectives, such as education, and public awareness initiatives.

Chapter 6: Constraints and Gaps, and Related Financial, Technical and Capacity Needs: identifies the constraints and gaps in implementing the convention and outlines the financial, technical, and capacity needs to address these challenges.

Chapter 7: References: lists all the references used in the report.

Chapter 8: Appendices: includes supplementary materials, data, and additional information that support the main content of the report.

2 NATIONAL CIRCUMSTANCES

2.1 INTRODUCTION

This chapter presents an overview of the Eswatini profile from a geographical, climatic, environmental, political, and socio-economic perspective. The key focus is to unpack the development context and sensitivities to climate change and variability. In line with preceding National Communications, the national circumstances are summarized to set the basis for expositions and detailed discussions in the document's bulk.

2.2 GEOGRAPHICAL PROFILE

The Kingdom of Eswatini is a landlocked and mountainous country bordered by only two countries, namely South Africa in the north, west and south and Mozambique in the east. The western border of the country is located at a transition of the South African Plateau (reaching 1 500 m above sea level) to the Mozambican coastal plain. The total area of the country is 17 364 km² and has been classified to four major agroecological zones considering elevation, landforms, geology, soils, climate, and vegetation. The four agroecological zones are known as the Highveld, Middleveld, Lowveld, and Lubombo Plateau. The Highveld (HV), in the west, covers about 30% of the territory and is characterised by high-altitude steppes and extensively planted eucalyptus and pine forests (Mason, 2020). The Middleveld is divided into Upper Middleveld (MU) and Lower Middleveld (ML) which together span about 25% of the surface area. The Lowveld is demarcated into Western Lowveld (LW) and Eastern Lowveld (LE). The Lubombo Plateau (LP) is a narrow strip of land in the far east of the territory, covering about 1 500km² and rising to about 600m above sea level (Rommelzwaal, 1993). See Figure 2-1 for the first level agroclimatic zones.

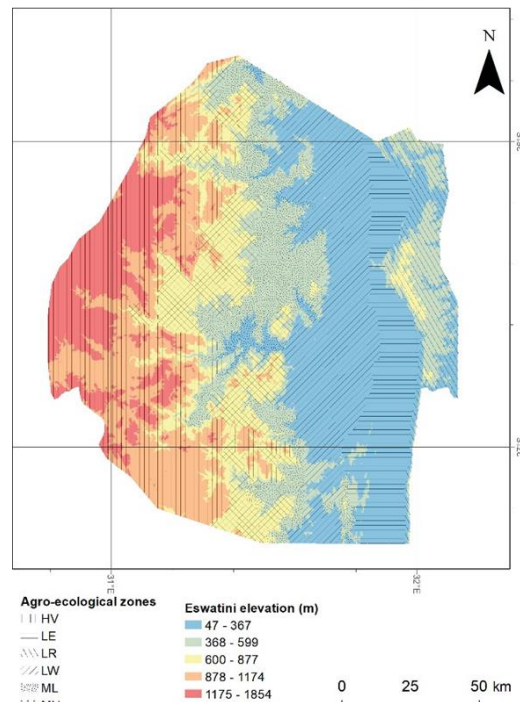


Figure 2-1: Map of Eswatini agro-ecological zone and the associated elevation (Rommelzwaal, 1993; Dlamini, 2017).

2.3 POLITICAL SETUP

The Kingdom of Eswatini is a monarchy with a political and legal system that is dual in nature due to both traditional institutions and western methods of modern governance playing equal and important roles. The Constitution of Eswatini, Act No.1/2005, is the supreme law of the land. The Constitution provides for three organs or arms of government, that is the Executive, a bicameral Legislature, and the Judiciary. Each of these organs is independent from the other arms¹.

2.4 ADMINISTRATIVE

The country practices a Tinkhundla-based electoral system of government in which there are four administration regions comprised of 59 Tinkhundlas, each of which elects a representative to the House of Assembly in Parliament (MEPD, 2019). Regional Administration and Tinkhundla Administration are the second and third level of governance, respectively the number of Tinkhundla centres per region are as follows: 15 in Hhohho, 18 in Manzini, 15 in Shiselweni, and 11 in Lubombo (Figure 2-2).

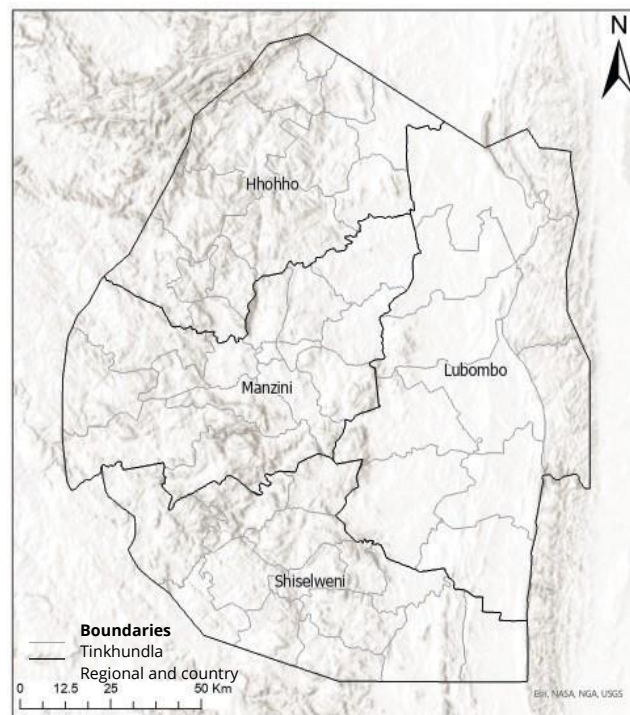


Figure 2-2: Eswatini administrative boundaries

2.5 WEATHER AND CLIMATE

Eswatini is characterised by warm to hot summers (October-March) and cold, dry winters (April-September) with a possibility of frost occurrences in the higher-lying regions. In the Highveld, the highest average monthly temperatures are relatively low reaching as high as 22°C while in the

¹ <https://www.gov.sz/index.php/about-us-sp-15933109/governance>

Lowveld the average monthly temperature rise as high as 29°C. Summer season temperatures between 1961 and 1990 averaged to 22.3 and 22.8°C during the first part of the season (October-December) and the second part of the season (January-February), respectively. The winter season is characterised by the lowest mean temperature of about 16.7°C, while the transition season April-May-June (AMJ) records mean temperatures of about 18.6°C. The departures of the annual mean temperature from the long-term annual mean during the climatological period 1961-1990, as seen in Figure 2-3, has an increasing trend suggesting that the annual temperature during the baseline has been on the rise.

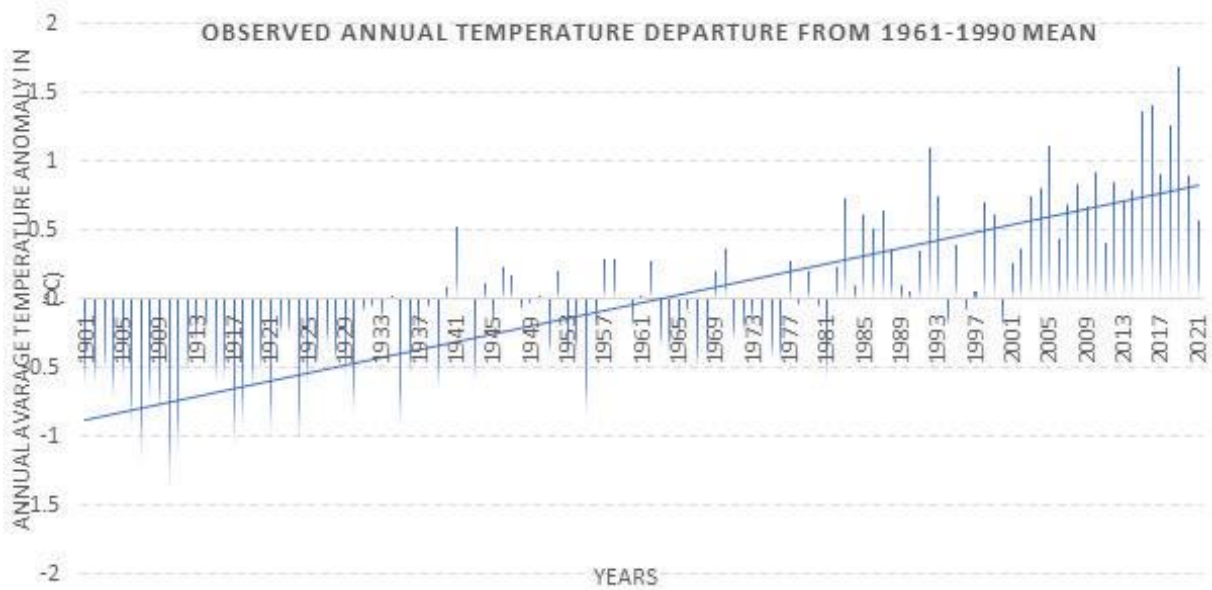


Figure 2-3: Annual temperature anomalies relative to 1961-1990 baseline period calculated from observed, historical data produced by the Climatic Research Unit (CRU) of University of East Anglia

The climate of Eswatini varies from near temperate to tropical. Like most countries in Southern Africa, the climate of Eswatini is influenced by tropical, subtropical, and mid-latitude climate dynamics. The spatial extent of the total average annual rainfall in Eswatini is shown in Figure 2-4. The summer rainfall is attributable to convectional and tropical storms, while winter rainfall is associated with frontal systems (Matondo et al., 2004). Most of the summer rainfall in the country falls between October and March accounting for about 75-80% of the total annual rainfall, while winter rainfall happens between April and September. The Highveld receives the highest annual rainfall accumulation ranging from 900mm to 1500mm. The Lowveld, in the east, records the least rainfall amounting to less than 500mm, making it susceptible to drought. The Lubombo Plateau receives rainfall within the same range as that of Middleveld (700 to 1000mm).

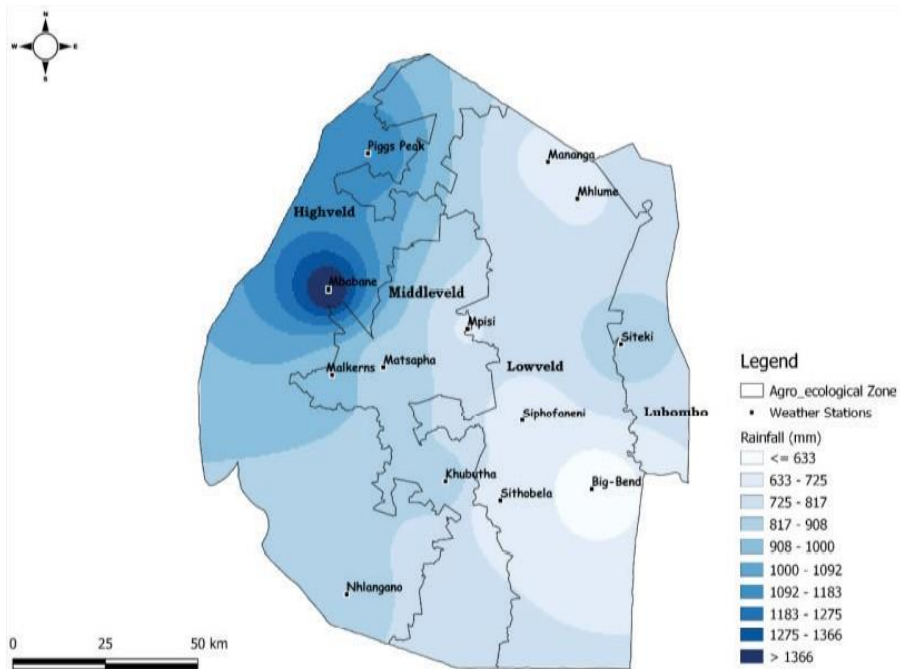


Figure 2-4: The total average annual rainfall in Eswatini (Source: Meteorology (2021))

Rainfall trends, calculated from observations, suggest a decline in rainfall over Eswatini (Figure 2-5), however, the trends have mostly not been statistically significant. The decline in rainfall over the country is accompanied by warming in temperatures with the period 2011-2020 being the hottest on record (World Meteorological Organisation, 2021).

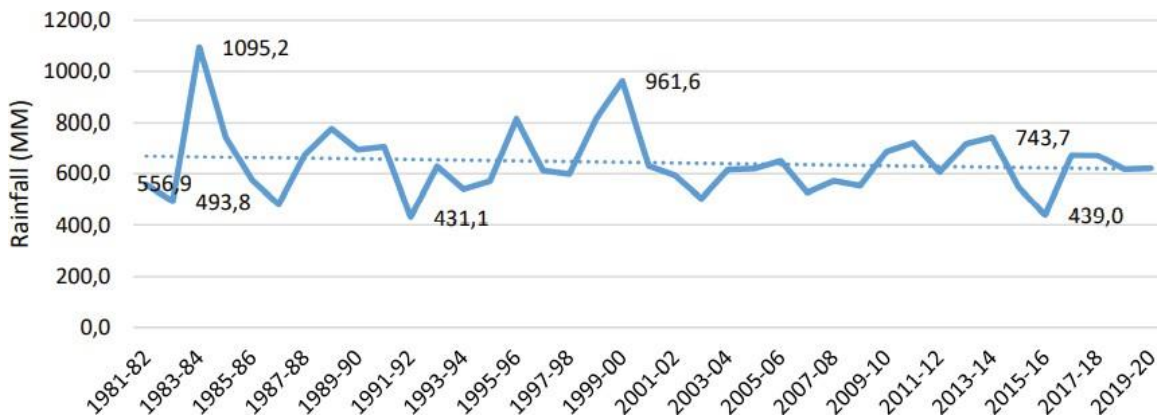


Figure 2-5: Decline in rainfall over the country (Meteorology Department, 2021)

Over Eswatini the changes in temperature and precipitation make the country vulnerable to meteorological hazards such as extreme heat, drought, hailstorms, floods and wildfires. The general increase in temperature and water vapour could be associated with the increase in heavy precipitation associated with tropical storms and cyclones (Tadross et al. 2009; Davis-Reddy and Vincent 2017). Further research is needed to better understand changes in the characteristics of tropical cyclones occurring over the southwest Indian Ocean that make landfall in Mozambique through the Mozambique Channel and subsequently affect Eswatini.

The country's average monthly maximum temperature ranges from 15.1°C (in winter) to 29.5°C (in summer). Average minimum temperatures can go as low as 7.5°C in the coldest winter month and as high as 17.8°C during the warmest summer month. Daytime temperature extremes can rise high as 40°C (in the Lowveld) in summer and drop as low as 0°C in winter (over the Highveld).

2.6 CLIMATE CHANGE IN ESWATINI

In Southern Africa, the decrease in precipitation is mostly found to be simultaneous, with an increase in the consecutive dry days and a decrease in the consecutive wet days (Chemura et al., 2022). These projected changes suggest a significant risk potential to climate-sensitive economic sectors, human livelihoods, ecological systems, and water resources. The IPCC Special Report, on the impacts of Global warming of 1.5 °C above pre-industrial levels (SR1.5), identified Southern Africa as a climate change hotspot. These findings are premised on the fact that the region's subtropical climate is already warm and dry, suggesting that the impacts of climate change are abnormally high in a global change context (IPCC, 2022).

The Third National Communication (TNC) reported a 3°C increase in Eswatini during the 1961 - 2010 period. The temperatures have continued to increase, with the last decade (2011 – 2020) currently being the warmest on record (WMO, 2021). A Vulnerability and Adaptation (V&A) assessment was undertaken (2022) for some of the major economic sectors (health, tourism and built Infrastructure) of Eswatini using publicly available global datasets such as the WorldClimat V2.0 (Fick and Hijmans, 2017) and Agriculture and Food Security (CCAFS) dataset (Navarro-Racines et al., 2020) for the climate change risk mapping. The V&A Assessment dynamically downscaled high horizontal resolution data (at 8 km over Eswatini) to produce anomalies of precipitation and temperature, and the associated extreme climate events' indices.

The assessment indicates a decrease in precipitation, which is consistent with Model outputs, which indicate that a large part of Southern Africa is likely to experience the same. This is found to be consistent with an increase in consecutive dry days and decrease in consecutive wet days (Chemura et al., 2022). Eswatini, like the rest of the world, is also experiencing an increase in average temperatures. These projected changes suggest a significant risk potential to climate-sensitive economic sectors, human livelihoods, ecological systems, and water resources.

The impacts of climate change and its associated extremes in Eswatini, over the years, are most evident in the agriculture and environmental sectors. According to the National Disaster Management Agency (NDMA) report of 2017, the 2015/16 El Niño, attributable to climate change, resulted in crop failure, livestock destruction, and increased food insecurity affecting about 50% of the population in Eswatini. The Vulnerability Assessment Committee (VAC) report of 2018 also pointed out that a decline in rainfall combined with elevated temperatures are key drivers of food insecurity because of crop failure. Potential changes in the temporal distribution of rainfall necessitate robust monitoring systems to inform predictive models and hence, relevant adaptation strategies.

2.7 DEMOGRAPHY: POPULATION AND HUMAN DEVELOPMENT INDICATORS

The total population of Eswatini is estimated at 1,093,238 with 51% representation from women. The population has risen exponentially at 2% or more since the 1950's. But a significant decline was observed in the rate of increase over the past two decades as shown in Figure 2-6 below.

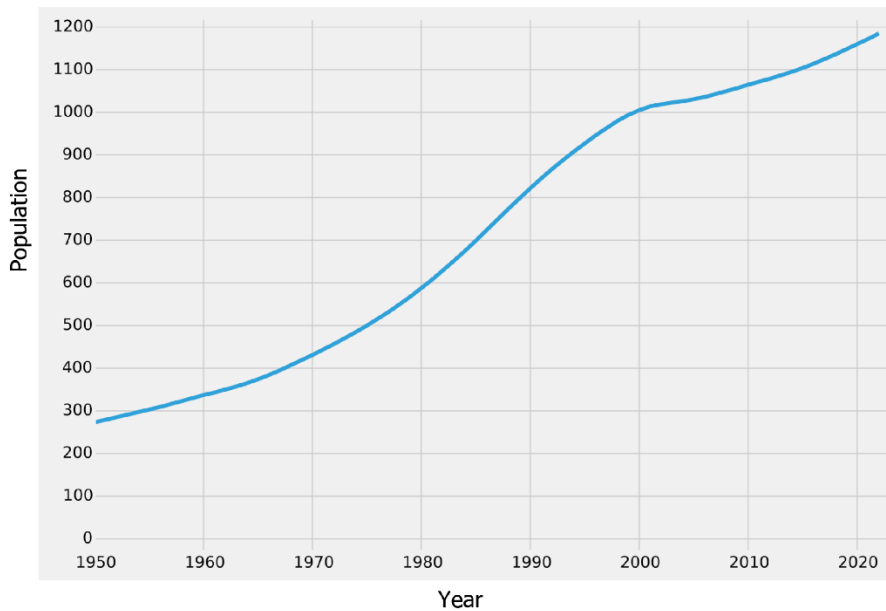


Figure 2-6: Demographics of Eswatini, Data of UNDESA (Population Division)

76.2% of the country's population is classified as rural, with great dependence on urban areas for employment. The remaining 23.8% constitutes urban population, with Manzini and Mbabane concentrating around 20% of the total population. Urban population growth increased from just over 13,000 in 1960 to almost 300,000 in 2021 (CSO, 2017). This translates into almost a growth from 4% of the population that was urbanized in 1960 to 24% in 2021. The distribution of the rural and urban population according to age and sex categories is shown in Figure 2-7.

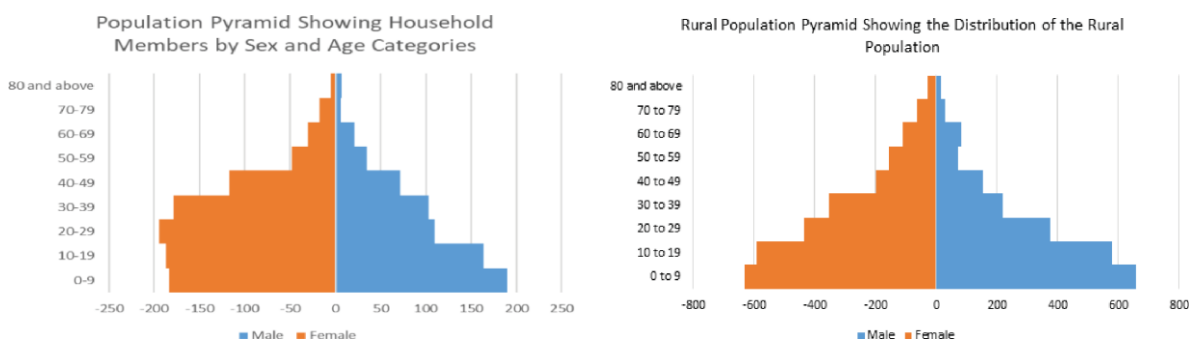


Figure 2-7: a) Urban and b) rural population distribution (source: CSO, 2017)

Figure 2-7 shows that the bulk of the urban population falls in ages 20-49, declining as the population ages. The statistics show that generally the females are more than males, especially in

the rural population. According to the United Nations Human Development Report, the Human Development Index (HDI) of Eswatini improved from 0.46 in 2007 to 0.61 in 2019, deteriorating again to 0.597 in 2021. The Inequality-adjusted HDI for Eswatini (IHDI) was 0.372 in the year 2022, this represented a decline of 0.53% from the previous year (UNDP, 2023). Eswatini's HDI value positions the country in the medium human development category, ranking at 138 out of 189 countries and territories. The inequalities can be attributed to extreme poverty levels and unemployment, a high HIV/AIDS prevalence and uneven distribution of resources which has implications for sustainable development.

2.8 GENDER DYNAMICS AND CLIMATE CHANGE

Eswatini's National Development Strategy (NDS) aims to improve the quality of life in the country through poverty eradication, employment creation, gender equity, social integration, and environmental protection. In Eswatini, females continue to lag behind males in various socioeconomic aspects. Nonetheless, since the last NC the Government of Eswatini has undertaken numerous initiatives to eliminate gender gaps and ensure the full and coherent participation of all genders in achieving national objectives. One of these key initiatives is the adoption of the Sexual Offences and Domestic Violence (SODV) Act in 2018. Women, as well as children and the elderly, are globally more vulnerable to the effects of climate change (Arora-Jonsson, 2011), and Eswatini is no exception. It is therefore imperative for the long-term benefits of societal stability and health that gender balance and equity are resolved.

2.8.1 WOMEN IN THE LABOUR FORCE

Disaggregated unemployment and labour force data (which is reported from 2007 to 2016) shows that women are at a disadvantage in terms of labour force participation and employment rates compared to their male counterparts. The percentage of females who are unemployed is higher than that of males, at 24.8% for females compared to 21.2% for males in 2016. However, it must be noted that this is a significant improvement from the 32.2% and 24.4% unemployment rates, reported for females and males respectively, in 2013, as shown in Figure 2-8.

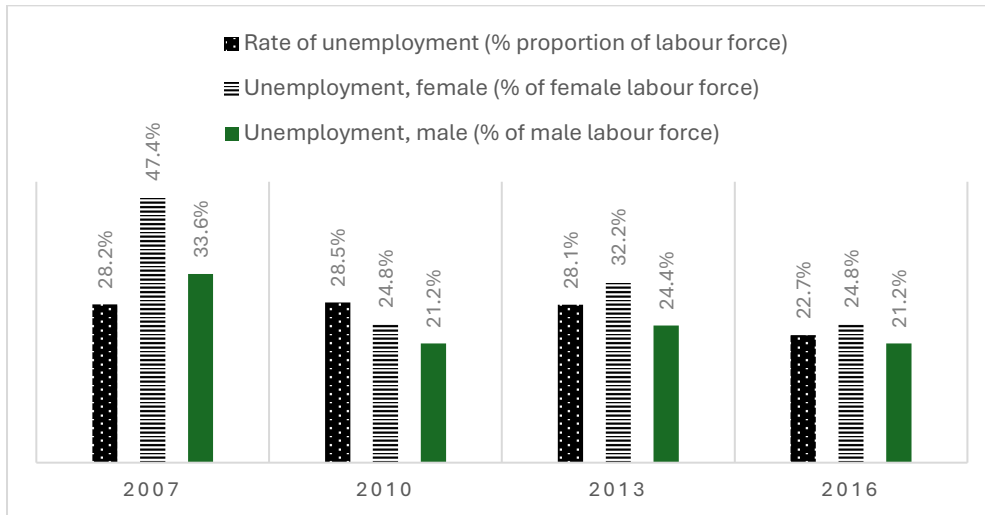


Figure 2-8: National Unemployment by gender (Central Statistics Office, 2020)

Furthermore, there is a higher percentage of females working in the informal sector compared to males, at 70.9% for females compared to 64.3% for males in 2016. There has been a significant increase (for both genders) in the number of people working in the formal sector, as these were reported at 32.5% and 24.9% for females and males respectively in 2013 (see Figure 2-9).

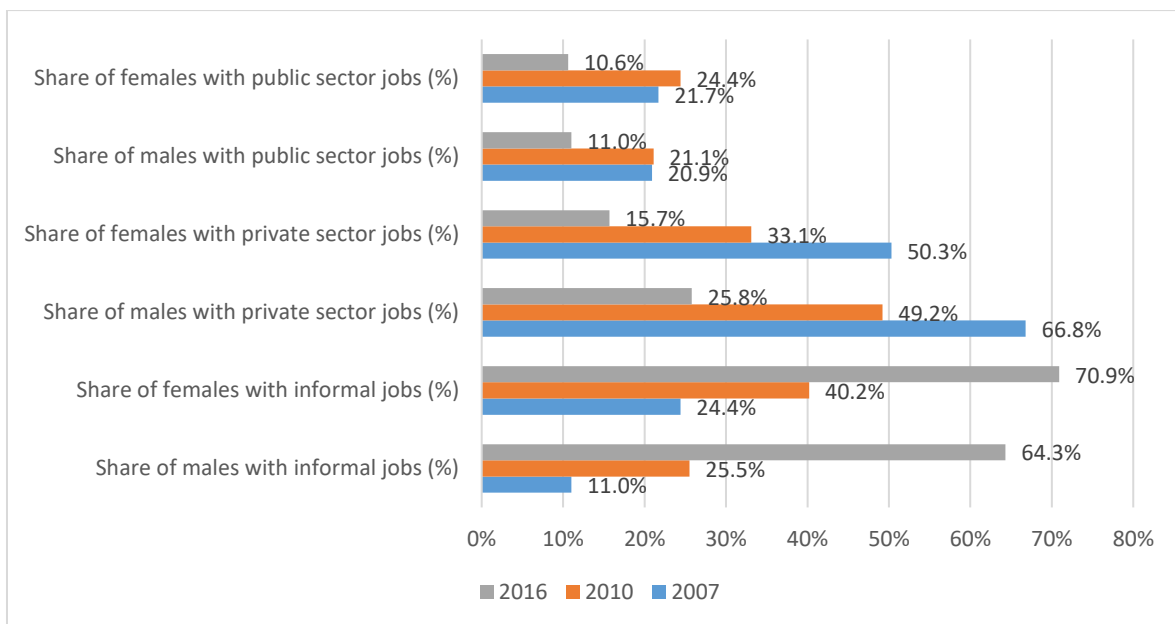


Figure 2-9: Share of Jobs by Sector by gender, (Central Statistics Office, 2020)

2.8.2 PARTICIPATION OF WOMEN IN THE ECONOMY

The Eswatini Household Income and Expenditure Survey (EHIES) shows that in 2018 the gross national income per capita for females was SZL 5720.00 while for males stood at SZL 9640.00. This disparity could mean women have less opportunity to shape their lives and are engaged in less economically productive activities than men. This implies that women in Eswatini are less able to immediately adapt to climatic change related shocks or disasters. In terms of education, literacy

indicators by gender were also provided from 2007 to 2018. Differentials between men and women show that literacy levels for females have been consistently higher than their male counterparts over the years. The literacy rate for women increased from 95.3% in 2014 to 96.7% in 2018 whilst for men it increased from 92.1% in 2014 to 94.3% in 2018. The gender parity index at the primary school level (enrolment) has also evened out from 0.92 in 2012 to 1.01 in 2014, which indicates greater parity between females and males at the primary level. Moreover, the proportion of seats held by women in the national parliament and local government significantly increased from 6% in 2013 to 22% in 2018.

Figure 2-10 shows the number of male and female maize farmers in the years 2014, 2015, and 2016. The three-year trend shows that generally, the number of maize farmers has been increasing across the regions of the country. It is noticeable; however, that the Manzini region has more male farmers compared to the other regions; in 2014 about 1,031 male maize farmers were recorded compared to 588 female farmers, whilst in 2016 the number of male farmers tripled to 3,801 compared to 1,710 female farmers. Nevertheless, the graph also shows that in the regions with lower social and economic wellbeing (Shiselweni and Lubombo) the number of female farmers is increasing. This may also be explained by the support targeted by non-governmental organisations, such as COSPE and the Rural Women's Assembly, who are specifically supporting women farmers in these regions.

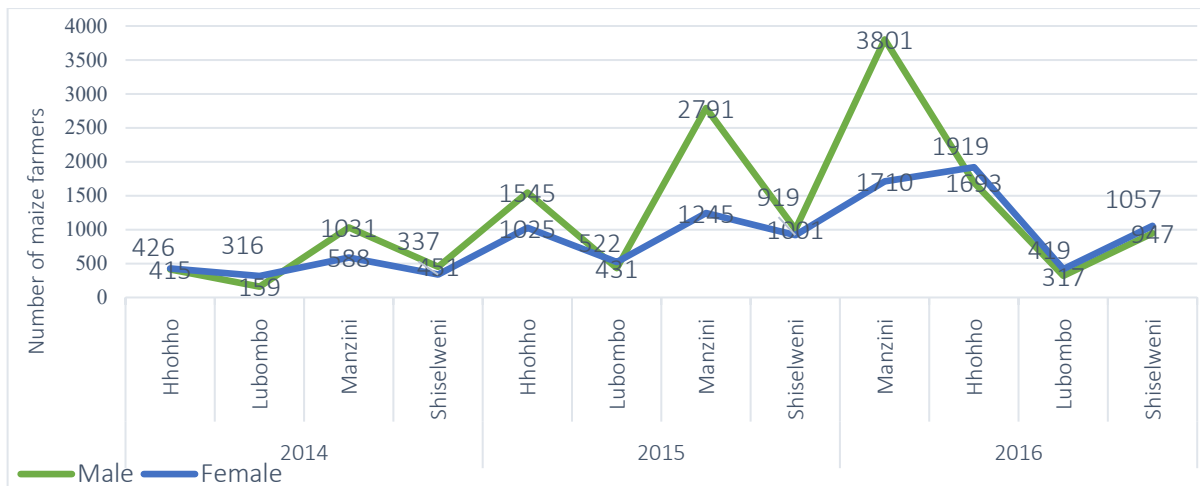


Figure 2-10: Number of Maize Farmers in 2014 - 2016 (Ministry of Agriculture, 2020)

Information on gender from the public awareness survey shows that a majority (29.1%) of participants in urban areas do not believe that climate change affects men and women equally (refer to Figure 2-11). Similarly, about 15.3% of participants in rural areas believe that climate change does not affect men and women the same way. On the other hand, about 20.7% of the urban participants perceive that climate change affects men and women equally. Additionally, only 5.9% of participants in the rural areas somewhat believe that climate change affects men and women equally. This indicates that participants in rural and urban areas do understand that climate change can be a gendered issue, as it affects them differently.

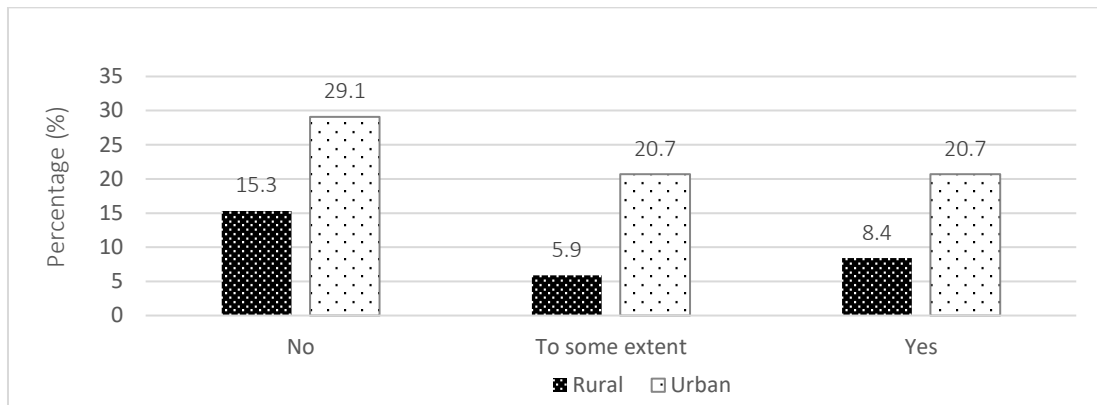


Figure 2-11: Perceptions on whether climate change affects men and women equally

To supplement the secondary data, and to understand if gender is mainstreamed in climate change institutions, data was also collected from key informants in NGOs, as well as the private and public sectors. The results show that about 65% of institutions do integrate a gender consideration into the development of climate policies, plans, and actions within their organisations. Also, 66.6% of the organisations purposely target gender in their climate change projects or activities. Even though about 61% of the organisations perceive that climate change impacts more on females than males, only 35% of the organisations have facilitated/developed gender-responsive climate change programs in the past 5 years. Results also show that 35.7% of organisations perceive that climate change affects males and females equally. This shows that the development of climate change policies and plans within an organisation does not guarantee the awareness of the gender-bias of climate change, nor the implementation of gender-responsive programs.

Of the implemented projects, 83% of women participated in decision making. Most of the projects specifically benefit women compared to men. For example, of the 50,000 beneficiaries from Eswatini Water Services Corporation (EWSC), about 70% are female. Also, from a total of 1,400 beneficiaries with the NGO ACAT 70% are female. Another NGO, Green Living Movement, consists of 190 females which represents 63% of all beneficiaries.

According to the survey, the difference between men and women lies in the fact that, as much as both men and women live in the same household, most households depend on women for daily resilience. As a result of social norms, everyday roles of the two groups vary, with women having the primary responsibility for providing water, sanitation, food preparation, farming and child care. The impact of climate change has increased the burden as women carry out their household duties. With the drying of rivers and loss of forests due to prolonged dry spells, women now travel long distances to seek water and firewood. There are increased risks of attacks in these longer journeys, as well as the heavy strain of transporting water over long-distances (especially if they are with a child). Rural and uneducated women often depend on the environment for subsistence farming and income, and therefore climate change often burdens them more than men in this regard, and will continue to do so as the impacts become more severe.

2.9 ECONOMIC OUTLOOK AND DEVELOPMENT

Eswatini's economy is predominantly driven by agriculture-based industries, contributing nearly 6% of the country's gross domestic product (GDP). Sugar cane, citrus, pineapples, and cotton are the main economic activities in this sector. The informal agricultural sector provides a livelihood for three quarters of the population, who reside in rural areas, particularly through rain-fed subsistence agriculture mainly maize and livestock (cattle and goats). The informal agricultural sector is also responsible for producing maize, legumes, sorghum, and sweet potatoes. The manufacturing and forestry sectors are also key contributors to the GDP, with the manufacturing sector accounting for approximately 27% of the GDP and the forestry sector providing employment for thousands of people in Eswatini. Services account for more than half of GDP. The annual average growth rate of GDP per capita was 5.1% between 1971 and 2018, with GDP per capita reaching \$4,146 in 2018. In recent years the economy has faced challenges of slow economic growth, high levels of youth unemployment, inequality, and poverty. In addition to this there is a high incidence and prevalence of communicable (HIV and TB) and non-communicable diseases that also negatively impact on the economy. These challenges have been further compounded on by the COVID-19 pandemic, with the GDP estimated to have contracted by 2.4% in 2020. The adverse impacts of COVID-19 on livelihoods will most likely lead to a stagnation in poverty rates in the near-to-medium term through a reduction in employment incomes and remittances, among other channels. A summary of the economic features of Eswatini for 2018-2021 is given in Table 2-1.

Table 2-1: Summary of economic features including the reference year.

Indicator Name	2018	2019	2020	2021
GDP, PPP (constant 2017 international \$)	9.68E+09	9.94E+09	9.79E+09	1.06E+10
Gini Index				
GNI (constant 2015 US\$)	3.98E+09	3.94E+09	3.89E+09	4.3E+09
GNI (current US\$)	4.34E+09	4.04E+09	3.59E+09	4.36E+09
GNI growth (annual %)	1.871617	-0.98437	-1.32694	10.64224
GNI per capita (constant 2015 US\$)	3427.164	3366.779	3291.034	3605.798
NI per capita (constant LCU)	33276.7	32690.38	31954.93	35011.18
GNI per capita (current LCU)	49559	49948.41	50084.78	54085.55
GNI per capita growth (annual %)	1.07819	-1.76194	-2.24977	9.564279
GNI per capita, Atlas method (current US\$)	3550	3630	3360	3650
GNI per capita, PPP (constant 2017 international\$)	7746.02	7609.54	7438.343	8149.766
GNI per capita, PPP (current international \$)	7950	7970	7880	8950
GNI, PPP (constant 2017 international \$)	8.99E+09	8.9E+09	8.78E+09	9.72E+09
GNI, PPP (current international \$)	9.23E+09	9.32E+09	9.31E+09	1.07E+10
GNI: linked series (current LCU)	5.75E+10	5.84E+10	5.91E+10	6.45E+10
Human Capital Index (HCI) (scale 0-1)	0.369541		0.372501	

1 <https://hdr.undp.org/data-center/human-development-index#/indicies/HDI>

2 https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD?most_recent_year_desc=false

Source: World Development Indicators (<https://data.worldbank.org/country/SZ>)

2.9.1 ECONOMIC SECTORS

2.9.1.1 AGRICULTURE AND FOOD SECURITY

Smallholder agriculture forms the backbone of rural livelihoods in Eswatini, and together with the commercial sector contributes 8.5% of the country's GDP. Food is produced on both freehold or 'title deed land' (TDL) as well as through subsistence farming on customary or 'Swazi Nation Lands' (SNL) (FAO et al., 2022). TDL is used for commercial farming in which significant areas are under irrigation. Approximately 79% of freehold land is planted and contributes approximately 80% of overall agriculture production (Eswatini, Ministry of Economic Planning and Development, 2018). SNL is used for rain-fed cropping and grazing, with approximately 55% of these lands under crops.

Over 70% of the country's rural population, 60% of whom are women, is dependent upon subsistence agriculture. According to FAO's most recent hunger figures, one in three people in Eswatini is undernourished (FAO et al., 2022). Between December 2021 and March 2022, around 336,000 people (29% of the population in Eswatini) are estimated to be facing high acute food insecurity (IPC Phase 3 Crisis or above) and require urgent humanitarian assistance (IPC, 2022). The prevalence of food insecurity is the result of the protracted consequences of the COVID-19 pandemic, increasing levels of unemployment (which have risen from 23.5% in 2020 to 33.5% in November 2021), and increasing food prices. The result is high poverty levels in the country which leaves the poorest people chronically vulnerable (Castro and Byenkya, 2019)

Eswatini is highly dependent on food imports to feed its people, with major imports being wheat, yellow maize, rice, and whole maize while the imports of fruits and vegetables have also grown substantially in recent decades. Major constraints to national production include frequent droughts, erratic rainfall, prolonged dry spells, rudimentary farming technology, low investment in seeds, fertilizers and equipment, and structural barriers preventing access to formal markets. This situation appears set to continue, with imports likely to increase further (FAO et al., 2022). Figure 2-12 shows the Eswatini projection update map for food insecurity phase classification.

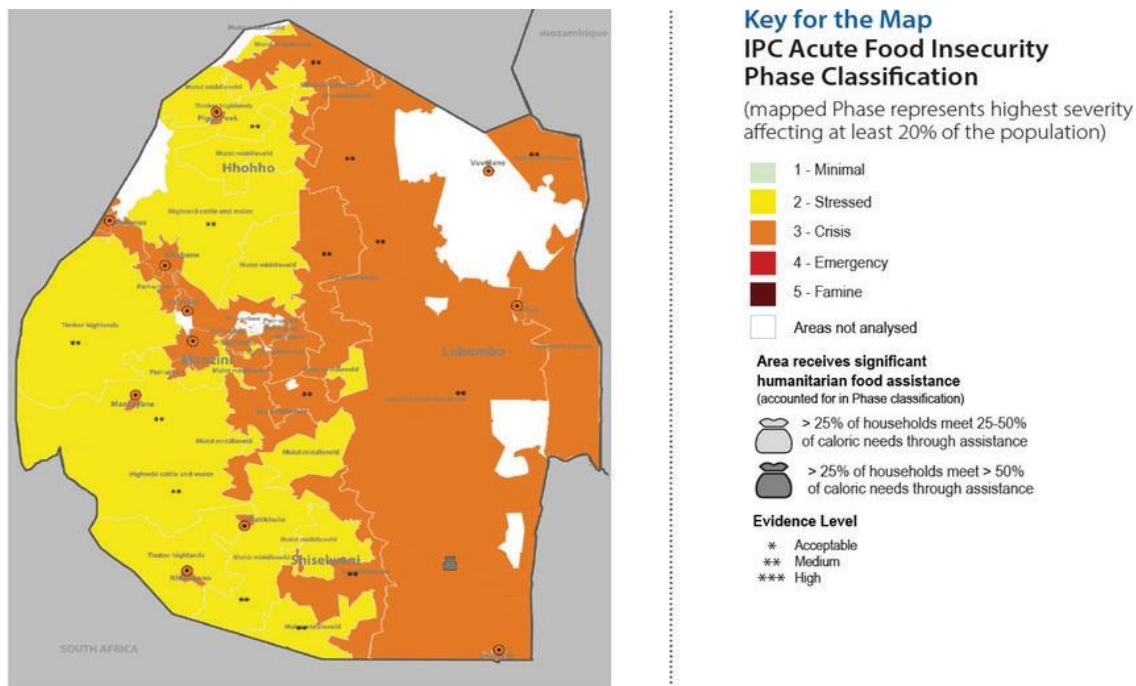


Figure 2-12: . Eswatini projection update map for food insecurity phase classification (December 2021 March 2022) (IPC, 2022)

2.9.1.2 RAINFED CROP PRODUCTION

Eswatini is a food-deficit country and imports grains to meet the domestic demand gap, mainly from neighbouring South Africa. Maize is the staple food of Eswatini, and it is the main crop grown by most of the smallholder farmers. These farmers combine maize farming with traditional livestock-keeping practices and tend to have low output and productivity, use traditional tools, apply few improved inputs (such as fertilizers), and have little capital expenditure. Maize production occupies 84% of total area under crop production under the Swazi Nation Land (Figure 2-13). Other crops that are grown include cotton (in the Lowveld), groundnuts (Middleveld/SNL), legumes, root crops (sweet potato), and sorghum. The production of maize is mostly rain-fed and average maize yields are around 1.1 tonnes/ha which is well below the estimated potential of 4–6 tonnes/ha (Eswatini, Ministry of Economic Planning and Development, 2018). This causes a shortfall in the domestic demand, which is then mostly supplemented by imports from South Africa. Due to a significant increase in rainfall during the 2021/22 season as compared to the long-term average for the period October 2021 to March 2022, there was a 27% increase in maize yield from the 2020/2021 season. The above-normal rainfall conditions also had a huge positive impact on the yield of other crops such as Sweet Potatoes, Sorghum, Legumes/pulses beans, groundnuts, and cowpeas. Maize is particularly susceptible to climate change, with huge implications on its production by 2050 due to climate change (Cairns et al., 2013). More climate-resilient maize systems are needed, with increased studies on, or diversification towards, exploring more drought-resistant crops such as sorghum and millet.

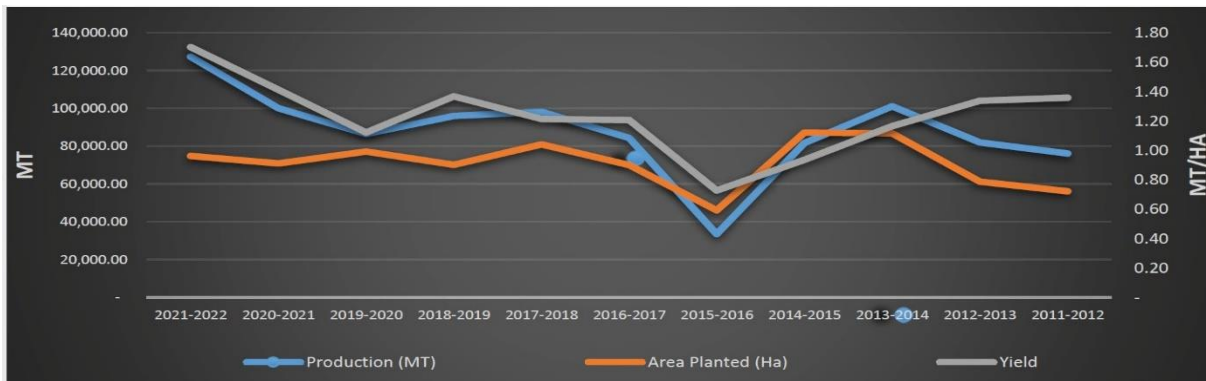


Figure 2-13: Maize Production (Area planted, MT Produced and Yield) 2012 – 2022.

Source: Eswatini Ministry of Agriculture, 2022

2.9.1.3 SUGAR INDUSTRY

The sugar sector is considered the ‘heartbeat’ of the Eswatini economy and contributes between 12% and 16% to the country's GDP, while also directly employing about 16 000 workers. Sugarcane is grown under irrigation mainly in the Lowveld of the country on 60 000 hectares of land. The sugar industry comprises three sugar cane millers, four sugar estates (large-scale sugar cane producers holding land that exceeds 1 000 ha each), 38 medium-scale sugar-cane farmers (holding land between 50 and 1 000 ha), and more than 2 500 small-scale farmers (less than 50 ha of land, as classified by the Eswatini Sugar Association, mostly on Eswatini Nation Land) (ESA, 2021). Smallholder sugar cane production is seen as a crucial means of overcoming rural poverty in the poorest region, the semi-arid Lowveld.

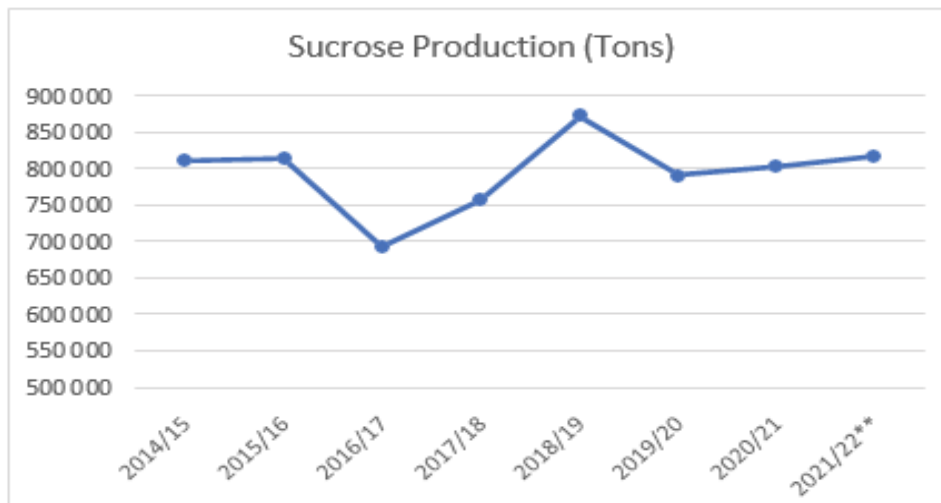


Figure 2-14: Sugar Production (2014-2021) in metric tonnes. Eswatini Sugar Association, 2022

Sugar estates, large and medium sized, as well as small sugar cane growers, comprise the Eswatini sugar industry, and the industry is centrally regulated by the Eswatini Sugar Association (ESA) which runs all sales and marketing to international markets (EU, SACU, COMESA, and world market). The

Southern African Customs Union (SACU) is the most important market for this, accounting for 45% to 70% of sugar exports.

2.9.1.4 LIVESTOCK FARMING

Livestock rearing is an important livelihood strategy and source of food security for most Swazi people in rural areas. While livestock production ensures both income and food, it also provides manure for crops and plays an important role in the cultural context. The livestock sector is, however, characterized by low productivity, mainly due to overgrazing, poor nutrition, and poor management practices (Eswatini, Ministry of Agriculture, 2015). Figure 2-15 shows a graphical presentation of the number of red meat livestock in Eswatini from 2011-2018 (Dlamini and Huang, 2019).

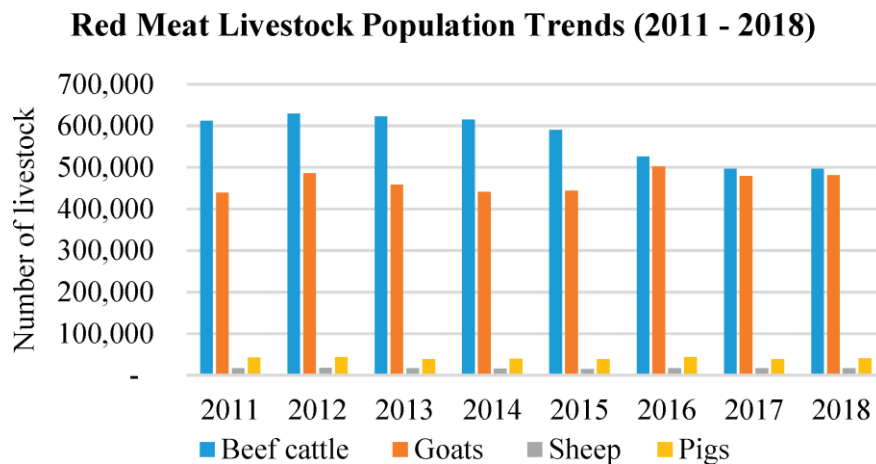


Figure 2-15: A graphical presentation of the number of red meat livestock in Eswatini from 2011-2018 (Source: Dlamini and Huang, 2019)

2.9.2 ENVIRONMENT

In line with the Sustainable Development Goals, environmental sustainability is a key outcome for the country of Eswatini. The range of climatic conditions across the country contributes to the diversity of flora, fauna, and waterbodies in the country. The four main ecosystems are:

1. montane grasslands,
2. savanna-woodland mosaic,
3. forests, and
4. aquatic systems.

Together, the savanna and grassland ecosystems make up over 90% of the country. The savanna-woodlands occur mostly in the central and lower parts of the country, while the montane grasslands occur largely in the Highveld region. The Highveld is, however, also dominated by plantation forests, mainly Pinus and Eucalyptus. Over 3,500 plant species have been recorded, with 12 being endemic and 305 more species listed in National Red Lists (IUCN, 2020). Of the 813 species of vertebrates recorded, only one, the major rock gecko (*Afroedura major*), is endemic. The vegetation types of

Eswatini are shown in Figure 2-16.

Eswatini has 14 protected areas covering 738 km² of very small and vulnerable areas fragmented across ecosystems. Creating corridors and expanding protected areas through partnerships with landowners and communities is, therefore, critical to protect ecosystems.

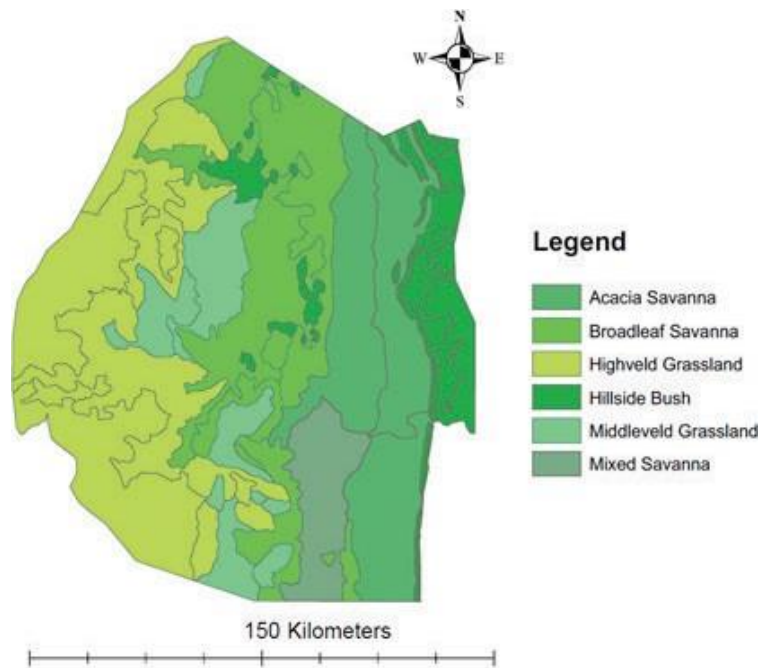


Figure 2-16: Vegetation types of Eswatini

There are five major river systems in Eswatini which flow from west to east across the country, and discharge into the Indian Ocean (Le Roux, 2020). These five systems are the Lomati, Nkomati, Mbuluzi, Great Usuthu, and Ngwavuma (Figure 2-17). The Great Usuthu is the largest of these river systems and originates in South Africa, from where it flows through Eswatini and leaves the country in the Lubombo mountains east of Big Bend. The rivers of Eswatini are critical to the agricultural sector, especially for irrigated sugarcane production. Other sectors such as tourism and hydro-power production also depend greatly on healthy river systems. Similarly, wetlands are important areas for recreation and tourism, small-scale agricultural production, and harvesting of plant resources. Several wetland resources, especially fibre plants, are used for making woven craft products.

Riverine wetland systems are the most common type of wetlands in the country, and the sustainable utilization of wetland resources has become a major policy issue in the Kingdom of Eswatini (Singwane et al., 2019).

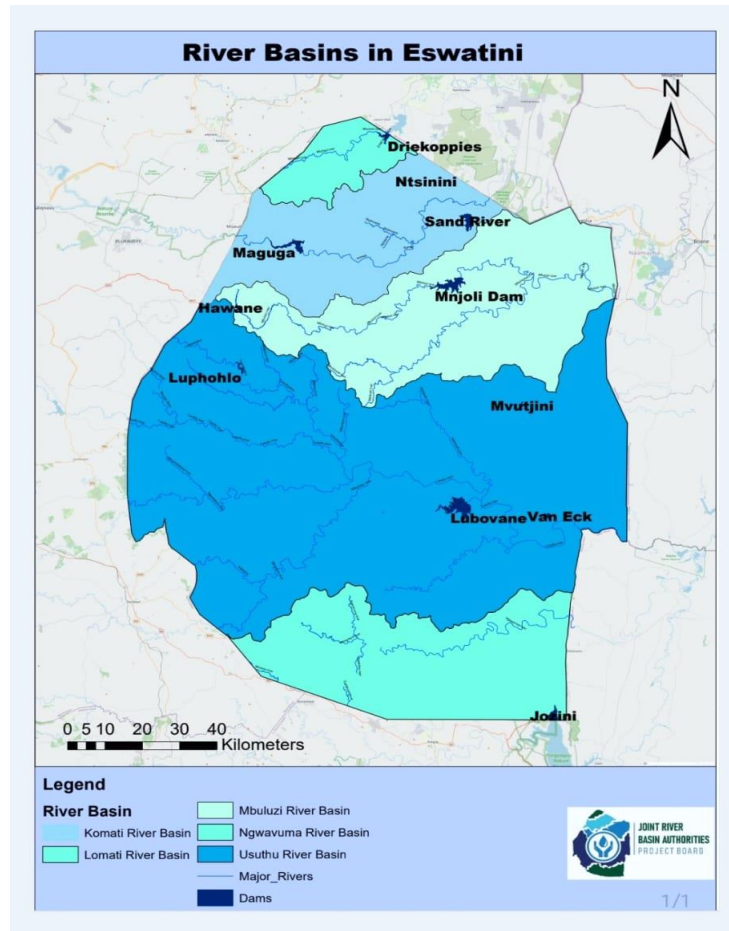


Figure 2-17: Main River systems of Eswatini

Other important pressures contributing to the decline of biodiversity include the conversion of natural to other land uses; alien plant invasions; rapid expansion of settlements and urbanization; frequent and intense wildfires; climate change; overgrazing and overexploitation of plant resources; as well as illegal and uncontrolled hunting. This has resulted in the extermination of most of Eswatini's vertebrates, especially on Swazi Nation Land (SNL).

2.9.2.1 ENVIRONMENTAL ISSUES

Important pressures affecting the country's changing biodiversity include habitat transformation and habitat loss due to urban and agricultural expansion, uncontrolled wildfires, invasive species, overexploitation of plant resources, uncontrolled hunting, and water pollution from industrial and agricultural waste. Rapid population growth and urbanization are putting severe pressure on natural resources across Eswatini.

2.9.2.2 LAND DEGRADATION AND HABITAT TRANSFORMATION

Land use change in Eswatini occurs through the increased demand for land by agricultural activities, as well as residential and infrastructure development. This is driven by population growth, urbanization, and increasing food needs. Clearing natural vegetation for sugarcane cultivation has been the main land use conversion and subsequent cause of habitat loss affecting the savanna ecosystem in Eswatini.

2.9.2.3 WATER POLLUTION

Growing population and increased economic development have led to higher water use and increased competition among water users. With the growing industrial sector and rising interest in tourism and recreational activities involving water bodies, the pressure on water resources has increased. Industrial pollution threatens river systems such as the Lusushwana River, while urban waste and agricultural chemicals pose a serious risk to the environment and public health.

2.9.2.4 WASTE DISPOSAL

The Eswatini Environmental Authority (EEA) and municipalities have raised concerns about the inappropriate disposal of household and commercial waste nodes, which also contribute to environmental degradation. This inadequate waste collection, improper disposal, and inappropriate siting of facilities are having increasingly negative impacts on environmental and societal health. In the rural areas of Eswatini, all solid waste is usually disposed of through open burning in waste pits or indiscriminately disposed and most often burnt in wildfires or carried into water courses. A lot of disposed waste is ultimately burnt, whether intentionally or unintentionally, and these have detrimental effects on the environment, including through emissions that contribute to global warming. Urban waste is generally taken to landfill sites through coordinated pickups by the relevant municipalities. Some of these sites, such as in Mbabane, are trying to separate organic waste through large-scale composting projects – both to minimise landfill quantity, as well as reduce landfill gas (LFG) emissions.

2.9.2.5 INVASIVE SPECIES

Large tracts of Eswatini are infested with invasive alien plant species, which causes widespread degradation of rangelands, water resources, and crop lands. *Chromolaena odorata*, specifically, a fast-growing perennial shrub native to South America, is an aggressive plant that has caused widespread damage to native vegetation in Eswatini. The moist Middleveld, peri-urban areas, dry Middleveld, timber highlands, and the Lubombo Plateau are the most affected livelihood zones (Dlamini, 2021). These plants impair many aspects of community livelihood strategies – including food and shelter, health, security, and social interaction.

2.9.2.6 UNSUSTAINABLE HARVESTING OF NATURAL RESOURCES

Over-exploitation of plant and animal species for medicinal purposes is a major threat in Eswatini and some indigenous medicinal plants have become endangered and are threatened with extinction. The availability of fuelwood in the country averages 50%, with most of the fuelwood obtained freely

from non-commercial communal forests. Unsustainable gathering of fuelwood and charcoal production from natural forests has resulted in deforestation and land degradation with major impacts on habitats for many bird and mammal species. Illegal hunting and poaching of wildlife have caused a significant decline in wildlife resources over the years. As a result, very few large mammals still survive outside of national parks, reserves, or privately owned ranches (BSAP 2001; Monadjem 1998). This has resulted in the extermination of most of Eswatini's vertebrates, especially on Swazi Nation Land (SNL).

Generally, there is poor compliance with existing environmental laws, such as the Flora Protection Act. In addition, protection of the environment is not given priority when new urban developments and industries are planned. Environmental law enforcement is necessary to ensure effective and efficient policy implementation at all levels. Therefore, there is a need to enhance the capacity, including financial and technical, of key environmental enforcement institutions.

2.9.3 ENERGY

Household access to electricity in Eswatini has improved from 46% of the total population in 2010 to 80% in 2020. More than 92% of the urban population had access to electricity in 2020 while 76% of the rural population had access to electricity in 2020, up from 40% in 2010 (Figure 2-18).

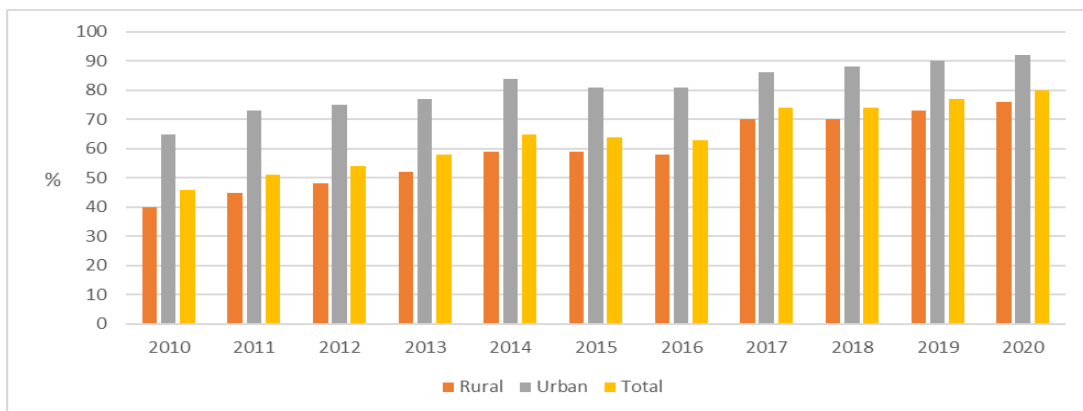


Figure 2-18: Household access to electricity as a percentage of the total population

Eswatini has developed policies and legislation which aim to promote clean, reliable, sustainable, and affordable energy. These policies focus on increasing access by supporting local energy expansion to reach greater energy independence. These include the Energy Master Plan of 2018-2034, National Energy Policy of 2018, and National Energy Policy Implementation Strategy of 2018.

Although Eswatini is making progress towards achieving universal access to electricity, the country is still lagging in renewable energy production, investment, and usage. Many bottlenecks existed in the renewable energy production and investment space between 2010-2020, as a result, the share of renewable energy in final energy consumption in the country has not increased significantly

during the period.

Most of Eswatini's electricity (80%) is imported from South Africa and Mozambique. Domestic production is mainly through four hydropower plants and sugarcane-based co-generation. Biomass (fuelwood and agricultural waste) is used mainly for household cooking and heating. As such, to increase the domestic supply the following future scenarios for energy production have been considered (MNRE, 2018)

- 300MW coal fired thermal power plant;
- 40 MW Solar PV;
- 40MW biomass.

This focus on coal-generated power is in response to the remaining coal reserves available in the Lowveld region of the country, as well as the secure energy generation expected from the burning of coal. The current objective is to revive the old coal mines of Mpaka, Eswatini, to set up a coal thermal power plant in the Lubhuku area.

Sources of total primary energy supply (TPES) in Eswatini include hard coal, renewables and waste, hydropower, electricity, and petroleum. Renewables and waste contribute 60% of the TPES, hydropower contributes 3%, imported electricity contributes 7%, coal (imports) contributes 6%, and petroleum (imports) contributes 24% (Kingdom of Eswatini, 2018).

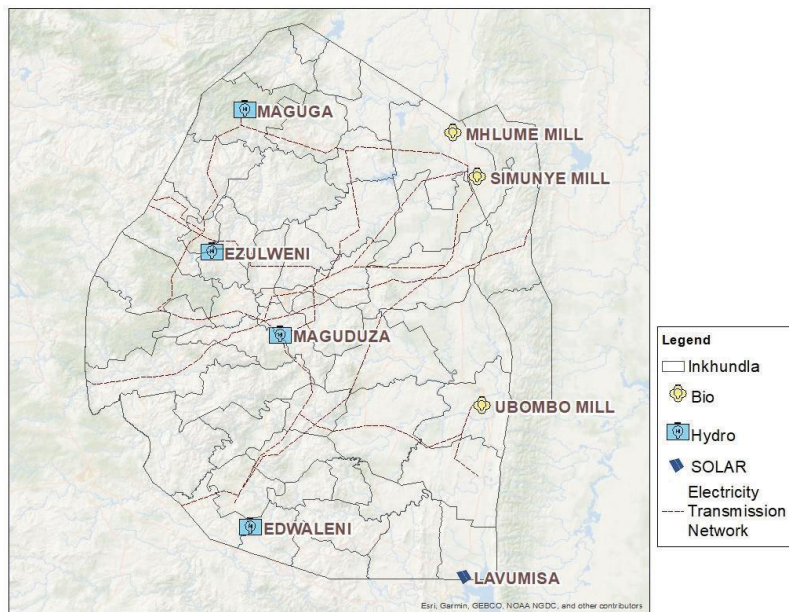


Figure 2-19: Eswatini power plants and electricity transmission network

The contribution of each energy source to the country's energy supply is shown in Figure 2-20.

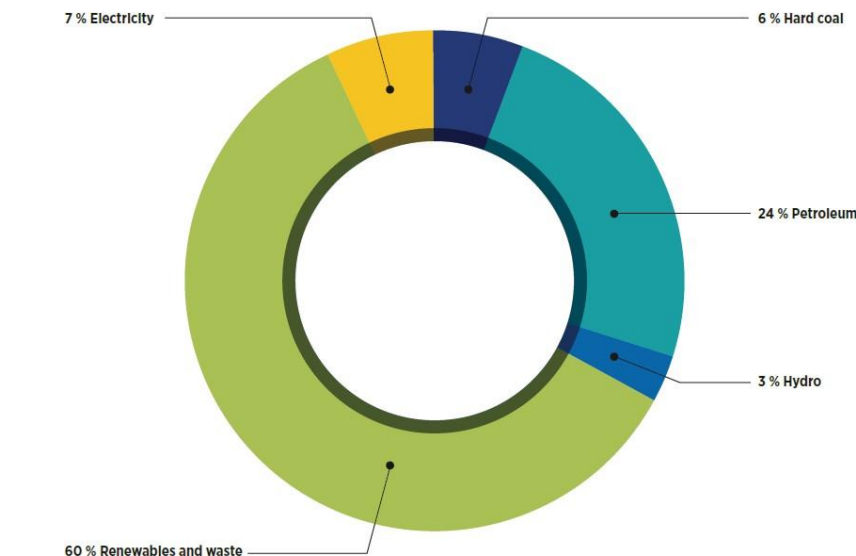


Figure 2-20: Total primary energy supply in Eswatini in 2014 (Kingdom of Eswatini, 2018)

2.9.4 INFRASTRUCTURE AND BUILT ENVIRONMENT

Eswatini has made substantial investments in its infrastructure in recent years. There are, however, specific challenges with various infrastructure types, including those relating to transport, electricity, and telecommunications, all of which increase the cost of doing business. There is also still a huge divide between the coverage and quality of infrastructural facilities in rural areas compared to urban areas. Specific problems in the infrastructure sector relate to a lack of proper maintenance, capacity constraints and skills shortages, old infrastructure in deteriorating condition, as well as a lack of adequate investment in the electricity sector and telecommunication services. Capacity and skill constraints are due to the small population size and skills mismatch, which have a persistent and adverse impact on the quality of public services. Deteriorating infrastructure is especially prevalent in transport, energy, water, and telecommunications sectors. The Global Competitiveness Index ranks Eswatini at 73 out of 144 countries. According to the Global Competitiveness Report (WEF, 2019), the quality of Eswatini's roads ranked 70/141, roads connectivity 99/141 and airport connectivity 139/141. The aviation sub-sector is deemed commensurate with the country's demand for aviation services as it has one public airport. The transport infrastructure is shown in Figure 2-21.

High transport costs also affect the country's competitiveness. Roads provide the dominant form of transportation and account for at least 86% of the trade logistics. The main road network is about 1 500km, of which 75% are paved and 65% are in good or fair condition. However, most district roads (about 2 055km) are unpaved and in poor condition. The networks in the urban centres, particularly those servicing commercial and industrial hubs, are increasingly becoming congested and restricting mobility and, thus, require expansion. The railway network makes up a substantial share of the country's freight transport, linking the country to the key ports of Durban and Richards Bay in South Africa and Maputo in Mozambique. Of this network, about 131km needs rehabilitation. The planned Eswatini Rail Link project is expected to create additional commodities traffic equivalent to 10.3 million tons through Eswatini.

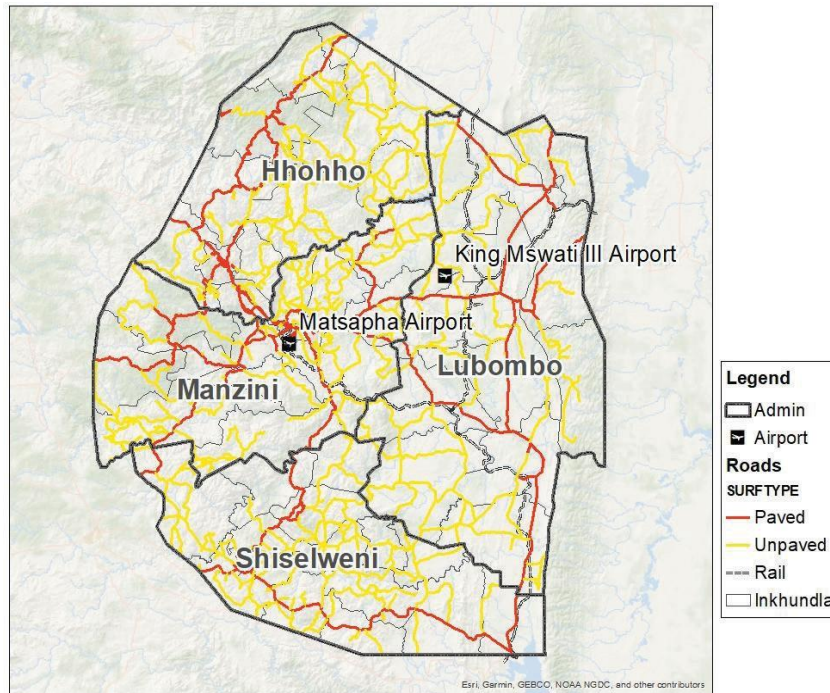


Figure 2-21: Eswatini transport infrastructure showing roads, railways, and airports

2.9.5 INFORMATION AND COMMUNICATION TECHNOLOGY

Information and communication technology is a key infrastructure in supporting economic and social activities as it enables communication and information sharing. Eswatini telecommunications infrastructure consists of radio, television, fixed and mobile telephones, and the internet.

2.9.6 TOURISM

Eswatini has agro-ecological zones that create multiple unique natural environments with rich diversity of plant and animal species, streams, rivers, and wetlands, creating a unique potential for adventure and tourism. These zones are individually distinguished by their climate, elevation, topography, geology, and soils (Figure 2-22), which allows the distinctive experiences at the many tourism attraction destinations and accommodation facilities in the sector. The country comprises a vast number of rocks, minerals, fossils, landscapes, various archaeological features including old mining sites as important geo-sites and heritage features that play a role in the tourism sector of Eswatini (Schlüter and Schumann, 2018). Figure 2-22 below also illustrates the locations of some important heritage sites. In addition, due to its unique ancient cultural ceremonies where natives pride themselves on their culture and heritage through performances, artefacts, and traditional attires and foods, Eswatini markets itself as a cultural tourism destination (Dlamini et al., 2020). These ceremonies are dependent on the availability of natural capital such as reeds, marula and lusekwane.

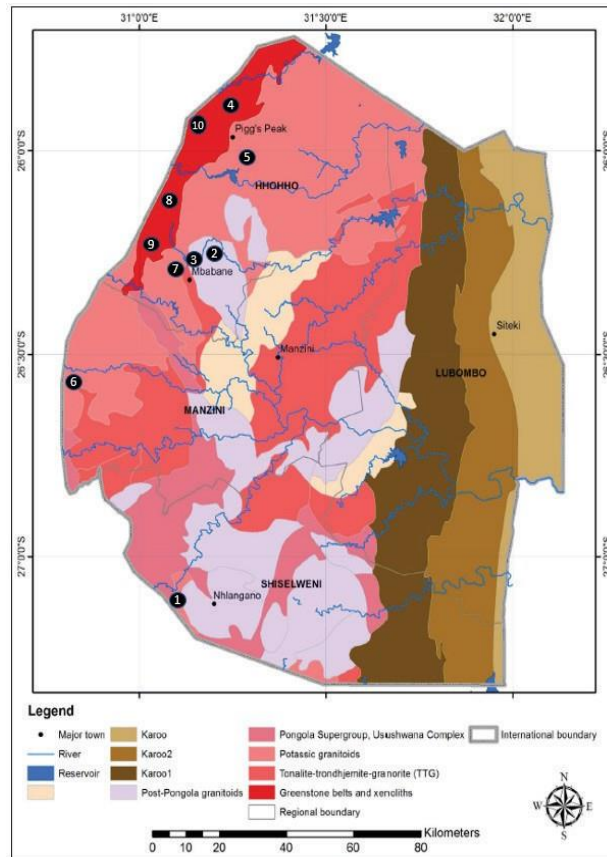


Figure 2-22: Geological overview map of Eswatini (modified after Schlüter, 2008). The numbers indicate the following geo-sites: 1: Mahamba Gorge; 2: Sibebe Monolith; 3: Gobholo Cave; 4: Pigg’s Peak gneisses; 5: Nsangwini rock paintings; 6: Sandlane rock shelter and paintings; 7: Hholoshini rock shelter and paintings; 8: Forbes former gold mining deposit; 9: Ngwenya iron ore deposit; 10: Bulembu former asbestos mine

Eswatini also hosts non-cultural events such as music festivals which bring a multitude of local and international supporters, thus generating revenue for the tourism sector. During these events Eswatini’s locals showcase and engage with participants through workshops, exhibitions, music and art festivals. Multiple crafters have produced traditional crafts for many years using indigenous plant species mainly from wetlands. Various materials such as grasses, cane, sisal, bamboo, palm leaves, as shown in Table 2-2 (Pullanikkatil et al., 2021) are used to produce the different crafts.

Table 2-2: Types of handicrafts produced using different plants species in Eswatini. Source: Pullanikkatil et al., 2021

Products	Main plant forms	Scientific names
Brooms, chicken coops, baskets, floor mats, coasters and table mats	Grasses, sisal	Coleochloa setifera, Agave spp., Digitaria swazilandensis
Calabash	Gourds	Luffa cylindrica, Cucurbita moschata
Decorative flowers and pots	Palm leaves, pinecones, grasses	Hyphaene petersiana, Raphia farinifera, Digitaria swazilandensis
Ornaments	Sisal	Agave spp.
Curtains	Grasses, corn cobs	Coleochloa setifera, Zea mays
Basotho hats	Grasses	Coleochloa setifera, Digitaria swazilandensis

According to Chaitoo and McGinn (2022), Eswatini’s tourism sector consists of accommodation

establishments, restaurants and fast-food outlets, tour operators, travel agencies and tour guides, touristic transport providers, and different types of attractions and activities.

2.9.6.1 TRAVEL AND ACCOMMODATION TRENDS

The Eswatini tourism sector comprises a wide range of industries that attract visitations from the USA, Europe, Asia and Africa. Most originate from Africa, accounting for 93.4% of the visits, followed by Asia and Australia (2.9%), and Europe (2.5%) (Eswatini Tourism Authority; ETA, 2021). Through tourism the country generates income, foreign-exchange earnings, and creates employment. With tourism being highly linked to travel and approximately 94% of visitors arriving through border posts, Eswatini has fairly well-developed road and railway networks, multiple border posts and an international airport to enhance the travelling experience of tourists. Most tourists travel to Eswatini to visit friends and family, for holiday or leisure, as well as for business and conference purposes. The types of accommodation establishments include Bed and Breakfasts (B&Bs), hotels, lodges, guest houses, backpackers, and self-catering establishments to accommodate budgets and preferences. Eswatini receives most arrivals through three border posts, namely Ngwenya, Lavumisa and Lomahasha. Figure 2-23 illustrates the important connection between travel, tourism, and infrastructure which is further emphasized by having most accommodation facilities positioned near roads that directly connect to the border posts that receive high tourist influxes (i.e., Ngwenya and Lomahasha border ports).

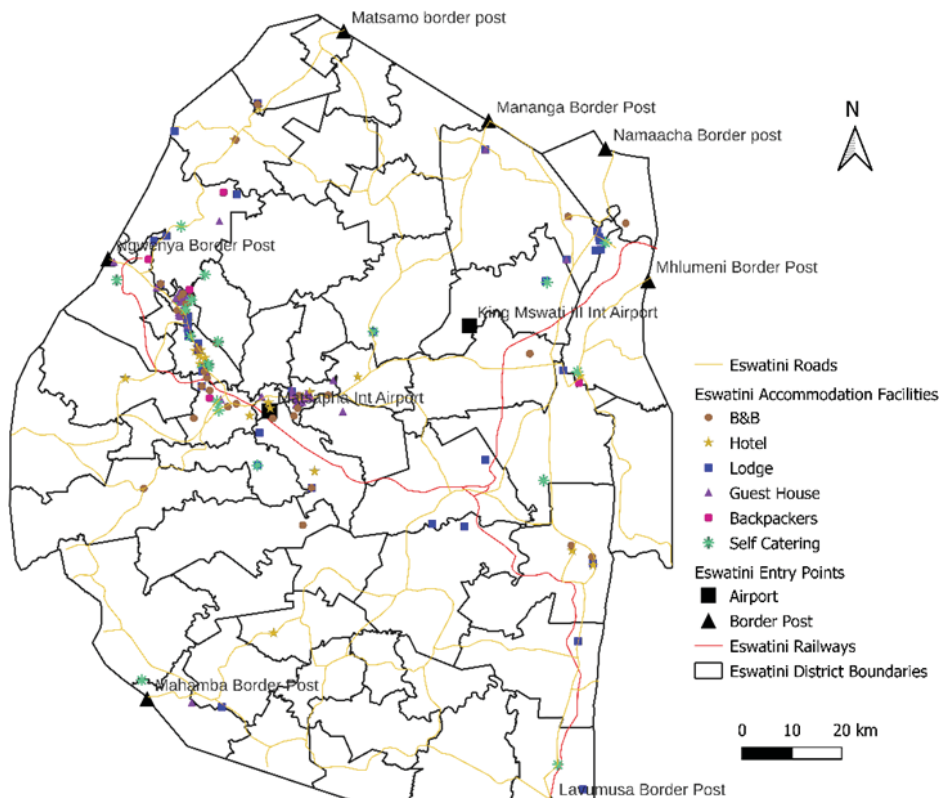


Figure 2-23: Map of accommodation facilities, roads and different ports of entry in Eswatini

2.9.6.2 RESERVES AND CULTURAL EVENTS

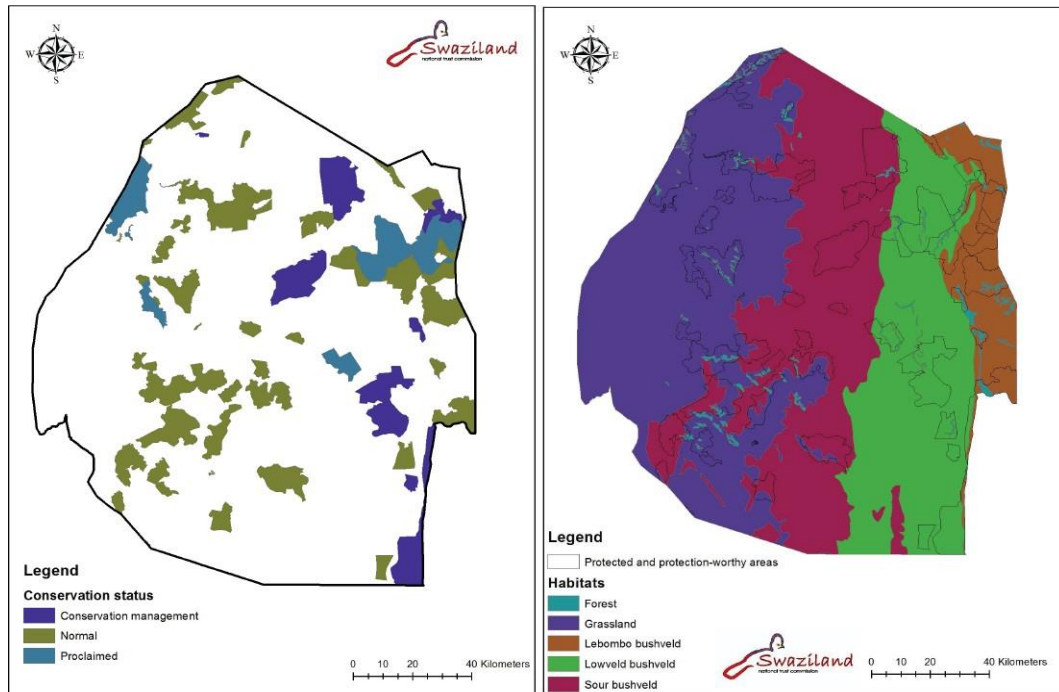


Figure 2-24: Map of Eswatini's conservation areas and their conservation statuses (a) and a map of the types of ecosystem habits per agro-ecological zones (b). Source: Dlamini (2012)

Most international tourists visit Eswatini's game reserves as well as cultural and heritage events which occur throughout the year. The establishment of 5.47% (ENTC) of ecosystem habitats as Protected Areas (PAs) to conserve and protect its ecosystems from activities such as poaching, rock and plant removals, while providing multiple activities in the areas has further contributed towards attracting tourists to Eswatini. The country has 17 conservation areas with different conservation statuses as illustrated in Figure 2-24a.

The conservation sites are depicted in Figure 2-24a and include National Parks, Nature Reserves, Game Reserves, Ramsar sites, as well as Other Effective Conservation Measures (OECMs). Six out of the seventeen areas, that is three nature reserves (Mlawula, Malolotja, and Mantenga) and three game reserves (Mlilwane, Mkhaya, and Hlane), cover about 86% of the area under conservation in the country. These areas are proclaimed or gazetted mostly by the Eswatini National Trust Commission (ENTC) Act (Dlamini, 2012) or are under private management of big game parks. The rest of the conservation areas, fall under the non-gazetted areas with no Act backing them. Figure 2-25 shows the locations of the protected and protection-worthy areas.

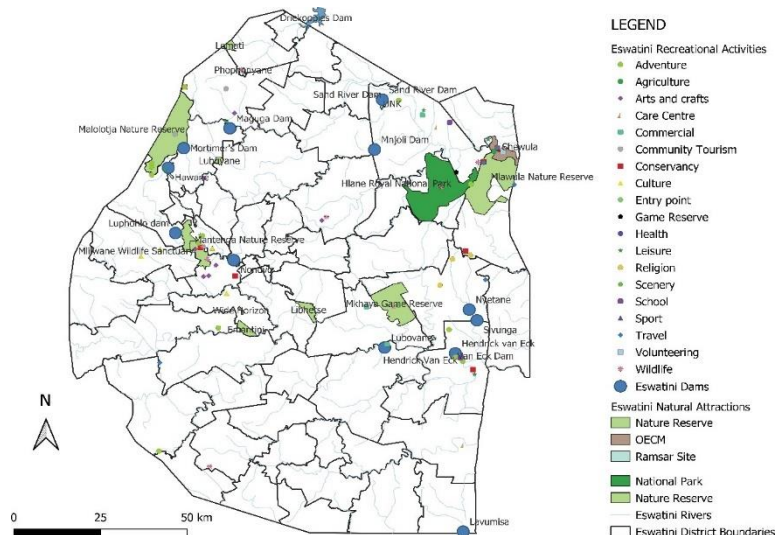


Figure 2-25: Map of Eswatini's protected and protection-worthy areas

For sustainable tourism the country needs to ensure that cultural heritage and conservation plans are ongoing. The country is working towards having at least one heritage site listed on the UNESCO World Heritage List.

2.9.7 WATER AND SANITATION

The country is yet to achieve universal access to safe water and sanitation as part of Eswatini's National Development Strategy. There have been improvements in terms of water access since the last National Communication in 2016. This has been facilitated by the adoption of the Water Policy of 2018, which provides the framework for water management. The proportion of Eswatini's population with access to safe drinking water improved from 58% in 2016 to 72% in 2019 (Figure 2-26). The increase in the number of water service connections in Eswatini is shown in Table 2-3.

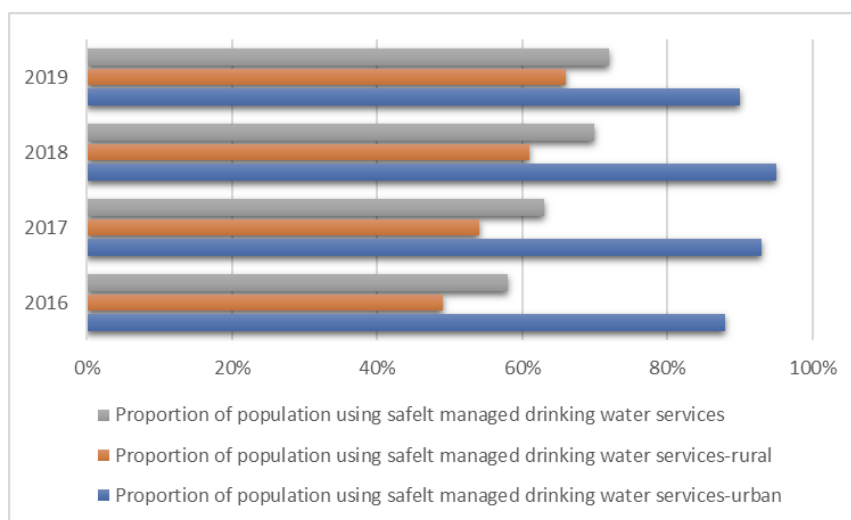
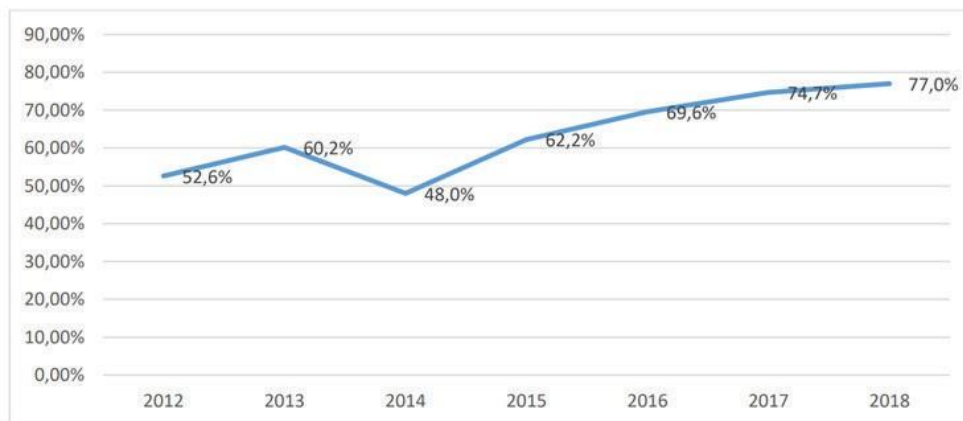


Figure 2-26: Eswatini's population with access to safe drinking water (source: Department of Water Affairs, 2020)

Table 2-3. Number of water service connections and water consumption in Eswatini (Eswatini Water Services Corporation (EWSC), 2021).

	2017	2018	2019	2020	2021
Water connections	53 081	57 634	61 263	63 352	69 313
Sewer connections	10 840	12 820	12 770	12 885	14 159
Total water consumption (m3)	11 899 115	13 697 672	14 031 201	14 360 249	13 861 132

However, access to water continues to be a challenge for many households because the infrastructure is expensive and technically challenging. To address the issues of rural water schemes, the DWA is currently piloting the possibility of establishing a small water utility instead of EWSC in rural Lubombo, through the Coca-Cola Fund. The scheme will use solar power to pump and store water in five 10 000-litre tanks to supply a community of households. Figure 2-27 shows the proportion of the population using safely treated water between 2012 and 2018.



Source: Department of Water Affairs, 2020

Figure 2-27: Proportion of population using safely treated water between 2012 and 2018

The wide-scale degradation of wetlands in urban areas of Eswatini contributes to water quality and flooding issues. Wetlands play an important role in maintaining local water quality, flood control, and providing fish and wildlife habitats. The country has recently adopted a wetlands policy and is preparing a strategy and action plan to improve the enabling environment for wetlands management. This should culminate in the development and adoption of legislation on wetlands under the biodiversity theme. About 82% of the population are using improved sanitation facilities, a significant rise from the 2015 levels of 57.5%. Moreover, the proportion of wastewater safety as measured by safely treated water has gradually increased over the years from 62.20% in 2015 to 77% in 2018 (Figure 2-27).

Clean water supply coverage, in the form of taps inside or outside houses, community taps, and boreholes, were 42% for the rural population and 87% for the urban population in 2005 (FAO, 2005). Access of the population to basic drinking water services has, however, increased substantially since 2000 (53.2%), to 2010, (62.2%) and was at 70.7% in 2020. Rivers and unprotected wells, however, still

form an important source of household water for people in the countryside.

2.9.7.1 RIVER AND DAM LEVELS

Eswatini has about 4,500 million cubic meters of available freshwater resources, of which 666.4 million cubic meters is stored in large dams and another 73.6 million cubic meters in small private dams (MNRE, 2018). Five of the country's most important dams include the following (see Table 2-4 and Figure 2-28):

- Hawane Dam which supplies the capital city;
- Lumphohlo Dam which is mainly used for generating electricity;
- Maguga Dam which is the biggest dam used for irrigation and generating electricity;
- Mnjoli Dam – the source for most of the irrigation;
- Lubovane used for irrigation.

Table 2-4. The five major dams in Eswatini with the associated river source and storage capacity

Name of dam	River	Full supply storage (million m ³)
Mnjoli	Black Mbuluzi	177
Lubovane	Great Usuthu	155
Maguga	Komati	332
Hawane	Black Mbuluzi	2.75
Lumphohlo	Lusushwana	23.6

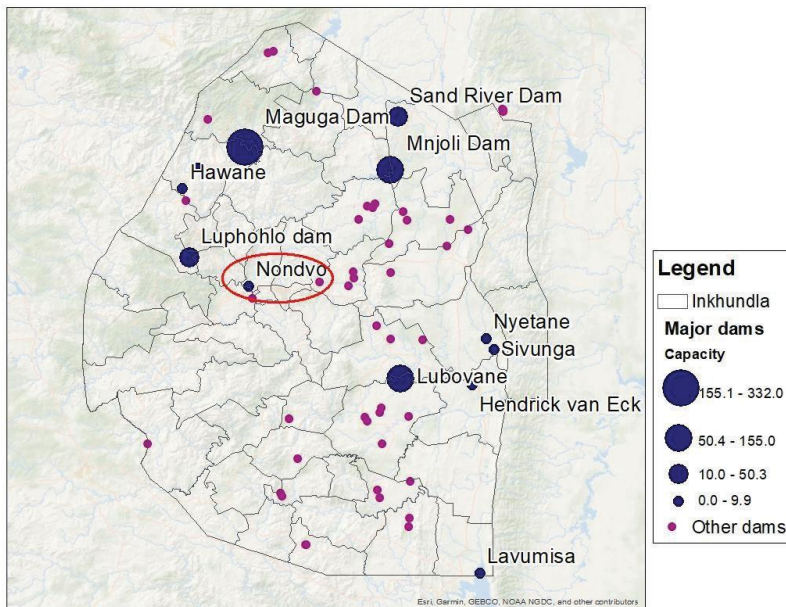


Figure 2-28: The location of major dams in Eswatini and their storage capacities ($\times 10^6$ m³).

Another dam, called Nondvo, is planned. Nondvo multi-purpose dam will provide potable water supply for the Mbabane and Manzini cities, hydropower energy as well as water resources allocated

for downstream irrigation purposes. The construction of Nondvo Dam and the raising of dam-walls for two existing dams (Luphohlo Dam and Hawane Dam), will ensure availability of potable water and irrigation in the Mbabane -Manzini corridor until mid-century.

An analysis of river stream flow data between 2010 and 2018 indicates that the country's rivers experienced declining water levels over this period as shown in Figure 2-29. This corroborates the projections that the streamflow of rivers in the country could decline by 40% by 2050. This will have serious consequences for irrigation and livelihoods over the coming decades. Similarly, dam levels have fluctuated over the years, presenting varying volumes in water storage because of declining rainfall, dry spells and rising evaporation rates (rising temperatures).

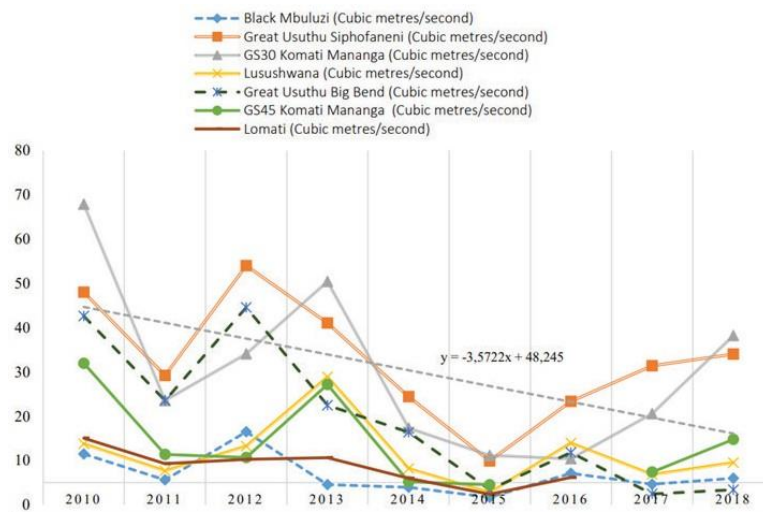


Figure 2-29: Eswatini River Capacity. 2010 –2018

2.9.7.2 TRANSBOUNDARY WATER RESOURCES

Eswatini shares all five of its river basins with neighbouring countries. Several treaties and agreements have been signed between 1983 and 2010 to manage and coordinate water resources between these three countries. However, agricultural expansion and urban development has led to a substantial increase in water demand. Seen against the backdrop of changing climate conditions and water levels in the rivers, this is at the expense of water users in Eswatini.

Sugarcane is one of the major cash-crops in the country and is largely irrigated. Sustainable irrigation infrastructure together with sustainable supply of water is critical for success. The Lower Usuthu Smallholder Irrigation Project (LUSIP) has made a significant contribution in this regard by providing infrastructure for irrigation, as well as water and sanitation by creating an off-river reservoir. This provides irrigation water for 11 500 ha of land. LUSIP II will increase the area under irrigation by 5 273 ha. Water resources and irrigation development are vital for agriculture production, especially in the face of climate variability where dependency on rainfed agriculture is no longer sustainable for ensuring household and national food security.

2.9.8 HEALTH

Eswatini has made significant progress over the past decade in terms of improving access to health systems, reducing HIV/AIDS incidence rates, improving treatment of TB, and has made good progress on the management of malaria (MEPD, 2019). However, some key challenges remain. These include institutional issues such as inefficient health spending compared to other countries in the region, inadequate maintenance of current infrastructure, poor alignment and awareness of plans, poor sector coordination, and a lack of monitoring and evaluation data (MEPD, 2019). Equity concerns in terms of immunization and nutrition, unequal access to social services as well as in the gender distribution of access to wealth and social services contributes to the health burden. (WHO, 2018).

Sanitation and hygiene coverage has also been decreasing over the years, contributing to the high incidence of water and sanitation related diseases. Faecal-oral diseases are among the top five leading causes of morbidity in the country.

The National Health Sector Strategic Plan has been developed in response to the health challenges faced by the country, with a focus on three strategies: improving the institutional capacity of the Ministry of Health; ensuring access to adequate and appropriate curative care; and providing sufficient public health services. The vision and mission of the 2019-2023 Eswatini National Health Sector Strategic Plan underlines the Health Ministry's commitment to comprehensive and integrated health service that will ensure good health and quality of life for the people of Eswatini. The plan had been inspired by the 2017 Census which showed significant improvement in impact indicators such as life expectancy at birth and some improvement in maternal, infant, and under-five mortality. The vision has been informed by 'Vision 2022', as well as the Sustainable Development Goals, and specifically SDG 3 (ensuring healthy lives and promote well-being for all at all ages), SDG 2 (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) and SDG 6 (clean water and sanitation for all).

According to the WHO, life expectancy at birth increased from 54 years in 2014 to 59 years in 2018 (WHO, 2018). In 2019, the life expectancy at birth was 60.5 years (58.9% for males and 63.5% for females) and is expected to be 61% and 66% respectively, by 2023 (National Health Sector Strategic Plan (NHSSP), 2019). However, in 2021, the overall life expectancy at birth decreased again to 57.1 years (UNDP, 2023), which was during the Covid-19 period.

Infant mortality and under-five mortality rates have improved over the same period (2014-2018); from 79 to 42.7, and 104 to 56.3 per 1 000 live births, respectively (WHO, 2018). The maternal mortality rate increased from 320 in 2010 to 593 in 2012 and decreased to 389 per 100 000 live births in 2018, while the neonatal mortality rate at 19.5 per 1 000 live births in 2018, showing an upward trend from 2014. The top 10 causes of morbidity in Eswatini (2017) are shown in Table 2-5 (Eswatini HMIS, 2017).

Table 2-5: The top 10 causes of morbidity and mortality in Eswatini

Top 10 causes of morbidity		Top 10 causes of mortality	
1	Upper respiratory infections	1	Tuberculosis
2	Skin disorders	2	Acquired Immune Deficiency Syndrome
3	Hypertension	3	Pneumonia and influenza
4	Musculoskeletal conditions	4	Diabetes mellitus
5	Acute watery diarrhoea	5	Cancers
6	Lower respiratory infection (mi	6	Non-infective enteritis and colitis
7	Digestive disorders	7	Disease of blood and blood-forming organs
8	Diabetes mellitus	8	Inflammatory diseases of central nervous systems
9	Eye diseases	9	Cerebrovascular diseases
10	Injury	10	Hypertensive diseases

Non-Communicable Diseases (NCDs) contributing to the disease burden in Eswatini include diabetes mellitus, cardiovascular diseases such as hypertension and stroke, malignancies, and chronic obstructive pulmonary diseases especially asthma (WHO, 2018). NCDs have been on the increase since 2010 (WHO, 2017). According to the 2014 Steps Survey, 43.8% of the population was overweight and 20.5% was obese. Of the 24.5% who had raised blood pressure, 78.9% were not on medication. In 2017, NCDs accounted for 30% of the outpatient cases and 14% of the inpatient cases. The incidence of non-communicable diseases (NCDs) continues to rise.

Malaria is still a public health concern, although the incidence rate has seen a significant reduction over the years (WHO, 2018). Malaria cases increased by 53% from the 2015/16 to the 2017/18 season, with the majority being classified as of local origin. More than half of malaria cases occur in the Lubombo region (WHO, 2018).

Neglected tropical diseases have also not been given sufficient attention, resulting in increases in cases. Neglected tropical diseases (NTDs) that are prevalent in Eswatini include:

- intestinal worms, for which 0.18 million school-aged children needed treatment in 2017, with 0.15 million receiving treatment;
- Bilharzia, for which 0.11 million needed and received treatment (Uniting for Combat, 2017).

The **HIV** prevalence of Eswatini is one of the highest in the world, with knowledge of HIV status still a challenge in males, children, adolescents, and young people (NHSSP, 2019). The baseline number of new HIV infections per 1 000 uninfected population, by sex, age and key populations is 1.36/1000. The tuberculosis incidence rate is at 3.98/1 000,000.

Overall, 37% of households are hosting HIV patients (VAC, 2022). The Dry Middleveld (DMV) livelihood zone had the most households (53.3%) with HIV/AIDS patients members, followed by Lowveld Cattle and Maize (LCM) (43.8%); Highveld Cattle and Maize (HCM) (38.3%), Peri Urban PURB (25.9%), Timber Highlands (THL) (32.7%), and Lubombo Plateau (LP) (35.6%) (VAC, 2022). More women are living with HIV than men (35% compared to 19%) (Armstrong, 2021).

Acute Respiratory Infections (ARI) in rural children were especially prevalent in the LP (33.3%) and DMV (23.1%) (VAC, 2022). **Diarrhoea** is also common among children in rural Eswatini, particularly in the LP (13.7%) and HCM (19.1%) livelihood zones.

Mental health remains an important health concern in Eswatini. The lack of both a Mental Health Policy (still in draft form since 2013) and a Comprehensive Mental Health Programme have constrained mental health service delivery, affecting especially rural settings.

Comparison of areas with the highest population and the most vulnerable populations (VAC, 2022) shows that Lomahasha and Siphofaneni were the Tinkhundla with the highest proportion of vulnerable people. Siphofaneni was also one of the Tinkhundla with the highest number of people relative to other Tinkhundla. Indicators used in the most recent census (CSO, 2017) were used to compare the relative distribution of social vulnerability among Tinkhundla (Figure 8-2, in Appendix A). The values of the highest numbers for each indicator are shown in (Table 8-1 in Appendix A). Mpolonjeni, Ngudzeni, and Sigwe had the highest number of indicators in the high vulnerability range, followed by Emkhiweni and Shiselweni.

Shiselweni is the only region that recorded that most households are female-headed (52%). Shiselweni also has a household size above the national urban average (VAC, 2022). The overall dependency ratio has decreased for all regions between 1986 and 2017 (CSO, 2017) with the overall dependency ratio by Tinkhundla for 2017 shown in Figure 2-30. The figure shows that Madlangampisi in the north and several Tinkhundla in the south and east of the country are especially vulnerable in this regard (CSO, 2017).

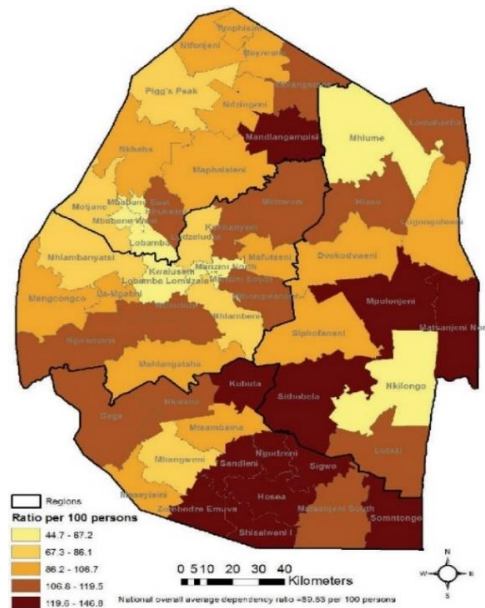


Figure 2-30: Overall dependency ratio by Tinkhundla (Source: CSO, 2017)

The proportion of population living below the poverty line has mostly decreased, but an increase was seen in the male population compared to the female population. Shiselweni also saw an increase compared to the other regions (Table 2-6).

Table 2-6. Proportion of population living below the poverty line (Source: National Health Sector Strategic Plan (2019-2023))

	Year: 2010	Year: 2017
National	63	58.9
Rural	73	70.2
Urban	31	19.6
Male	59	67.0
Female	67	59.4
Hhohho	61	54.1
Manzini	58	51.5
Lubombo	68	67.3
Shiselweni	69	71.5

- Based on the sampled households, Shiselweni was the region with the highest percentage (18%) of people living with disability, while the lowest (0.13%) was Hhohho region (VAC, 2022).
- Across the country, 28% of households hosted orphans.(VAC, 2022). More than half of all children younger than 17 years in Eswatini are classified as orphaned and vulnerable (OVC), with almost 60% of these losing their parents due to HIV and AIDS-related deaths (WFP, 2021; Armstrong, 2021).
- The mortality of breadwinners is of concern, especially in the Hhohho region where over 36% of the surveyed population reported to have lost

primary breadwinners in their households. (VAC, 2022).

2.9.8.1 NUTRITION AND FOOD SECURITY

The **Household Hunger Score** is used as a proxy for food access and contains three basic questions about perceptions on the number of times a household has experienced hunger within the past 30 days (VAC, 2022). The score indicates that:

1. 11% of rural households are faced with severe hunger.
2. The highest proportion of households facing severe hunger (15%) was in Shiselweni, with the highest proportion of households experiencing moderate hunger (23%) being in the Lubombo region.
3. The Lubombo Plateau is observed to be the worst livelihood zone with 43% of the population faced with moderate to severe hunger. Of this population, 32% were female-headed households.

The **Reduced Coping Strategy Index (RCSI)** measures the degree to which households use food-based coping strategies during times of food shortages and scarcity, with a high index indicative of high household food insecurity. This index shows that 57% of rural households did not have any food-based strategies. The most vulnerability regions were the Lubombo Plateau and the LCM zone, with the highest proportion of households (18%) with severe coping strategies.

The Household Emergency and Crisis Livelihood Coping Strategies indicator showed that, in rural households, both crisis and emergency coping strategies were 11%. The Lubombo urban area has the highest proportion of households with crisis and emergency coping strategies (35%). During the latest assessment, the region with the most children who did not receive a minimum meal frequency (used as a proxy for a child's energy requirements) was Hhohho region (19.1%).

More than 182,600 people (16% of the population) were estimated to face acute food insecurity between June and September 2022, with 169,000 people facing crisis food insecurity (IPC Phase 3) and 13,543 facing emergency food insecurity (IPC Phase 4) (VAC, 2022). The situation has, however, improved significantly from the 2021/22 food insecurity situation. The distribution of the food insecure population for each Tinkhundla is shown in Figure 2-31. More recent contributors to food insecurity include the COVID-19 pandemic, the Russia-Ukraine conflict, poor harvest, escalating food prices, deepening poverty, and civil unrest (VAC, 2022).

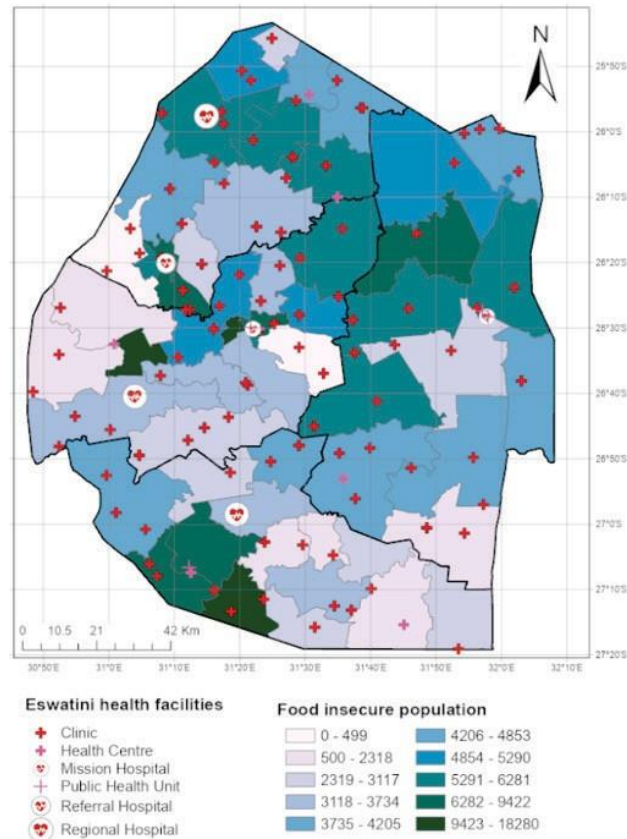


Figure 2-31: The distribution of the food insecure population by Inkhundla in relation to health facilities (source: VAC, 2022).

2.9.8.2 WATER AND SANITATION

Safe and sustainable water supply, especially safe drinking water, is essential for good health (VAC, 2022). Lubuli, Sigwe, Somntongo in the south-east of the country, and Hlane (north-east) had the highest proportion of households that take above an hour to travel to a water source (CSO, 2017). Overall, 31.6% of households only have access to un-improved water sources (i.e., piped water, rain, and spring water). The livelihood zones with the highest unimproved household water access include the DMV (50%) and LP (51%).

A total of 33.6% of rural households use un-improved sanitation facilities (i.e., not hygienically separating human excreta from human contact). The PUR livelihood zone has the lowest household access to improved sanitation facilities (43.8%) (VAC, 2022). A total of 5.3% of households are using the bush/field (i.e., no available toilet facilities). In rural households, 14.6% have no access to either water or soap for hand washing, with 25% of households in the LCM zone not having access to water and soap for hand washing.

An assessment of environmental hazards indicated that 14.6% of households have environmental hazards next to their water sources, with the LP livelihood zone being the most affected zone (32.9%). Solid waste was the most reported environmental hazard, with the highest presence in the Lubombo Plateau (reported by 87.5% of households).

2.9.8.3 HEALTH AND SERVICE DELIVERY

The number of healthcare facilities in the country has doubled (from 154 to 327) between 2010 and 2017, but are still concentrated in the urban areas (SARA, 2017 in Armstrong, 2021). The distribution of health facilities across Eswatini and its relationship to Tinkhundla population size (2017) is depicted in Figure 2-32 a and b.

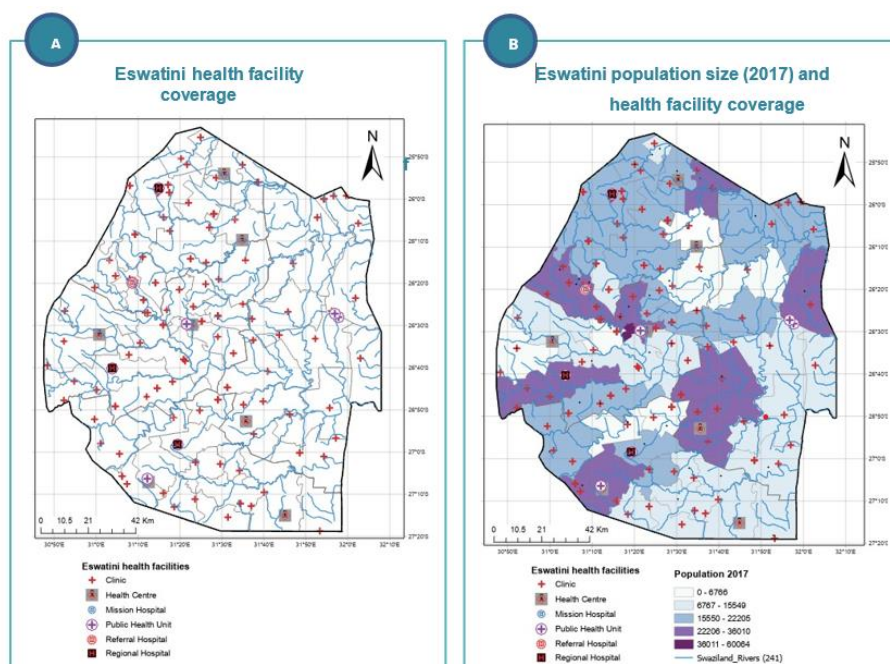


Figure 2-32 a and b. Eswatini population size (2017) and health facility coverage

The service delivery capacity as indicated by the numbers of facilities by region are shown in Table 2-7.

Table 2-7. Service delivery capacity, by Region (Swaziland NTD Plan, 2015-2020)

Region	Number of facilities				# of facilities/10 000 population (2013)
	Total	Tier 2	Tier 3	Tier 3	
Hhohho	83	79	3	1	2.7
Lubombo	48	46	2	0	2.2
Manzini	121	117	2	2	3.4
Shiselweni	36	33	3	0	1.7
Total	288	275	10	3	10

In 2019, the density of doctors, nurses, and midwives per 10,000 was 1.66 and is expected to reach 2.2 by 2023 (NHSSP, 2019). The percentage of essential equipment that was functional in 2019 was 74%, and is expected to increase to 100% in 2023. In 2019, 55% of hospitals and health centres had at least an ambulance with less than 5 years of service (NHSSP, 2019).

2.9.8.4 HEALTH AND EMERGENCIES

The capacity of health facilities to handle health emergencies is summarized in Table 2-8. General service readiness was estimated to be 66% in 2018 (baseline), and was expected to increase to 90% by 2023 (NHSSP, 2019).

Table 2-8. Indicators of health emergency preparedness (NHSSP 2019-2023)

Indicator	Baseline (2018)	End-term (2023)
Multi-hazard national public health emergency preparedness and response plan developed and implemented	50%	100%
Priority public health risks and resources mapped and used	10%	60%
Capacity to activate emergency operations	50%	100%
% of health facilities with disaster/emergency preparedness and response plans and able to handle emergencies	10%	60%
Average response time:		
urban areas: per 8 minutes	9.2 min	100%
rural areas: per 14 minutes	35 minutes	94%

Health sector needs for adequate healthcare delivery include appropriate infrastructure, equipment and transport, and adequate financing for critical interventions (NHSSP, 2019). Challenges in financial governance in the health sector include inadequate tracking of financial resources and expenditure, insufficient accountability, inefficient allocation and use of resources, service expenditure with a curative rather than preventative focus, resources not allocated in an equitable manner, and some critical areas relying largely on donor funding, which is not sustainable (NHSSP, 2019).

2.10 INSTITUTIONAL FRAMEWORK ON CLIMATE CHANGE

The Ministry of Tourism and Environmental Affairs (MTEA) is mandated to manage climate change impacts and thus plays the lead role in climate change reporting in Eswatini; it established a National Climate Change Unit (NCCU) in 2016. The ministry is responsible for the coordination and management of all climate-change related activities such as mitigation, adaptation, and compilation of the national GHG inventory.

The MTEA is the United Nations Framework Convention on Climate Change (UNFCCC) focal point responsible for the preparation of all reports required under the Convention and Paris Agreement through the Department of Meteorology which hosts the NCCU. As part of fulfilling the UNFCCC requirements, the country has compiled three national communication reports, namely: the Initial, Second, and Third National Communications (2002; 2012; and 2016), consecutively. The initial Nationally Determined Contribution (NDC) was developed and submitted in 2015 and updated in 2021.

Since publishing its First National Communication in 2002, several activities which focused on addressing climate change were undertaken and these include the establishment of a National Climate Change Committee (NCCC) and other coordination structures. Due to the cross-cutting nature of issues related to climate change, there are several ministries and other national institutions which have mandated and assigned lead roles important for aligning sectoral policies with requirements for climate action and strengthening stakeholder capacity.

Institutional arrangements for the compilation of national communications and biennial update reports are structured at three tiers, namely: project advisory, co-ordination, and implementation levels, illustrated in Figure 2-33. Reporting is currently completed on a project-by-project basis, and the arrangements depicted in this figure support the implementation of the country's Fourth National Communication (NC4) and the First Biennial Update Report (BUR1).

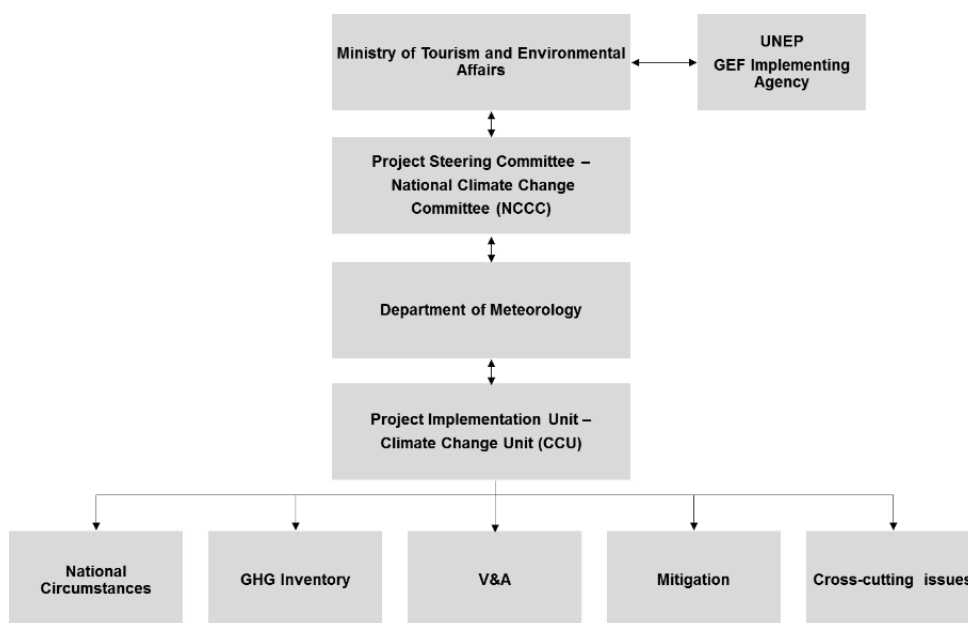


Figure 2-33. Institutional Arrangements for Compiling the Fourth National Communication.

2.11 POLICIES AND STRATEGIES THAT ADDRESS CLIMATE CHANGE

The Kingdom of Eswatini has made substantial progress towards becoming a low carbon and climate resilient society and has committed to several protocols, treaties, and conventions on climate change at the international level. Eswatini became Party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1996, signed the Kyoto Protocol in 2006 and the Paris Agreement in 2015. The country is also signatory to the Vienna Convention for the Protection of the Ozone Layer, Convention on Biological Diversity (CBD), and the Cartagena Protocol on Biosafety. The country has domesticated many of these conventions through the development of a legislative framework which includes the National Climate Change Policy 2016, National Disaster Risk Reduction Policy, and Disaster Risk Reduction National Action Plan (SDRNAP) 2008-2015, Promulgation of the Ozone Depleting Substances Regulations (2003), National Biodiversity Strategy

and Action Plan (NBSAP), Protection of Freshwater Fish Act, National Biodiversity Conservation and Management Policy, 2007, and the Biosafety Act.

Eswatini has developed and implemented a host of overarching policies and frameworks to guide adaptation and mitigation practices in the country. These policies present the government's vision and strategy for an effective response to climate change over the short, medium, and long-term. The National Development Strategy (NDS), formulated in 1997 and reviewed in 2014, is the overarching framework that provides a platform for the achievement of sustainable development in the country and outlines various national strategies to address climate change, within the context of national development. It was through the NDS that efforts were made to incorporate adaptation priorities into national planning, and highlighted climate change as a cross-cutting theme. One of the strategic objectives of the NDP (2019/20-2021/22) is to "manage the country's natural resources in order to reverse environmental degradation, build resilience and adapt to climate change with entrenched ideas of disaster risk management and environmental sustainability". The National Climate Change Policy (2016) supports the priorities outlined in the National Development Plan.

The National Development Strategy, National Climate Change Policy, and the National Development Plan are among the various policies that link climate change adaptation to socio-economic adaptation in Eswatini; other policies include the Poverty Reduction Strategy and Action Plan (2007); Strategy for Sustainable Development and Inclusive Growth (SSDIG, 2017); National Policy for SMMEs in Swaziland (2002); and the National Climate Change Strategy and Action Plan (2016-2020).

The annual Vulnerability Assessment and Analysis Report (VAC), State of the Environment Report (SOER, 2020), Technology Needs Assessment (TNA, 2018) and Third National Communication (2016) are among the key assessments conducted in the country in the recent years.

Eswatini submitted its updated NDC (GoE-MTEA, 2021) in October 2021 which highlights that despite the country's contributions to climate change emissions being miniscule, the country is committed to prioritizing climate resilient, sustainable, and equitable development. The key economic sectors prioritised for adaptation in the country in the NDC include water resources, agriculture and food security, biodiversity and ecosystems, health and nutrition, and infrastructure. Other sectors such as gender, tourism, energy, and education are also considered very important for adaptation. Linkages between climate change targets and the larger developmental priorities are highlighted in the NDC with synergies identified between NDC targets (adaptation and mitigation measures) and SDGs, targets in the Sendai framework, and outcomes in the National Development Plan (2019/20-2021/22).

2.11.1 ADAPTATION

The focus of adaptation efforts in Eswatini is on cross-cutting measures in priority areas related to water, agriculture, biodiversity, and health. Along with the National Climate Change Strategy and Action Plan (2016-2020), National Climate Change Policy (2016) and National Development Plan (2019/20-2021/22), several adaptation measures in these sectors were adopted which are related to various agricultural and community irrigation projects as well as biodiversity and conservation efforts. Examples of adaptation projects and programmes undertaken for these sectors since 2015

include (GoE-MTEA, 2021b):

- Incorporation of Climate Smart Agriculture in Eswatini Schools and Agriculture Training Centres;
- Increasing Farmer Resilience to Climate Change Upscaling Market Oriented Climate Smart Agriculture Project;
- Strengthen Eswatini's Early Warning System and Climate Services;
- Eswatini Drought Preparedness;
- Mkhondvo-Ngwavuma Water Augmentation Program (MNWAP);
- Ezulwini Sustainable Water Supply and Sanitation Service Delivery Project;
- Water Harvesting, Small and Medium Earth Dams Project;
- Food-IAP: Climate-Smart Agriculture for Climate-Resilient Livelihoods (CSARL);
- The Smallholder Market-led Project (SMLP);
- Lower Usuthu Smallholder Irrigation Project;
- High value Crop and Horticulture Project (HVCHP);
- Water and Sanitation Drought Mitigation and Response Plan;
- Health System Strengthening for Human Capital Development in Eswatini Project;
- Open Defecation Free Project;
- Strengthening the National Protected Areas System of Swaziland (SNPAS).
- Eswatini's TNA for adaptation which prioritised the following technologies:
 - Water sector integrated river basin management, rooftop rainwater harvesting, and wetland restoration.
 - Agriculture sector livestock and poultry selective breeding, conservation agriculture, and micro and drip irrigation.
 - Forestry and biodiversity sector agroforestry, conservation of genetic resources, and alien invasive species management.

2.11.2 MITIGATION

From a mitigation perspective, while emissions in Eswatini are not significant compared to those of developed countries, there is potential to reduce emissions and the country has undertaken considerable efforts to achieve this since it recognizes that national emissions will increase with

population and economic growth. Key policies and regulatory frameworks to guide mitigation practices in the country include (GoE-MTEA, 2021b):

- National Energy Policy and Implementation Strategy of 2018;
- Energy Efficiency and Conservation Policy of 2019;
- Energy Master Plan 2034 of 2018;
- Independent Power Producer Policy of 2016;
- Competitive Bidding Method of Procurement for Power Projects of 2019;
- Climate Smart Agriculture Policy of 2019.

These policy measures have resulted in several projects planned by the Ministry of Natural Resources and Energy (MNRE) across various domains, for example, energy efficiency, grid electricity access, increased renewable energy power, renewable energy, and energy efficiency in the agriculture sector.

The country has taken progressive measures to define economy-wide greenhouse gas (GHG) targets covering all priority sectors. The revised Nationally Determined Contribution (NDC) of Eswatini in 2021 represents a progression beyond the country's first NDC in 2015 by adopting an economy-wide GHG reduction target of reducing total GHG emissions by 14% by 2030 compared to the baseline scenario (GoE-MTEA, 2021b). The revised NDC identified the following targets to reduce GHG emissions in the Energy, Waste, Industrial Processes and Product Use (IPPU), and Agriculture Forestry and Other Land Use (AFOLU) sectors:

- Energy – Reduce 23% GHG emissions by 2030 compared to baseline scenario;
- Waste – Reduce 16% GHG emissions by 2030 compared to baseline scenario;
- IPPU – Achieve net emissions reductions of 5.96 kt CO_{2e} by implementing the Kigali Amendment to the Montreal Protocol and other measures;
- AFOLU – 15% increase in overall emissions due to productivity improvement while still observing methane and nitrous oxide emissions from goat due to manure management (MM) action.

Eswatini's TNA for mitigation prioritised the following technologies:

- Energy (Power generation subsector) – Hydro power, biomass combined heat and power, solar photovoltaic (PV), and energy-efficient buildings;

- Waste – Separate/reuse/recycle, composting, semi-aerobic landfill.
- Land Use, Land-Use Change and Forestry (LULUCF) – agroforestry, urban forestry, grazing land management.

2.11.3 PROGRESS ON THE IMPLEMENTATION OF THE NATIONALLY DETERMINED CONTRIBUTIONS (NDC) AND SUSTAINABLE DEVELOPMENT GOALS (SDGs)

Eswatini has made commendable strides in the development and implementation of adaptation and mitigation projects and programmes. The formulation of the Intended Nationally Determined Contributions and the revised Nationally Determined Contributions (NDC) and the National Adaptation Plan (NAP) allowed extensive stakeholder consultations. Despite progress made in aligning INDC and later the NDC with the National Development Strategy and the National Climate Change policy, there is still a need to coordinate and synchronise all climate change efforts within the country to optimally contribute to the implementation of the Paris Agreement. The National Adaptation Plan, which is under development, stands a chance to benefit from the consultative process.

Examples of initiatives implemented by public institutions as per the initial Nationally Determined Contribution (NDC) are provided in Table 2-9. (ESEPARC, 2021).

Table 2-9. Initiatives implemented by public organisations as per the initial Nationally Determined Contribution (NDC) to the Convention on Climate Change/ Climate Change Policy (Source: ESEPARC (2021)).

Organisation	Project	Number of people reached
Ministry of Tourism and Environment Affairs	Afforestation and Reforestation Encouraging communities to plant trees Planting tree seedlings both (indigenous and exotic species) in schools, and Government Institutions Buildings Planting trees seedlings in degraded areas Encourage farmers to practice Agroforestry Enhancing Readiness for Investment in Low Carbon and Climate Resilient Development in Eswatini Lubombo Trans-frontier Project Strengthening the National Protected Area System of Eswatini Green Climate Fund Readiness Support for Eswatini	Pupils in more than 20 schools More than 500 people in communities
Ministry of Agriculture (Land use management department)	Medium Earth Dam Construction of dam to harvest water for vegetable production Rehabilitation and restoration of degraded land	11,200 people

Organisation	Project	Number of people reached
	Small Earth Dam Harvest water for animal production	
Ezulwini Municipality	Waste recycling Banning open burning of waste Schools Environmental Awareness Programs Upcycling	About 7,722 people
Department of Agricultural Research and Specialist Services (DARSS)	Climate-smart practices such as conservation agriculture, agroforestry, maize Intercropping, rotation, tillage methods, cover cropping. Control and management of emerging pests Evaluation of drought-tolerant varieties (maize, beans, sorghum, sweet potato).	No numerical data

Non-state actors such as ACAT, NERCHA and Swazi-Trails have integrated climate change into their operations and reached 4 700 people in their efforts to mitigate climate change issues (ESEPARC, 2021). These initiatives include activities in rural communities that contribute to assisting emaSwati to adapt and mitigate the effects of climate change through introducing rural masses to climate-resilient agricultural technologies, rooftop water harvesting, afforestation, donga rehabilitation, spring and wetland protection, savings and credit schemes, emphasising organic and traditional farming systems, amongst other activities. Efforts to curb the use of plastic water bottles and plastic packaging in catering operations also contributed to efforts to reduce emissions. Table 2-10 provides further detail on projects in which organisations in the private sector have been involved and the number of people that were reached.

Table 2-10. Initiatives implemented by organisations in the private sector as per the Intended Nationally Determined Contribution (INDC) to the Convention on Climate Change/ Climate Change Policy (Source: ESEPARC (2021)).

Organisation	Project	Number of people reached
NERCHA	30 projects implemented emphasising organic and traditional farming systems	300 households
ACAT	Assist rural households to build resilience towards climate change by promoting and supporting them to develop water-efficient farming agro-systems like permaculture. Assisting in the formation of savings and credit groups for easy and quick access to small loans for the betterment of their livelihoods. Water use efficiency and rainwater harvesting	1,400 households

Organisation	Project	Number of people reached
Swazi Trails	<p>Offering activities that avoid fossil fuels, promote less driving, more walking, cycling, rafting</p> <p>Closing of quad-biking operation as it is not climate friendly.</p> <p>Use reduce, reuse, and recycle principles in our procurement process.</p> <p>Banned the use of plastic water bottles and plastic packaging in company's catering operations.</p> <p>Deliberately avoided installing air conditioners and heaters in the company offices.</p>	2000-3000 clients per year

2.11.4 INTEGRATION OF CLIMATE CHANGE-RELATED POLICIES AND STRATEGIES

The Ministry of Tourism and Environmental Affairs facilitates the integration of climate change adaptation into relevant new and existing policies, programmes, and activities. The MTEA drives this integration through the Department of Meteorology, with a focus on development planning processes and strategies, interacting with multiple stakeholders at different levels. Policies at a sectoral level also include aspects of climate and environmental-related issues and policy suggestions.

In terms of the level of integration of climate-change related policies and strategies in societies, at the community level, 37% of institutions in urban areas and 19.8% in rural areas have integrated climate change issues into their policies. In contrast, 33.2% of organisations in the rural areas and 9.9% in urban areas do not consider climate-change related policies. This indicates a general limited understanding of climate change policies and strategies, thus suggesting a need for improved education and awareness in this regard, specifically in rural areas.

At an organizational level, it was found that 39.3% of organisations have not integrated climate change policies or strategies into their operations. Of the organisations recognizing climate change policies, approximately 50% state that they are equipped to implement climate change projects. The focus of the implementing organisations has been on public awareness initiatives, mitigation, and sustainability, with 73% of the institutions implementing such projects in the last five years. Barriers or challenges highlighted include a need for better integration and coordination of climate change at the national level, and this is largely due to a need for coordination mechanisms to support implementation by organisations. In addition, increased vulnerability of communities, especially rural communities, was emphasised. The revised NDC and the NAP process will support updating national priorities, including stakeholder mapping, outreach, and awareness raising, and support harmonization of efforts.

3 NATIONAL GREENHOUSE GAS INVENTORY

Eswatini's GHG emissions in 2018 are estimated at 3 240 Gg CO₂e. This total includes 1 551 Gg CO₂e from the Agriculture, Forestry and Other Land Uses (AFOLU) category; 1 304 Gg CO₂e from the energy category; 364 Gg CO₂e from the waste category, and 21 Gg CO₂e from the Industrial Processes and Product Use category (IPPU). The AFOLU category is responsible for the largest source of emissions (48%); followed by 40% from Energy, 11% from Waste, and IPPU provides the remaining 1%. Eswatini's total GHG emissions have been steadily rising since 1990, primarily driven by increasing emissions from the AFOLU sector. The main causes for increasing emissions in this sector are rising emissions in land use caused by the deforestation of indigenous forests, harvesting of timber in plantation forests, and infrastructure development including creation of dams for hydropower and irrigation.

The GHG inventory for the year 2018 is presented in this chapter. The GHG inventory is the fourth inventory in the series of National Communications since the third inventory for the 1990--2010 period was submitted in the Third National Communication (TNC).

The inventory covers sources of GHG emissions resulting from anthropogenic activities for direct greenhouse gases, including:

- Carbon dioxide (CO₂)
- Methane (CH₄)
- Nitrous oxide (N₂O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF₆)

The inventory also includes estimates of indirect GHG emissions from a limited number of sectors. These include the following gases:

- Nitrogen oxides (NO_x, as NO₂)
- Carbon monoxide (CO);
- Non-Methane Volatile Organic Compounds (NMVOC)
- Sulphur dioxide (SO₂).

GHG emission sources and sinks are reported according to the IPCC emission categories, namely:

- Energy;
- Industrial processes and product use (IPPU);
- Agriculture;
- Land use, land use change and forestry (LULUCF);
- Waste.

Emissions for each of the direct GHG emissions have been presented as carbon dioxide equivalent (CO₂e) using the 100-year global warming potentials (GWPs) contained in the IPCC Second Assessment Report (SAR) (1995). Table 3-1 illustrates the GWP value used for each gas.

Table 3-1: Global warming potential (GWP) values applied in the inventory (IPCC SAR, 1995).

GHG		GWP
Carbon dioxide	CO ₂	1
Methane	CH ₄	21
Nitrous oxide	N ₂ O	310
HFC-32	CH ₂ F ₂	650
HFC-134a	CH ₂ FCF ₃	1300
HFC-125	CHF ₂ CF ₃	2800
HFC-143a	CH ₃ CF ₃	3800
Sulphur hexafluoride	SF ₆	23900

3.1 NATIONAL GHG INVENTORY METHODOLOGY

For all categories in the energy sector, default emission factors were used from the 2006 IPCC Guidelines. The gases estimated are CO₂, CH₄, and N₂O and for all the sub-categories, Tier 1 method was used. The sub-categories included in the energy sector are fuel consumption emissions from electricity production, manufacturing, agriculture, transport, commerce, institutional and residential sectors, and fugitive emissions from surface coal mining and handling. Default Net Calorific Values (NCVs) were used throughout, except for conversion factors from litres to TJ for motor gasoline, diesel, and illuminating paraffin from the South African Energy Statistics. Data was sourced from the national energy balances produced by the Department of Energy of the Ministry of Natural Resources and Energy. The data was sometimes incomplete, in some cases other data sources had to be identified. Fuel consumption data for missing years was obtained from sources such as an open-access international dataset, directly from relevant industries, and data provided by the University of Eswatini's Centre for Sustainable Energy Research (CSER).

The GHGs included in the IPPU sector are CO₂, HFCs, SF₆ and N₂O. The industries covered in this sector include mineral industry (ceramics), non-energy products from fuels and solvent use (lubricants and paraffin wax) and product uses as substitutes for ozone depleting substances (use of HFCs in the manufacture and servicing of refrigerators and air-conditioning), other product manufacture and use (electrical equipment), and other (N₂O from product uses). Indirect GHG emissions were also estimated. These were from non-energy products from fuels and solvent use (solvent use and asphalt), pulp and paper industry, and food and beverages industry. The gases from these industries include NMVOC, CO, NO_x and SO₂. Tier 1 methodologies outlined in the 2006 IPCC guidelines were used for most of the categories, while Tier 2 was used for HFCs. Data was obtained from the previous inventory, national reports, the industries responsible, and expert judgement information from discussions with national experts. Other sources of data were the

Eswatini Environment Authority (EEA) and Eswatini Revenue Authority (ERA). Where population data was used, the Central Statistics Office (CSO) was consulted.

The GHGs estimated in the AFOLU sector include CO₂, CH₄, and N₂O. The three clusters of emission/removal categories are: livestock, land and aggregated sources, and non- CO₂ emission sources from land. Both Tier 1 and Tier 2 methodologies were used to quantify emissions in the livestock sector. Specifically, Tier 2 was applied to cattle data, while Tier 1 was used for everything else, including enteric fermentation and manure management. For livestock emissions, livestock population activity data was sourced from the Ministry of Agriculture. The Food and Agriculture Organization (FAO) provided data for dairy cattle, non-dairy cattle, sheep, goats, horses, mules, asses, swine, and poultry. Land cover maps are the main source of activity for land use emissions, which were mostly sourced from the Eswatini National Trust Commission, Eswatini Sugar Association, and Ministry of Agriculture. The activity data needed for aggregated sources and non-CO₂ emission sources from land are more varied. Annual burned area maps were produced from the MODIS Collection 6 Burned Area Product (MCD64A1v006) monthly burnt area product and used to quantify biomass burning emissions. Lime and urea importation data from the Eswatini Revenue Authority was used to quantify emissions from lime and urea application to soils. Livestock population, crop statistics and production, import and export statistics for wood products from FAO and Ministry of Agriculture data sources were used to quantify the emissions from managed soils and harvested wood products.

The GHGs included in the waste sector are CO₂, CH₄ and N₂O. The sub-categories are solid waste disposal into landfill; biological treatment of waste; incineration; open burning and wastewater treatment. A Tier 1 methodology was applied in all emission sub-categories. The main activity data in this sector were population; solid waste generation and composition; quantities of waste composted, incinerated, or burnt; and the utilization of waste-water treatment streams. Key data sources included Eswatini Central Statistics Office (CSO), Eswatini Environment Authority (EEA), municipalities, private companies, and Eswatini Water Services Corporation (EWSC).

3.2 QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Quality assurance and quality control (QA/QC) implemented for the compilation of the inventory followed the quality elements as provided in the IPCC Guidelines, namely:

- Transparency – comprehensive and clear documentation;
- Completeness – include all present sources and sinks;
- Comparability – use international reporting methods and formats;
- Consistency – use methods and data consistently across years;
- Accuracy – minimise over and/or under estimation of emissions.

Together, these are known as the TCCCA principles, and were used to ensure the inventory system produced a high-quality output, with QA/QC activities performed by inventory compilers and, where applicable, inventory QA/QC coordinators and inventory coordinators. These quality objectives and

activities are outlined in a QA/QC Plan which was developed at the beginning of the inventory cycle for the NC4/BUR1 project. The full plan is stored in the GHG Inventory Archiving Site being developed under the CBIT project. The plan includes:

- Definition of roles and responsibilities as described under the Institutional Arrangements section, defining which organizations contribute to the GHG Inventory compilation process in terms of data provision, calculations and compilation, QA/ QC and review, and coordination of the project.
- Work Plan outlining the steps required to produce the inventory, set deadlines and milestones, and assign responsibility for tasks.
- QA/QC Objectives defined at the start of the inventory compilation process, listing high level goals of the QA/QC system.
- QA/QC Activities defined during the compilation process, based on the UNFCCC Annex I Review Handbook 6 and input from the national and international experts. The quality activities should be reviewed throughout the compilation process to ensure that they are being performed. The full list has cross-cutting and sector specific activities and is available on the GHG Archiving site.

The inventory was compiled by a team of national experts and international consultants. All calculations were checked by multiple individuals using a transparent documentation and commenting system.

3.3 INSTITUTIONAL ARRANGEMENTS

A national GHG emissions inventory was compiled for reporting in the NC4/BUR1. The responsibility for the compilation of the GHG Inventory resides in the MTEA. The Department of Meteorology (MET) played a key role in coordinating the data collection processes, the sectoral experts and the GHG inventory archiving system for the compilation of the inventory reported in the NC4/BUR1. National consultants who are familiar with the different emission sectors were involved, in collaboration with international consultants, for coordinating the data collection and compilation of GHG inventory, overseen by a project steering committee. Data was sourced from national, regional, and local governments, the Central Statistics Office and private sector organisations. Sector level experts completed standard templates for activity data and emission factors which served as inputs into the national GHG management system.

Whilst the process for data sharing for the compilation of the GHG inventory is not underpinned by a formal legal framework, existing sectoral mandates assisted in the process. The Ministry of Natural Resources and Energy, through the Department of Energy, provided energy data and linked the project with key energy stakeholders in the country. Similarly, the Ministry of Agriculture is key to providing agriculture and land use data and linking with key agriculture stakeholders. The Central Statistics Office has the national legal mandate to collect and archive all national data and is, therefore, a key stakeholder for data collection and management.

A quality assurance and quality control (QA/QC) plan was developed at the start of the process for

the compilation for the GHG inventory for the NC4/BUR1 project. The plan defines roles and responsibilities for the QA/QC and the objectives of the QA/QC system to maintain and improve the quality in all stages of the inventory work, and was stored in the GHG Inventory Archiving Site being developed under the CBIT project. The Meteorology Department played a co-ordination role for QA/QC for the inventory reported in the BUR1, which was supported by national experts and external reviewers (e.g., United Nations Environment Programme - Global Science Diplomacy (UNEP-GSD)).

The overall arrangements for the compilation of the inventory are shown in Figure 3-1 below

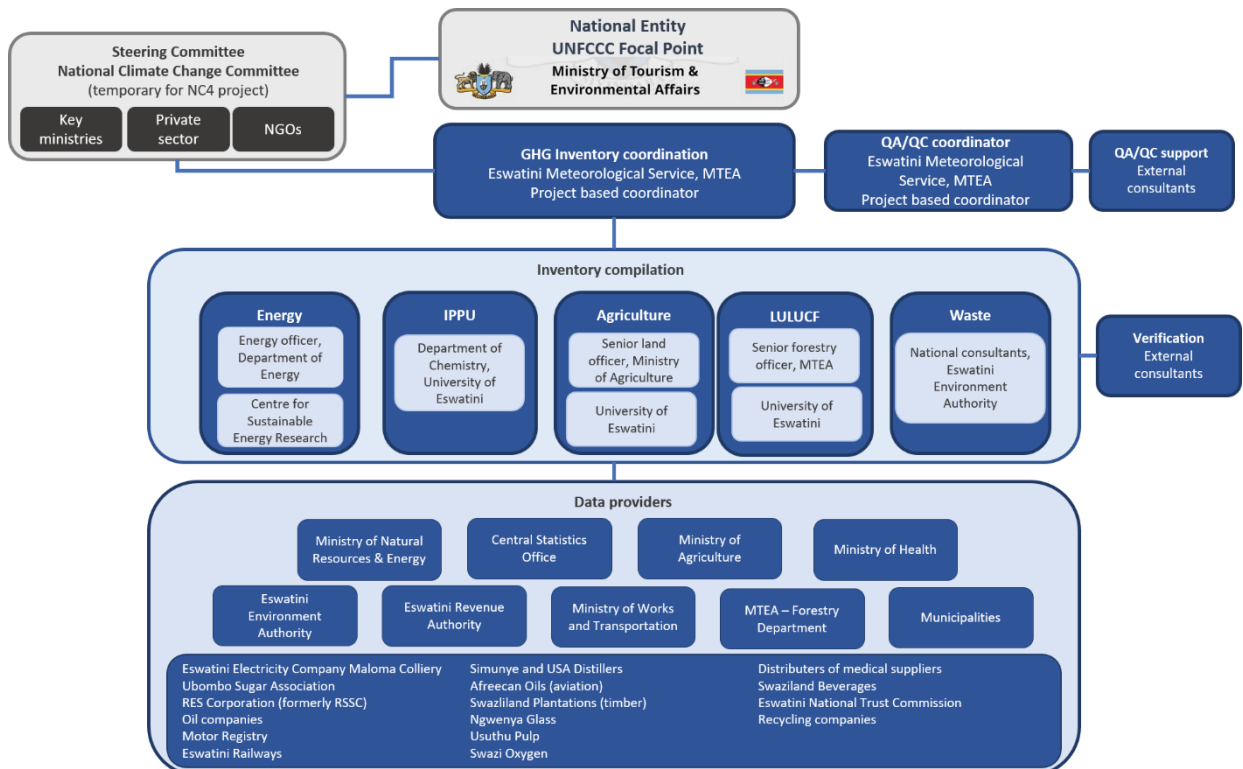


Figure 3-1: Institutional arrangements for the compilation of the GHG emissions inventory (MTEA, 2020).

No permanent institutional arrangements were put in place for the compilation of the GHG inventory. Institutional ownership is recognised by the UNFCCC as a key facet to ensure the sustainability of the NC/BUR development process. This includes having permanent coordination teams, developing institutional capacity and memory, archiving, and formal mandates for participation and data sharing.

The roles, responsibilities, and legal framework (organisational mandates) supporting the reporting of the GHG inventory will be further formalised through the enactment of a climate change act, wherein a bill is currently under development; and through upcoming support programmes including the United Nations Development Programme (UNDP) Climate Promise Initiative, the NDC Partnership support, and the Capacity Building Initiative for Transparency (CBIT) programmes of work (MTEA, 2020).

Capacity within the MTEA to coordinate inter-ministerial agreements and facilitate data sharing is a key factor, with the relevant department requiring dedicated financial resources and staff. There are improvements made in the current inventory that provide key steps towards improving continuity and supporting a continuous reporting system around data archiving, training, and current work to develop country-specific emission factors and thus supporting this process.

In terms of continuity, the previous inventory that had no archiving system in place, thus there was a lack of information and data available from that assessment. By having the process in place to ensure that the GHG estimates are transparent and accompanied by clear and up-to-date description of methodologies, data sources, assumptions, models, and underlying assumptions at sufficient category and subcategory detail, the basis for continually updating and improving the processes for the GHG inventory will be put in place. Through the current inventory process for the NC4/BUR1, a cloud-based IT system and a GHG Inventory Archiving Site is being put in place to store the data and information for all sectors covered in the GHG inventory. This site will provide a secure platform for data sharing and use across government departments during subsequent compilation processes.

Additionally, steps are being taken to enhance the co-operation between institutions, with a Memorandum of Understanding with the Ministry of Natural Resources and Energy and the MTEA initiated in order formalize the roles and responsibilities and procedures with respect to the collection of data and flow of information for the energy sector. Similarly, such institutional arrangements are needed for other sectors. These arrangements would also need to be initiated guided by the key mitigation actions that are contained with the NDC and related sectoral policies.

The compilation of the current inventory also contributed to enhancing the technical capacity of national consultants through a team of international and regional consultants with the aim of building national capacity to compile the inventory independently. As part of this capacity building programme, the tools, templates, and systems have also been updated for the compilation of the NC4/BUR1 GHG inventory. Through the process of the inventory compilation as well as the mitigation assessment undertaken for the NDC, opportunities to improve the GHG inventory have been documented, with the activity data for industrial processes and waste sectors further improved on.

Processes are already underway to address the data gaps and develop country specific emission factors. Ongoing projects with support from the Initiative for Climate Action Transparency (ICAT) are aimed at improving the collection of activity data and institutional arrangements for all the sectors of the NDCs. The ICAT project is supporting the government to set-up sectoral MRV systems and enhance capabilities such that the GHG inventory for the agriculture sector can be compiled using Tier 2 data for future inventory compilation. Specifically, data collection templates for Tier 2 agriculture GHG inventory are being developed and a roadmap for agricultural GHG emissions reporting, enhancing the data collection and institutional arrangements. Similarly for the energy sector, work is underway to produce more robust energy balances in the future, thereby improving the estimation of GHG emissions from the energy sector. These steps will contribute towards ongoing efforts to improve the availability, collection, and quality of data required for estimating

emissions in the energy and AFOLU sectors, and enables Eswatini to meet its enhanced international reporting requirements.

3.4 KEY CATEGORY ANALYSIS

The key category analysis, as detailed in the 2006 IPCC Guidelines, provides a useful analysis of the inventory estimates by highlighting the more significant categories. By so doing the inventory compilation team can better prioritise for improvement of data gathering and methodologies. Other users of the inventory can also clearly identify those categories that may be more applicable for mitigation to reduce national GHG emissions.

There are three ways of determining a key category:

- Level assessment – order the inventory categories from large to small in terms of emissions for a single year and highlight all categories that contribute to 95% of the total emissions.
- Trend assessment – order the inventory categories from large to small in terms of their contribution to the total trend and highlight all categories that contribute to 95% of the total trend.
- Qualitative assessment – inventory team identifies categories in addition to those flagged by the Level and Trend assessment that are deemed significant, and this could be due to expected growth or completeness of the inventory.

Table 3-2 below provides a summary of the key categories in the inventory, highlighting the absolute value in 1990 and 2018, as well as the percentage contribution over the assessment period.

Table 3-2: Summary of the key categories in the inventory, highlighting the absolute value in 1990 and 2018, as well as the percentage contribution over the assessment period.

Rank	IPCC Category Code	IPCC Category	Green-house Gas	Identification criteria	1990 Absolute Value	2018 Absolute Value	1990-2018 Contribution (%) All sectors
1	3B1a	Forest land Remaining Forest land	CO ₂	L1_1990, L1_2018, T1	2147.88	94.64	31.06%
2	3B1b	Land Converted to Forest land	CO ₂	L1_2018, T1	38.02	1614.64	20.30%
3	3B2b	Land Converted to Cropland	CO ₂	L1_1990, L1_2018, T1	175.20	1118.81	11.83%
4	3D1	Harvested wood products	CO ₂	L1_1990, L1_2018, T1	630.10	98.24	8.20%
5	3B3b	Land Converted to Grassland	CO ₂	L1_1990, L1_2018, T1	248.35	877.73	7.61%
6	1A3b	Road transportation Liquid Fuels	CO ₂	L1_1990, L1_2018, T1	283.19	696.81	4.75%
7	1A2	Manufacturing Industries and Construction Solid Fuels	CO ₂	L1_1990, L1_2018, T1	370.09	120.08	4.01%
8	3A1aii	Enteric Fermentation Dairy Cattle	CH ₄	L1_1990, L1_2018, T1	463.84	323.29	2.79%

Rank	IPCC Category Code	IPCC Category	Green-house Gas	Identification criteria	1990 Absolute Value	2018 Absolute Value	1990-2018 Contribution (%) All sectors
9	3B4b	Land Converted to Wetlands	CO ₂	L1_2018, T1	4.41	78.85	0.95%
10	3C4	Direct N2O MS Organic inputs Manure application	N ₂ O	L1_1990, L1_2018, T1	219.84	185.86	0.90%
11	3A2a ⁱⁱ	Manure Management (MM) -Dairy Cattle	N ₂ O	L1_1990, L1_2018, T1	141.14	98.37	0.85%
12	1A3c	Railways Liquid Fuels	CO ₂	L1_2018, T1	14.31	78.35	0.80%
13	3C6	Indirect N2O from MM Non-Dairy Cattle	N ₂ O	L1_1990, L1_2018, T1	127.25	88.69	0.77%

Note: L1_1990 = key category according to an approach 1 level assessment for 1990 data, L1_2018 = key category according to an approach 1 level assessment for 2018 data, T1 = key category according to an approach 1 trend assessment for 1990-2018. MM= manure management

3.5 NATIONAL 2018 GHG INVENTORY SUMMARY

Eswatini's National GHG inventory for 2018 includes both direct and indirect, from a range of GHGs.

3.5.1 2018 EMISSIONS BY GAS

In terms of total GHG emissions by gas, Figure 3-2 shows that CO₂ is responsible for 52% of emissions followed by CH₄ at 26%, N₂O at 22% and the F-gases contribute less than 1%. 67% of CO₂ emissions are derived from fuel combustion sources in Road Transportation; Manufacturing Industries and Construction and Commercial/Institutional, Residential, and Agriculture/Forestry/Fishing/Fish Farms categories. 29% of CO₂ are from the AFOLU category and attributed to carbon stock changes in the land use category. The AFOLU category accounts for 69% of N₂O and CH₄ emissions, mainly from the livestock enteric fermentation, livestock manure management, and managed soils. The waste category accounts for 19% of N₂O and CH₄ emissions from solid waste disposed into landfills and wastewater treatment.

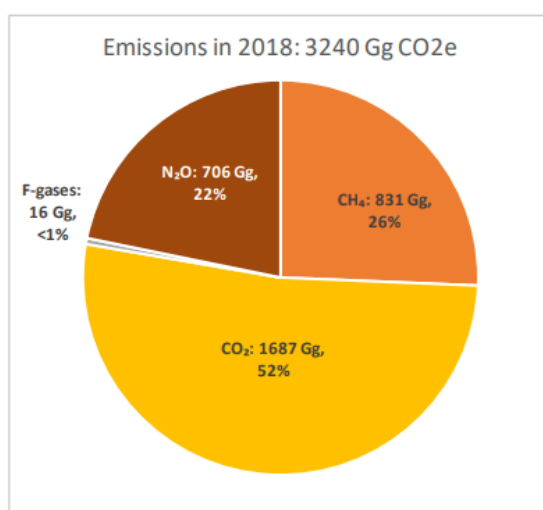


Figure 3-2: 2018 GHG inventory by gas (direct GHG emissions).

3.5.2 2018 GHG INVENTORY BY SECTOR

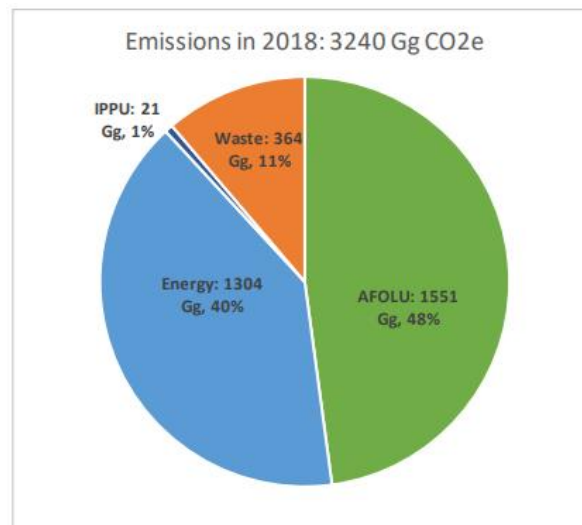


Figure 3-3: GHG per sector in the 2018 GHG inventory.

The total 2018 GHG emissions from the Energy, Industrial Processes and Product Use, Agriculture, Land Use, Land-Use Change, and Forestry and Waste categories came to 2 765 Gg CO₂ e. This value excludes the emission removals from the FOLU sector. As shown in Figure 3-3, the largest sources of GHG emissions were derived from AFOLU accounting for 48% (1 551 Gg CO₂e) of the total emissions, followed by energy at 40% (1 304 Gg CO₂e), waste with 11% (364 Gg CO₂e), and IPPU with 1% (21 Gg CO₂e). The main causes for increasing emissions in the AFOLU category are from reduced carbon stock in land use caused by the deforestation of indigenous forests, harvesting of timber in plantation forests, and infrastructure development including creation of dams for hydropower and irrigation. The emissions from all categories are presented in Table 3-3.

Table 3-3. Summary of GHG Emissions/Removals for Eswatini, 2018 GHG Emissions (Gg CO₂ e).

Greenhouse gas source and sink categories	Total GHG	Net CO ₂	CH ₄	N ₂ O	HFCs	PFCs*	SF ₆	CO	NO _x	NMVOCs	SO _x
Total (including FOLU)	3240.10	1687.06	831.08	706.16	14.55	NA	1.24	14.21	0.66	15.71	NA
Total (excluding FOLU)	2765.05	1212.02	831.08	706.16	14.55	NA	1.24	NA	NA	NA	NA
1. Energy	1303.81	1131.68	120.01	52.12	NA	NA	NA	NE	NE	NE	NE
2. Industrial Processes and Product Use	20.84	4.95	NE	0.10	14.55	NE	1.24	0.00	0.00	16.30	0.00
3. Agriculture, Forestry, and other Land Use (AFOLU)	1551.13	482.88	421.29	646.97	NA	NA		14.21	0.66	NA	NA
4. Waste	364.31	67.56	289.78	6.97	NA	NA	NA	NA	NA	NA	NA

Eswatini's 2018 national GHG emissions are further summarized per IPCC category and per GHG source and sink, in Table 3-4.

Table 3-4. 2018 GHG Inventory Summary.

Categories		Total GHG	CO ₂	CH ₄	N ₂ O	HFCs	SF ₆	NO _x	CO	NMVOCs	SO ₂
CO ₂ equivalents (Gg)		(Gg)									
Total National Emissions and Removals (including LULUCF)		3240.10	1687.06	831.08	706.16	14.55	1.24	14.21	0.66	15.71	0.00
Total National Emissions and Removals (Excluding LULUCF)		2765.05	831.08	706.16	14.55	NA	1.24	14.21	0.66	15.71	0.00
1 ENERGY		1303.81	1131.68	120.01	52.12			NE	NE	NE	NE
1A	Fuel Combustion Activities	1273.40	1131.68	89.60	52.12			NO	NO	NO	NO
1A1	Energy Industries	NO	NO	NO	NO			NO	NO	NO	NO
1A2	Manufacturing Industries and Construction	246.41	222.36	8.07	15.98			NE	NE	NE	NE
1A3	Transport	799.42	775.95	2.93	20.54			NE	NE	NE	NE
1A4	Other Sectors	227.57	133.37	78.60	15.59			NE	NE	NE	NE
1B	Fugitive Emissions from Fuels	30.41	NE	30.41	NA			NA	NA	NA	NA
1B1	Solid Fuels	30.41	NE	30.41	NA				NE		
1B2	Oil and Natural Gas	NO	NO	NO	NA				NE		
1B3	Other Emissions from Energy Production	NO	NO	NO	NO				NO		
2 INDUSTRIAL PROCESSES AND PRODUCT USE		20.84	4.95	NE	0.10	14.55	1.24				
2D	Non-Energy Products from Fuels and Solvent Use	4.95	4.95	NA	NA		0.00	0.00	0.00	16.30	0.00
2F	Product Uses as Substitutes for Ozone Depleting Substances	14.55	NA	NA	NA	14.55	NA	NA	NA	0.58	NA
2G	Other Product Manufacture and Use	1.34	NA	NA	0.10	NA					
2H	Other	0.00	NE	NE	NE						0.00
3 AGRICULTURE, FORESTRY AND OTHER LAND USE		1551.13	482.88	421.29	646.97			0.00		15.71	0.00
3A	Livestock	534.59		409.15	125.44			14.21	0.66	NE	NE
3A1	Enteric Fermentation	383.41		383.41	NA						
3A2	Manure Management	151.18		25.74	125.44						
3B	Land	573.29	573.29	NA	NA						
3B1	Forest Land	-1520.00	-1520.00	NA	NA			NE		NE	NE
3B2	Cropland	1121.49	1121.49	NA	NA			NE		NE	
3B3	Grassland	877.73	877.73	NA	NA						
3B4	Wetlands	78.85	78.85	NA	NA			NE		NE	
3B5	Settlements	14.92	14.92	NA	NA						NE
3B6	Other Land	0.00	0.00	NA	NA						
3C	Aggregate Sources and Non-CO ₂ Emissions Sources on Land	541.50	7.83	12.15	521.53	14.21	0.66				
3C1	Biomass Burning	24.73	NE	12.15	12.58	14.21	0.66	14.21	0.66	NE	NE
3C2	Liming	0.02	0.02					14.21	0.66	NE	NE
3C3	Urea Application	7.81	7.81								
3C4	Direct N ₂ O Emissions from Managed Soils	306.41			306.41						
3C5	Indirect N ₂ O Emissions from Managed Soils	105.97			105.97			NA		NA	
3C6	Indirect N ₂ O Emissions from Manure Management	96.56			96.56						
3D	Other	-98.24	-98.24	NA	NA						
3D1	Harvested Wood Products	-98.24	-98.24								
4 WASTE		364.31	67.56	289.78	6.97						
4A	Solid Waste Disposal	177.41		177.41	NA			NE	NE	NE	NE
4B	Biological Treatment of Solid	2.13		1.13	1.00						

Categories	Total GHG	CO ₂	CH ₄	N ₂ O	HFCs	SF ₆	NO _x	CO	NMVOCs	SO ₂
	CO ₂ equivalents (Gg)	(Gg)								
4C	Waste Incineration and Open Burning of Waste	84.16	67.56	12.38	4.22		NE	NE		NE
4D	Wastewater Treatment and Discharge	100.60		98.85	1.75				NE	
4E	Other (please specify)	NO	NO	NO	NO	NO	NO	NE	NE	NE
5 OTHER		NE	NE	NE	NE	NE	NE	NO	NO	NO
5A	Indirect N ₂ O Emissions from the Atmospheric Deposition of Nitrogen in NO _x and NH ₃	NE			NE					
5B	Other (please specify)	NA			NA					
	International Bunkers	NO	NO	NO	NO					
	International Aviation (International Bunkers)	3.75	3.72	0.00	0.03					
	International Water-borne Transport (International Bunkers)	NO	NO	NO	NO					
	Multilateral Operations	NO	NO	NO	NO					

3.5.3 INDIRECT GHG EMISSIONS

Air pollutants including NO_x, CO, NMVOC, and SO₂ are included in GHG inventories as they contribute indirectly to increasing the concentrations of GHG gases in the atmosphere. The indirect GHG emissions for 2018 are shown in Table 3-5 below.

Table 3-5. Indirect GHG emissions 2018 (Gg).

Categories	NO _x	CO	NMVOCs	SO ₂
	(Gg)			
1. Energy	NE	NE	NE	NE
2. Industrial processes and product use	0.00	0.00	16.30	0.00
3. Agriculture, forestry and other land use	14.21	0.66	NE	NE
4. Waste	NE	NE	NE	NE
Total National Emissions	14.21	0.66	16.30	0.00

3.6 ENERGY

The total calculated emissions from the energy sector, in Gg CO₂e, are shown in Figure 3-4 split by gas and split by IPCC category. The dominating GHG in the energy sector is carbon dioxide, followed by methane, and lastly nitrous oxide. The largest source categories in the energy sector are 1A3b Road Transport and 1A2 Manufacturing and Construction Industries, followed by 1A4 Other Sectors. A summary of the sub-category GHG emissions in the energy sector for 2018 is shown in Table 3-6 below. The GHG emissions from the energy sector in 2018 are estimated at 1303.81Gg CO₂e, of which the main emission sources are fuel combustion activities that contribute 1273.40Gg CO₂e; 246.41Gg CO₂e from manufacturing industries and construction, and 799.42Gg CO₂e from transport.

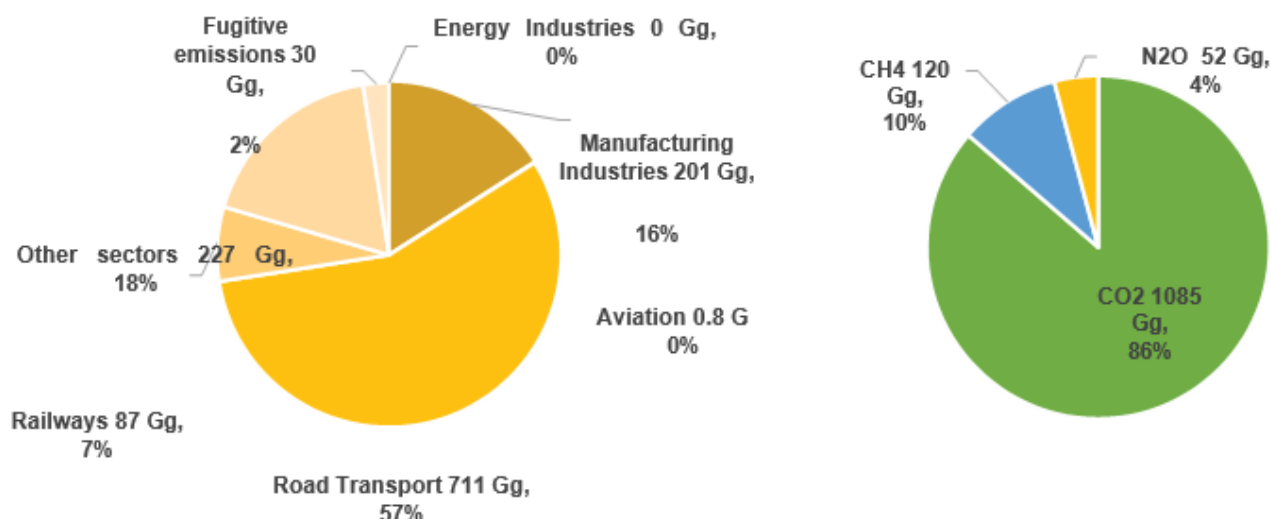


Figure 3-4. National GHG emission shares in the energy sector shown by a) sub-category and b) gas for 2018.

Table 3-6. Summary table of sub-category GHG emissions in the energy sector for 2018.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Total GHG	CO2	CH4	N2O	NOx	CO	NM VOC
1 Energy	1303.81	1131.68	120.01	52.12	NE	NE	NE
1A Fuel Combustion Activities	1273.40	1131.68	89.60	52.12	NE	NE	NE
1A1 Energy Industries	NO	NO	NO	NO	NO	NO	NO
1A1 b Petroleum Refining	NO	NO	NO	NO	NO	NO	NO
1A1 c Manufacture of Solid Fuels and Other Energy Industries	IE	IE	IE	IE	IE	IE	IE
1A2 Manufacturing Industries and Construction	246.41	222.36	8.07	15.98	NE	NE	NE
1A3 Transport	799.42	775.95	2.93	20.54	NE	NE	NE
1A3 a Civil Aviation	0.79	0.78	0.00	0.01	NE	NE	NE
1A3 b Road Transportation	710.82	696.81	2.84	11.16	NE	NE	NE
1A3 c Railways	87.81	78.35	0.09	9.37	NE	NE	NE
1A3 d Water-borne Navigation	NE	NE	NE	NE	NE	NE	NE
1A4 Other Sectors	227.57	133.37	78.60	15.59	NE	NE	NE
1B Fugitive Emissions from Fuels	30.41	NE	30.41	NA	NE	NA	NE
1B1 Solid Fuel	30.41	NE	30.41	NA	NE	NA	NE
1B1 a Coal Mining and Handling	30.41	NE	30.41	NA	NE	NA	NE
1A1 b Petroleum Refining	NO	NO	NO	NO	NO	NO	NO
1A1 c Manufacture of Solid Fuels and Other Energy Industries	IE	IE	IE	IE	IE	IE	IE
1A2 Manufacturing Industries and Construction	246.41	222.36	8.07	15.98	NE	NE	NE
1A3 Transport	799.42	775.95	2.93	20.54	NE	NE	NE
1A3 a Civil Aviation	0.79	0.78	0.00	0.01	NE	NE	NE
1A3 b Road Transportation	710.82	696.81	2.84	11.16	NE	NE	NE
1A3 c Railways	87.81	78.35	0.09	9.37	NE	NE	NE
1A3 d Water-borne Navigation	NE	NE	NE	NE	NE	NE	NE
1A4 Other Sectors	227.57	133.37	78.60	15.59	NE	NE	NE
1B Fugitive Emissions from Fuels	30.41	NE	30.41	NA	NE	NA	NE
1B1 Solid Fuel	30.41	NE	30.41	NA	NE	NA	NE
1B1 a Coal Mining and Handling	30.41	NE	30.41	NA	NE	NA	NE

NO: Not Occurring; NA: Not Available; NE: Not Estimated

3.6.1 GHG TRENDS

The largest fluctuations in energy sector emissions, as shown in Figure 3-5, are from category 1A2 Manufacturing and Construction Industries, driven by data on coal imports. The decline in emissions

seen in 1990-1993 was due to the drought in 1992, which caused a bad harvest of sugar cane in 1993 and lowered the demand of coal in the sugar industry. In 1999, there was a peak in emissions which was due the expansion of the Royal Eswatini Sugar Corporation's mill to accommodate cane purchased from new independent cane farmers. This increased demand for coal for processing the added cane.

The decline in emissions in 2005 was caused by an economic downturn which was experienced during that year, due to a decline in the manufacturing sector. As a result, coal consumption in the sector declined leading to reduced emissions. Furthermore, in 2005, the expiry of the Agreement on Textiles and Clothing affected several companies in the textile industry where many of them used coal to generate heat for dyeing, spinning, and ironing of apparel. These companies could no longer compete with companies from other countries and several of them had to shut down. The financial crash in 2008 caused a dip in emissions in 2010.

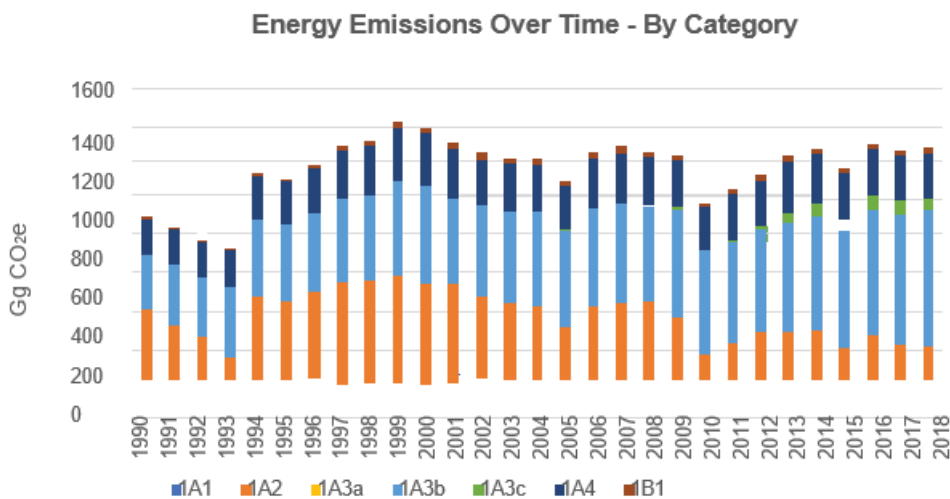


Figure 3-5. Energy Sector Emissions by Category.

There is an overall increase in the emission of CO₂ and CH₄ (Figure 3-6). The increase in CO₂ emission correlates with the fluctuations of emissions attributed to the manufacturing and construction category. Methane emitted from the coal mines over the years also shows a steady increase. However, there is an observed dip in 1993 which is attributed to the closure of Mpaka Mine in 1992 due to a decline in profits. A gradual increase in CH₄ emission was also seen due to the opening of the Maloma Colliery.

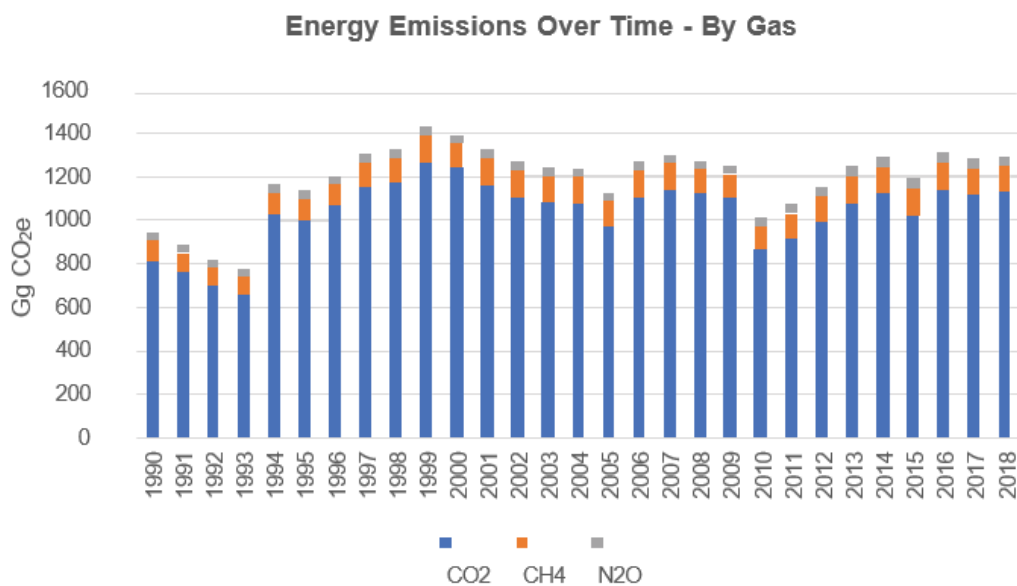


Figure 3-6. Energy Sector Emissions by Gas for the 1990 to 2018 period.

3.6.2 COMPARISON OF REFERENCE APPROACH AND SECTORAL APPROACH

The comparison of GHG emissions estimated using the sectoral approach and the reference approach is part of good practice to validate the energy GHG inventory. The energy balance from the Ministry of Natural Resources and Energy was the source of energy supply data that was used to quantify GHG emissions using the reference approach. The energy balances from 2010 to 2018 were complete and thus were used in the reference approach.

The comparison between the sectoral and reference approaches is shown in that there were no significant differences between the two estimations. The percentage error of GHG estimates between the two approaches are below 10% between 2012 and 2014, as shown in Figure 3-7. This is attributed to the limited reporting coverage of fuel consumed in manufacturing sub-sectors in energy balances. The energy balances included data about fuel use in food, beverages, and tobacco; mining and quarrying; wood and wood products; textiles and leather; non-specified industry; and the total manufacturing sector fuel consumption. Fuel use in mining and quarrying, wood and wood products, and textiles and leather were not reported for all years.

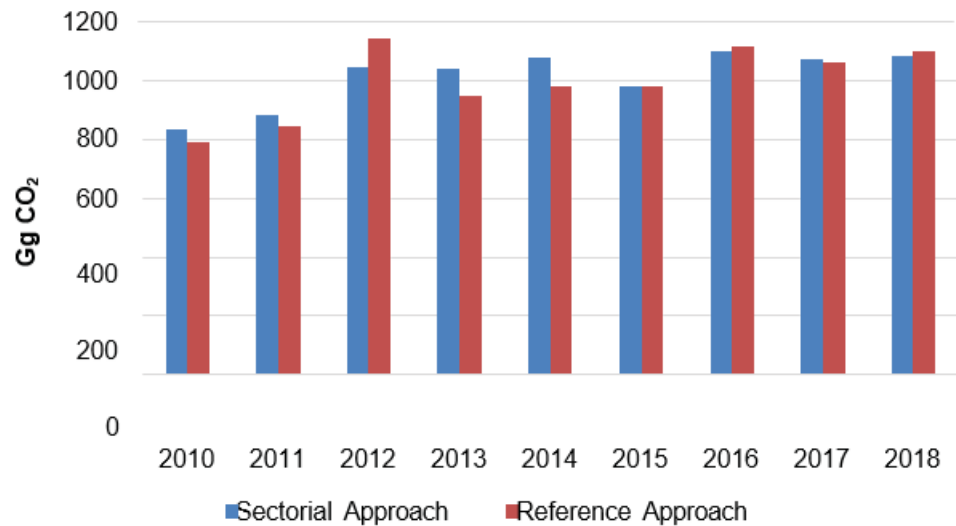


Figure 3-7: Energy sector emissions estimated using the reference approach compared to sectoral approach.

3.6.3 RE-CALCULATIONS

All emission estimates in this sector were re-calculated as the data from the previous inventory calculations was not available.

3.6.4 IMPROVEMENTS SINCE THE 2010 GHG INVENTORY

In the energy sector, previous inventory data were not available, therefore all emission estimates for this sector were re-calculated. A comparison between total emissions in each sub-category of the previous inventory and the current inventory indicates that estimates were similar. The methodology to quantify CH₄ and N₂O emissions in road transportation was moved to Tier 2.

3.6.4.1 SCOPE FOR IMPROVEMENTS

The MTEA is responsible for the compilation of the Energy GHG inventory. Ministry of Public Works and Transport and the Department of Treasury are responsible for the collation of activity data for the road transportation sub-category of the energy GHG inventory. Planned improvements for the energy GHG inventory include:

- Collecting actual data for fuel usage in the off-road vehicles used for agriculture and devise a better method to estimate fuel use;
- Improving coal usage data from agriculture;
- Collecting data on the abandoned Mpaka Mine and verify coal mining data;
- Collecting data on fugitive emissions from transport and distribution of oil products, and transport and distribution of LPG;
- Collation of data from missing years directly from the relevant

industries or ask them to verify the extrapolations;

- Working with the Eswatini Railway to establish emissions factors for their locomotives to move to 1A3c estimates to Tier 2;
- Improving biofuel estimates for 1990-2009. Get sector specific fuel consumptions or improve accuracy of percentage splits;
- Collecting data for different locomotive engine types to estimate emissions using Tier 2 methodology;
- Improving emission factors for specific ULP and Diesel 50ppm;
- Collecting information on the actual number of each type of vehicle on the road and including vehicle mileage and age of the vehicle during the annual license renewal of all vehicles;
- Collection of disaggregated data for aviation fuel consumption is necessary to show data used in the agriculture sector, other domestic aviation and international aviation;
- To obtain fuel use data directly from industries (particularly sugar industry) and improve collection of coal usage data from the manufacturing sector;
- To obtain actual fuel use data for 1990 to 1994;
- To include charcoal production activity data in the inventory (obtain from producers or estimate).

3.7 IPPU

Total direct GHG emissions from all source categories in 2018 were 20.84 Gg CO₂ e (Table 3-7). Product Uses as Substitutes for Ozone Depleting Substance Refrigeration and Air-Conditioning account for 68.24% of emissions or 14.55 Gg CO₂ e as shown in the table. Non-Energy products account for 4.14 Gg CO₂ e of emissions from lubricant use, paraffin wax use (0.81 Gg CO₂ e), and solvent use (0.58 Gg CO₂ e). The remaining 5.83% of emissions is from Other Product Manufacture and Use Electrical Equipment (1.24 Gg CO₂ e). A summary of the sub-category GHG emissions in the IPPU sector for 2018 is shown in Table 3-7.

The indirect GHG emissions from NMVOC in 2018 is 16.30 Gg. Other Food and the Beverages Industry account for 15.71 Gg of emissions. Non-Energy Products from Solvent Use account for 0.58 Gg of emissions. The emissions of CO, NO_x and SO₂ from other pulp and paper industry production is zero.

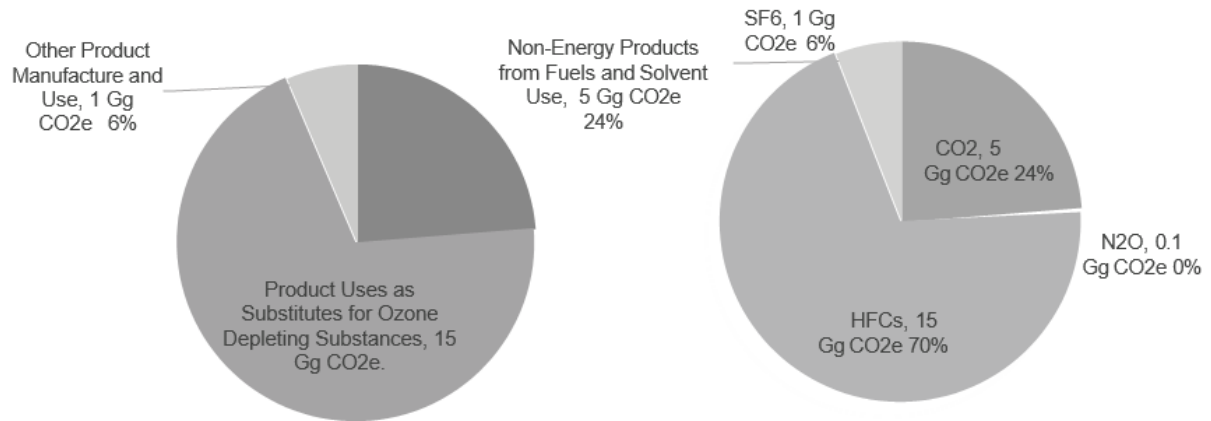


Figure 3-8: National GHG emission shares in the IPPU sector shown by a) sub-category and b) gas for 2018.

Table 3-7. Summary table of sub-category GHG emissions in the IPPU sector for 2018.

Greenhouse gas source and sink categories	Total GHG	Net CO ₂	CH ₄	N ₂ O	CO	NO _x	NMVOCS	SO _x	HFCs	PFCs*	SF ₆
	CO ₂ equivalent (Gg)			(Gg)					CO ₂ equivalent (Gg)		
2. Industrial Processes and Product Use	20.84	4.95	NE	0	0	0	16.30	0	NA	NA	NA
2D. Non-Energy Products from Fuels and Solvent Use	4.95	4.95	NA	NA	NA	NA	0.58	NA	NA	NA	NA
2D1. Lubricant Use	4.14	4.14	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D2. Paraffin Wax Use	0.81	0.81	NA	NA	NA	NA	NA	NA	NA	NA	NA
2D3. Solvent Use	0.00				NA	NA	0.58	NA	NA	NA	NA
2F. Product Uses as Substitutes for Ozone Depleting Substance	14.55	NA	NA	NA	NA	NA	NA	NA	15	NA	NA
2F1. Refrigeration and Air Conditioning	14.55	NA	NA	NA	NA	NA	NA	NA	15	NE	NA
2G. Other Product Manufacture and Use	1.34	NA	NA	0	NA	NA	NA	NA	NA	NA	1.24
2G1. Electrical Equipment	1.24	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.24
2G3. N ₂ O from Product Uses	0.10	NA	NA	0.10	NA	NA	NA	NA	NA	NA	NA
2H2. Food and Beverages	NE	NE	NE		NE	NE	15.71	NE	NA	NA	NA

Greenhouse gas source and sink categories	Total GHG	Net CO ₂	CH ₄	N ₂ O	CO	NO _x	NMVOCs	SO _x	HFCs	PFCs*	SF ₆
	CO ₂ equivalent (Gg)				(Gg)				CO ₂ equivalent (Gg)		
Industry											

3.7.1 GHG trends

Overall, direct GHG emissions from the IPPU sector have been steadily rising since 2000, from 9.55 Gg CO₂ equivalent in 2000 to 20.84 Gg CO₂ equivalent (Figure 3-9). This is primarily due to the increasing emissions from HFCs in refrigeration and air conditioning (Figure 3-10) which were imported products. The decline in total emissions between 2016 and 2018 is attributable to brick manufacturing in the ceramics industry. The single brick manufacturing company closed in 2018. No more emissions are expected from this company or ceramics as there is currently no company that produces ceramics in the country.

Indirect GHGs are dominated by NMVOC as shown in Figure 3-11 from the food and beverages which shows an increasing trend throughout the time series. The pulp and paper industry also contributed NO_x, CO, and SO₂. The company responsible for pulp and paper emissions closed in 2012 and hence there are no emissions from this category from 2012 onwards.

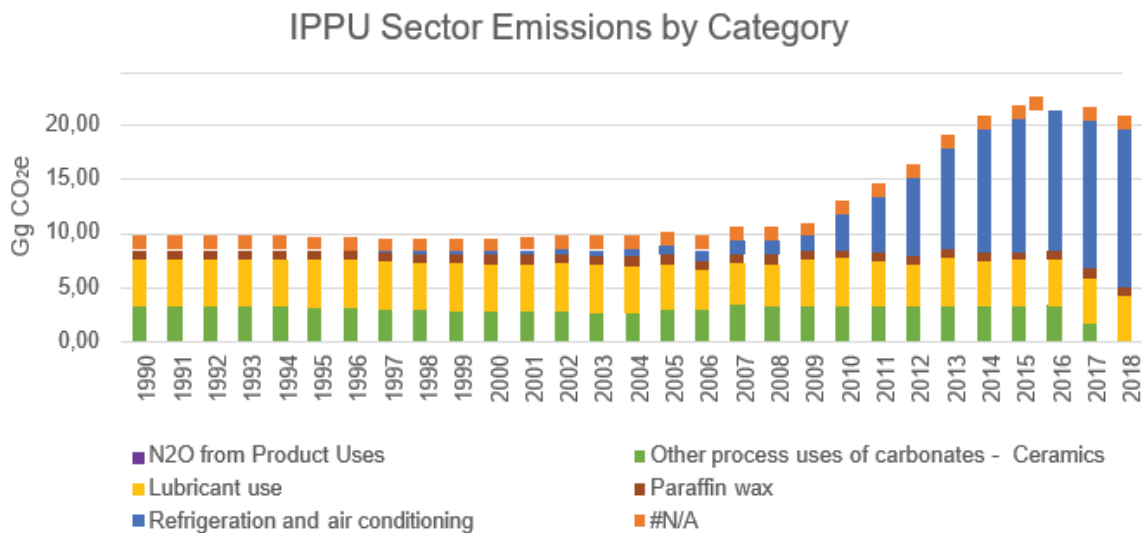


Figure 3-9: Timeseries of IPPU sector emissions from 1990 to 2018

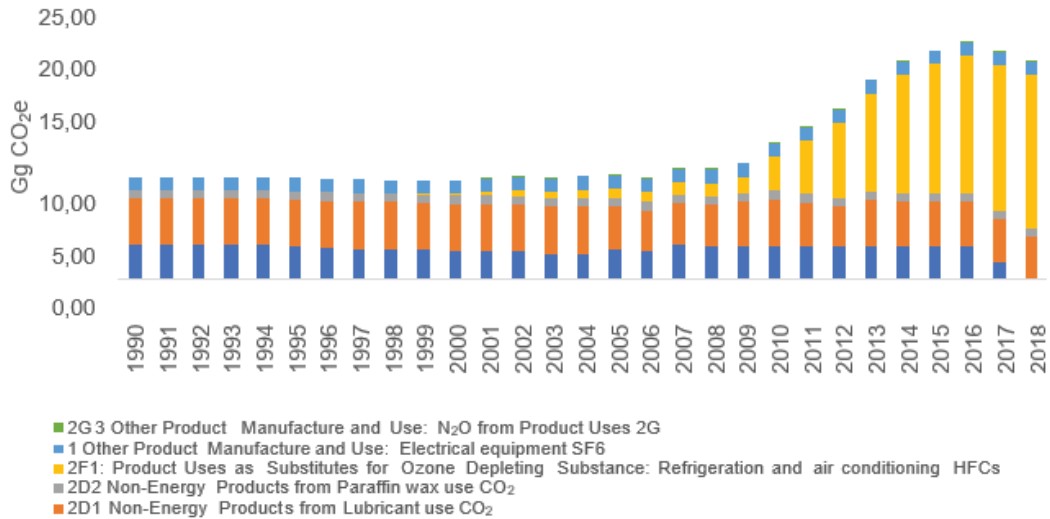


Figure 3-10: Direct GHG emissions of IPPU sector by gas in Gg CO₂ equivalent.

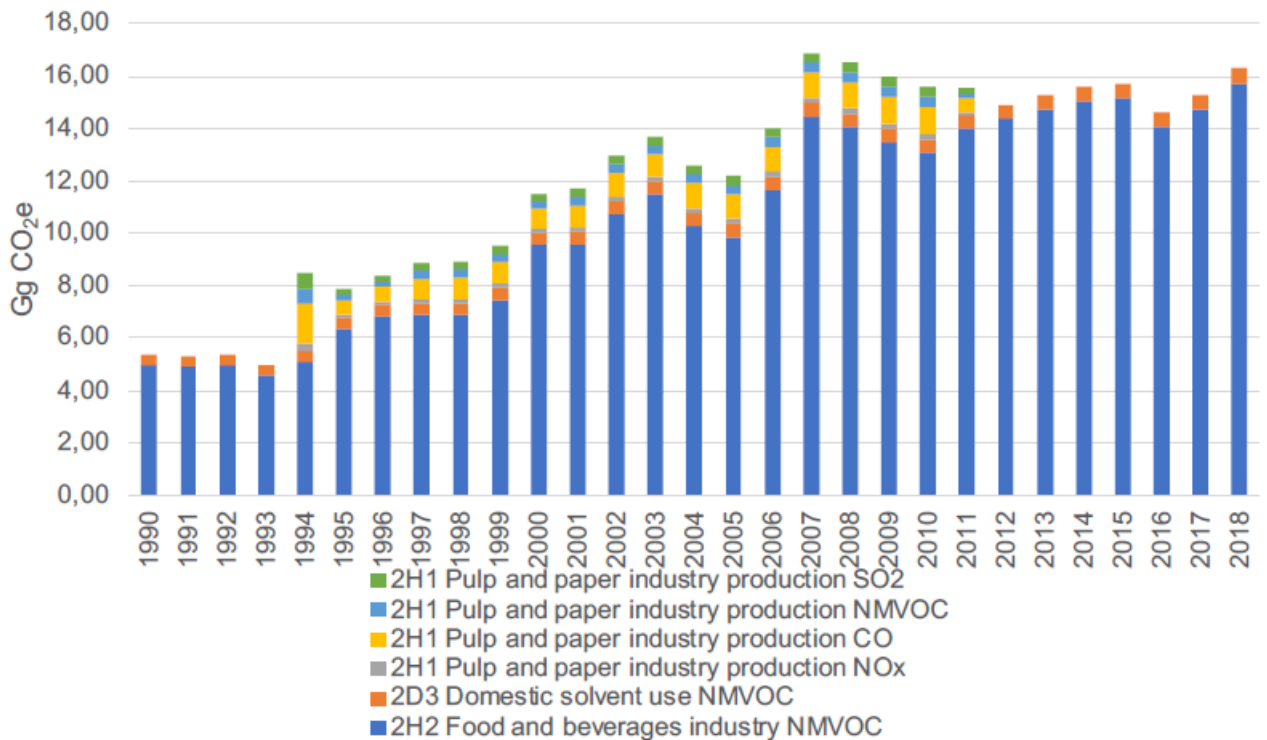


Figure 3-11: Indirect GHG emissions of IPPU sector by gas in Gg.

3.7.2 RE-CALCULATIONS

There is a 4.82% reduction in the total emissions from IPPU due to re-calculations completed for the 2018 inventory (Table 3-8). The source emission categories 2A Mineral Industry and 2D Non-Energy Products from Fuels and Solvent Use accounted for 87.80% of total emissions in the 2010 inventory.

2F1, Refrigeration and air-conditioning only accounted for 12.2% to the total emissions in the previous inventory which was erroneously reported as 99.3%.

Emissions in the mineral industry decreased by 50.03% due to changes in quantification. 2A4 Other Process Uses of Carbonates, specifically use of soda ash and clay brick production, were included in the 2010 inventory. For soda ash, activity data was obtained from the sugar mill companies for the 2018 inventory which suggested no use of sodium carbonate (Na_2CO_3) in the sugar production process. This indicates that emissions coming from sugar production based on the use of Na_2CO_3 are not applicable. This is a change from the previous inventory that assumed some use of Na_2CO_3 . For clay brick production, the previous inventory submission did not account for a default factor of 1.1 for the ratio of total production of soda ash products to the amount of clay consumed with respect to total production ('loss factor').

There is a 4.52% decrease in emissions quantified for 2D, and Non-Energy Products from Fuels and Solvent Use due to re-calculations. For 2D1 and 2D2 – non-energy product use – Lubricants and Paraffin Wax; a Net Calorific Value (NCV) of 42 TJ/kt was applied in the previous inventory. The reference NCV of 40.2 TJ/kt (IPCC, 2006) is applied in the current inventory.

For 2F1 Refrigeration and Air-Conditioning, the data used in the previous inventory was obtained from ERA and was associated with uncertainties as data from ERA does not give quantities or specifications of gas species. Emissions from aerosols were then not included as reliable data could not be obtained to use in the current inventory. Hence large re-calculations in this category are due to a change of data source of HFC blend imports/exports that significantly reduced the amount of HFCs consumed by the refrigeration manufacturing industry and, therefore, the amount of F gases released.

For 2G Other product manufacture and use, it is reported in the previous inventory that the emissions do not occur, which was erroneous. Since the source category was not quantified in the previous inventory, its addition to the current inventory implies an improvement rather than a re-calculation.

Although total indirect emissions per pollutant type were quantified in the previous inventory, emissions for each source category in IPPU were not specified. Emissions of NMVOC were quantified for 2D3 Domestic solvent use; 2H1 Pulp and paper industry production, and 2H2 Food and beverages industry. The total emissions of NMVOC are 84.29% lower due to re-calculations in the current inventory compared to the previous one. For 2D3 Non-Energy Products from Domestic solvent use a per capita usage method to model activity data is applied which is based on the EMEP/EEA Guidebook 2019 and is different to the method used previously. A higher quantity of solvent usage is re-calculated in the current inventory which results in greater emissions. For 2D3 Non-Energy Products from Road paving with asphalt the total surface area of roads paved was re-calculated in the current inventory and a correction factor used in the re-calculation of the emission factor which resulted in a decrease in emissions. For 2H2 Food and beverages industry, re-calculations were only done for sugar production where new datasets were obtained and hence used. All other food and beverages categories used data from the previous inventory.

Emissions for NO_x, SO₂ and CO were quantified for 2H1 Pulp and Paper industry production. In the current inventory, the emission factors were updated to be in line with Tier 2 values in EMEP/EEA Guidebook 2019. The emission factor for NMVOCs was 3.7 kg/Mg air dried pulp in the previous inventory, while it is 2 kg/Mg air dried pulp in the EMEP/EEA Guidebook 2019. This resulted in the reduction of emission estimates from pulp production. The estimated NO_x and SO₂ emissions decreased by 33.8% and 93.6% compared to the previous inventory, while CO emissions increased by 5.59%.

Table 3-8. Comparison of emission estimates between the previous inventory of TNC and the current inventory.

Greenhouse gas source and sink categories	TNC: 2010	BUR-1: 2010	Percentage difference (%)
	Total GHG (Gg CO ₂ equivalent)	Total GHG (Gg CO ₂ equivalent)	
2. Industrial Processes and Product Use	13.69	13.03	-4.82
2A. Mineral Industry	6.64	3.32	-50.0
2D. Non-Energy Products from Fuels and Solvent Use	5.38	5.14	-4.46
2F. Product Uses as Substitutes for Ozone Depleting Substance	1.67	3.25	94.61
2F1. Refrigeration and Air Conditioning	1.67	3.25	94.61
2G. Other Product Manufacture and Use	NO	1.32	Not estimated in TNC
2H. Other	NE	NE	Indirect GHG emissions estimated only

3.7.3 IMPROVEMENTS SINCE THE 2010 GHG INVENTORY

Improvements made to the IPPU inventory helped to identify where re-calculations showed that the sector is no longer a key category in the country. This was primarily linked to the previous data used for the TNC to estimate emissions from Refrigeration and Air-Conditioning being associated with uncertainties.

3.7.4 SCOPE FOR IMPROVEMENTS

The MTEA is responsible for the compilation of the IPPU GHG inventory. The Eswatini Environmental Authority and relevant industries are responsible for the collation of activity data for the IPPU GHG inventory. Planned improvements for the IPPU GHG inventory include:

- Improving data collection on lubricant use;
- Exploring other sources of data to estimate the amount of paraffin wax used;

- Developing a method of estimating country specific data for domestic solvent use;
- Verification of data on the length of paved roads and amount of asphalt used;
- Conducting local studies on life span of refrigerators and air-conditioners to improve the data collection for future inventories;
- Developing a data collection strategy for N₂O from product uses;
- Verification of data for the food and drinks category.

3.8 AFOLU

The emissions/removals from the AFOLU sector are influenced by the combination of the factors and implementation of national policies, available technologies, and management practices. The aggregate effects of the way policies, technologies, and management practices are used largely determine land use practices and the associated emissions or removal of GHG from the AFOLU sector. Some of the practices include: (a) livestock rearing, (b) land use change via forest conversion (deforestation), (c) afforestation, (d) wood-fuel extraction, (e) wildfire disturbance, and (f) application of nitrogen-based fertilisers.

FOLU accounts for 37% of the AFOLU sector emissions as shown in Figure 3-12. Aggregate sources and Non-CO₂ Emissions Sources on Land account for 35% of the total emissions. Cumulatively, 3A1 Enteric Fermentation and 3A2 Manure Management account for 35% of AFOLU sector emissions.

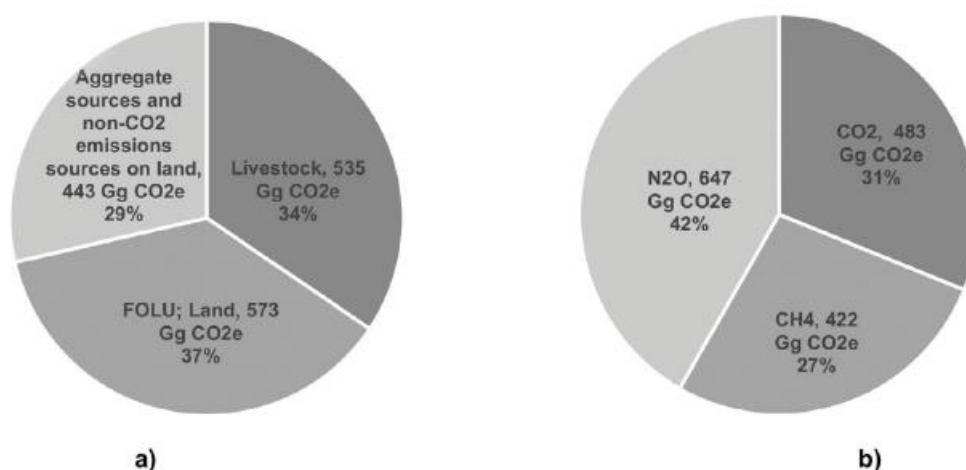


Figure 3-12. National GHG emission shares in the AFOLU sector shown by a) sub-category and b) gas for 2018.

Total direct GHG emissions from all source categories in 2018 is 1551.13 Gg CO₂ e including FOLU and 977.85 Gg CO₂ e excluding FOLU (Table 3-9). The difference between these two totals is 573.29

Gg CO₂ equivalent from FOLU. Indirect GHG emissions from SLCPs were quantified for CO and NO_x in 3C1. Biomass burning emissions from CO are 14.21 Gg and emissions from NO_x are 0.66 Gg. SLCP emissions are not required to be reported for livestock and land use categories according to the 2019 refinement to the 2006 IPCC guidelines since the potential for significant emissions are lacking for some land categories.

Table 3-9. Summary table of sub-category GHG emissions in the AFOLU sector for 2018.

Greenhouse gas source and sink categories	Total GHG emissions	Net CO ₂ Emissions/removals	CH ₄	N ₂ O	CO	NO _x
3. Agriculture, Forestry, and other Land Use (AFOLU)	1551.13	482.88	421.29	646.97	14.21	0.66
3A. Livestock	534.59	NA	409.15	125.44	NA	NA
3A1 Enteric Fermentation	383.41	NA	383.41	NA	NA	NA
3A2. Manure Management	151.18	NA	25.74	125.44	NA	NA
3B1. Forest Land	-1520.00	-1520.00	NA	NA	NA	NA
3B2. Cropland	1121.49	1121.49	NA	NA	NA	NA
3B3. Grassland	877.73	877.73	NA	NA	NA	NA
3B4. Wetlands	78.85	78.85	NA	NA	NA	NA
3B6. Other Land	0.30	0.30	NA	NA	NA	NA
3C. Aggregate Sources and Non- CO ₂ Emissions Sources on Land	541.50	7.83	12.15	521.53	14.21	0.66
3C1. Biomass Burning	24.73	NE	12.15	12.58	14.21	0.66
3C2. Liming	0.02	0.02	NA	NA	NA	NA
3C3. Urea Application	7.81	7.81	NA	NA	NA	NA
3C4. Direct N ₂ O Emissions from Managed Soils	306.41	0.00	NA	306.41	NA	NA
3C5. Indirect N ₂ O Emissions from Managed Soils	105.97	0.00	NA	105.97	NA	NA
3C6. Indirect N ₂ O Emissions from Manure Management	96.56	0.00	NA	96.56	NA	NA
3D. Other	-98.24	-98.24	NA	NA	NA	NA
3D1. Harvested Wood Products	-98.24	-98.24	NA	NA	NA	NA

3.8.1 GHG TRENDS

Overall, the AFOLU sector remained a net sink from 1990 until 2004; thereafter, it became a net emissions source. The net sink was driven mainly by removals by indigenous forest lands (Figure 3-13) of CO₂ (Figure 3-14). The shift from sink to source and increase in emissions relates to activities and management practices such as deforestation and biomass burning. The trend seen in the AFOLU sector is predominantly from emissions and removals from 3.B Land, which are driven by land use change. Land changes between 2000 and 2010 are driven by increased rates of

deforestation on the indigenous forests, harvesting of timber in the plantation forests, infrastructure development including creation of dams for hydropower, and irrigation and application of fertilisers in agriculture.

The Harvested Wood Products category experienced a downward trend from 1990 with the sink declining over the time series (Figure 3-15). This category had remained a removal category, even though with a very low annual value of less than 100 Gg CO₂ e, compared to values of approximately 1000 Gg CO₂ e in late 90s and 2000s. The 2007/2008 wildfires in the country adversely affected the forestry industry such that the major plantation forestry company, Usutu Forest Products Company Limited, closed its operations. This was also in response to falling demand for pulp and paper as recession in the world's largest economies caused job losses and curbed consumer spending. Since that time, there has been a gradual decline in the production of wood products in Eswatini.

Livestock emissions which are mainly from CH₄ in Eswatini between 1990 and 2018 generally show a downward trend, with notable declines recorded in the years Eswatini was faced with droughts, namely: 1992, 2001, and 2016. The country recorded the highest emissions from both enteric fermentation and manure management in 1992, but went down by approximately 100 Gg CO₂e the following year when the country experienced a very severe drought.

The aggregated and non- CO₂ emissions on land category also notably contributed about 600 Gg CO₂e annually, except for the years 2007 and 2008 where emissions hiked to about 700 Gg CO₂e. This was because of high incidences of wildfires experienced in the country.

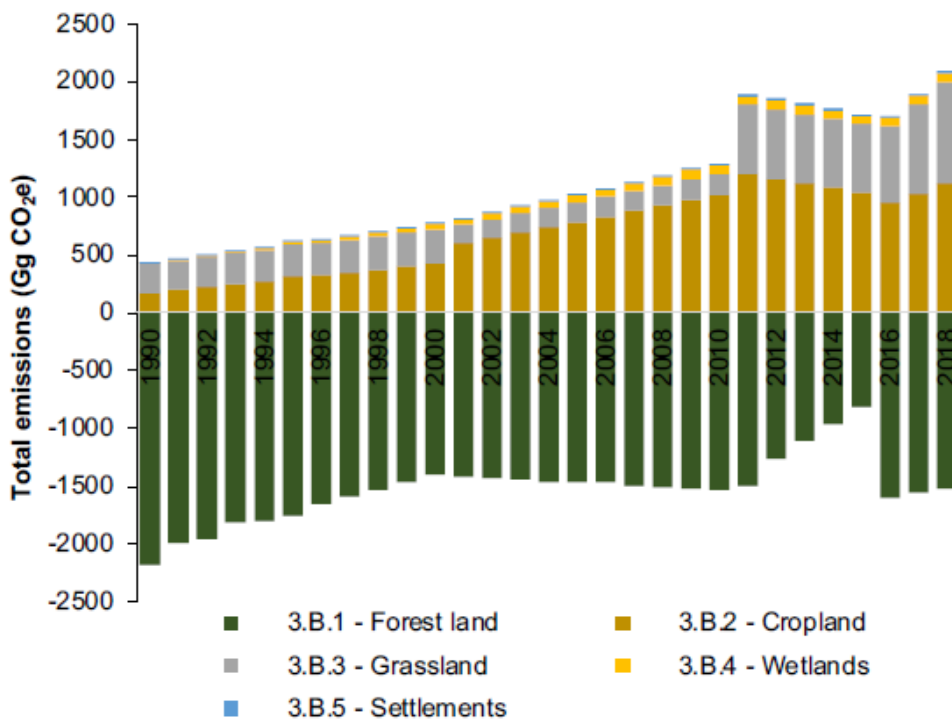


Figure 3-13. Land category emissions by land use type from 1990 to 2018.

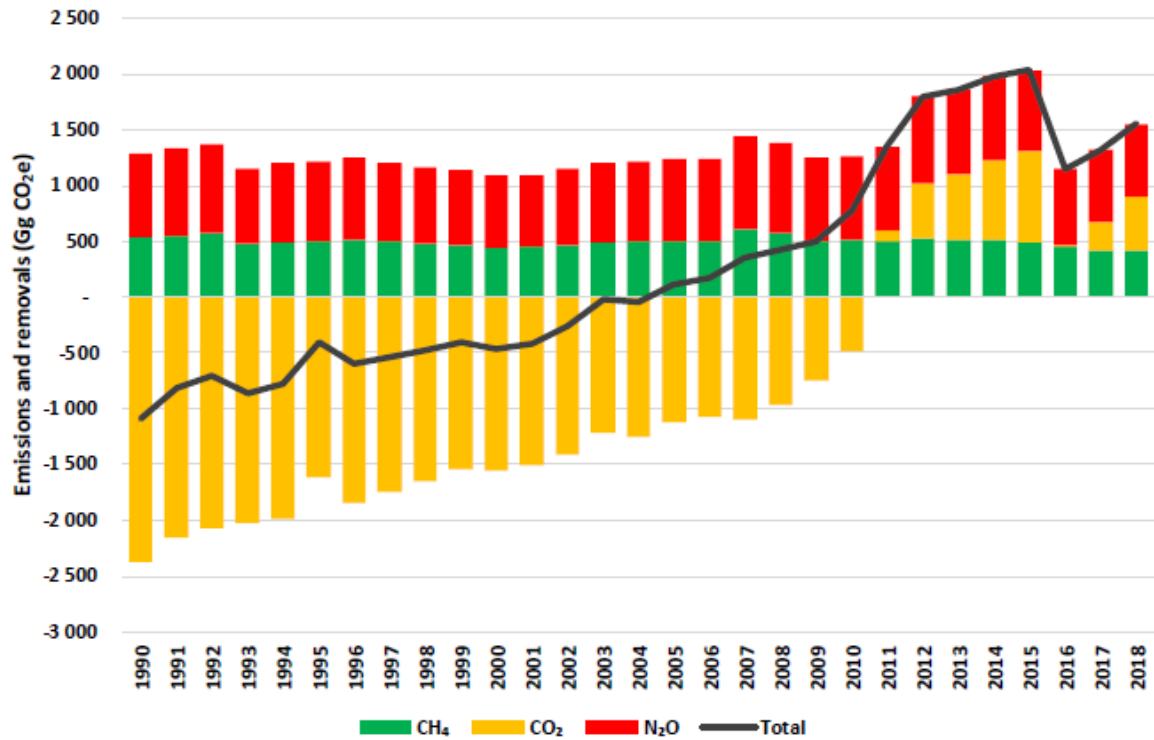


Figure 3-14: AFOLU Sector emissions by Gas from 1990 to 2018.

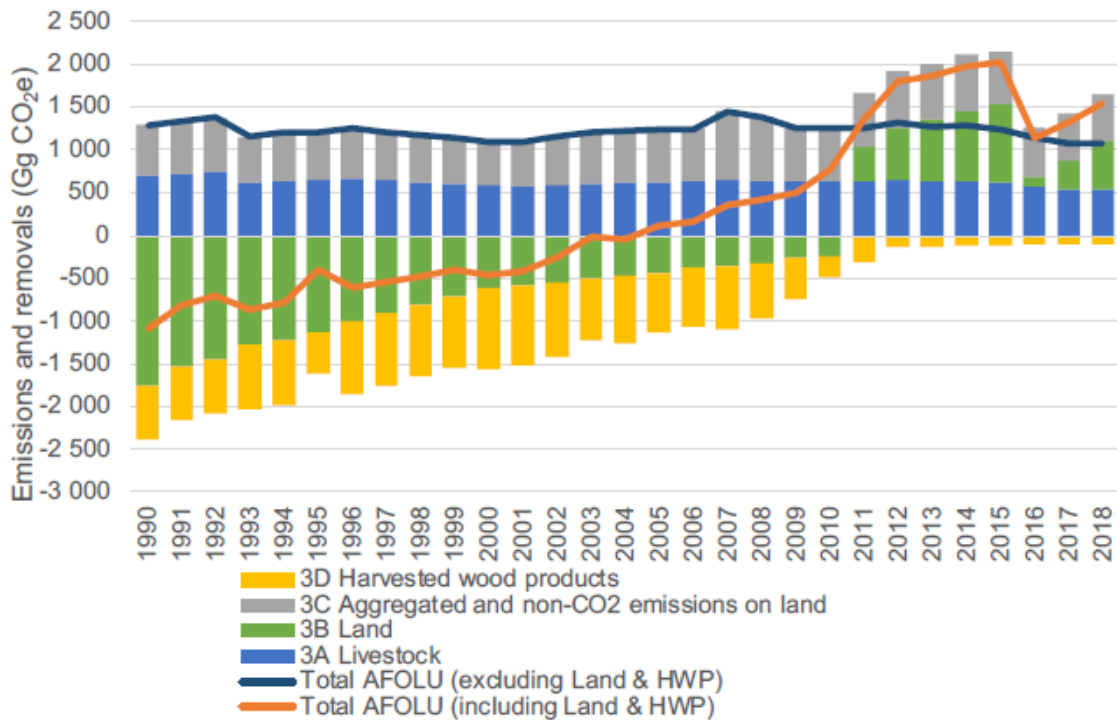


Figure 3-15. AFOLU Sector emissions by Category from 1990 to 2018.

3.8.2 RE-CALCULATIONS

In the 2010 inventory, the 1996 IPCC Guidelines were used, and the Agriculture and Land sectors were treated separately. In this inventory for the BUR-1/NC4 the 2006 IPCC Guidelines were used. As a result of this, the AFOLU sector has had re-calculations based on the improvements made that

include:

- Region specific (South African) emission factors were used in this inventory submission for some categories.
- Manure management data was adjusted to include region specific data from Moeletsi et al. (2015) and expert judgement on manure management in Eswatini.
- Complete overlay of GIS-based land cover/land use raster maps with soil, climate, and eco-region maps.
- Re-calculation of the annual change using these new map overlays.
- New biomass and soil carbon calculations due to the improved map overlays and new region-specific (South African) emission factors.
- Update of biomass and stock change factors.
- Improvement of calculations of biomass stock changes in converted land to move towards a Tier 2 approach in all land categories.
- Inclusion of litter data for all land categories.
- In the urea application category, country import data was sourced from Eswatini Revenue Authority, which was then used to recalculate emissions because of urea application.
- Updated biomass burning fuel loads and emission factors and updated HWP data due to an update in the FAO data.

Small changes in Category 3A emissions from livestock are due mainly to the incorporation of regional emission factors. Category 3B emissions and removals from land were estimated to be significantly lower than reported in the TNC due to the use of consistent land change maps between 1990 and 2015 and the inclusion of updated carbon stock and biomass data. Improved manure management data and updates in the methods for calculating managed manure availability and crop residue inputs resulted in a decline of Category 3C emissions.

3.8.3 IMPROVEMENTS SINCE THE 2010 GHG INVENTORY

For the AFOLU category 3B emissions and removals from land were estimated to be lower than reported in the TNC, due to the inclusion of consistent land change maps between 1990 and 2015. This allowed for estimates of emissions and removals from all 6 land classes and the conversion between land categories. In addition, carbon stock and biomass data were updated with the

incorporation of regional data.

3.8.4 SCOPE FOR IMPROVEMENTS

The MTEA is responsible for the compilation of the AFOLU GHG inventory. The Ministry of Agriculture and Sugar cane growers are responsible for the collation of activity data for the AFOLU GHG inventory. Planned improvements for the AFOLU GHG inventory include:

- Improving land cover classifications for the period 1990 – 2020 using improved remote sensing techniques and field data;
- Refining plantations data with cadastral and species data from individual companies;
- Introduction of age class data in plantations;
- Validation of biomass factors;
- Inclusion of specific crop data and fallow croplands to move to a higher tier calculation for croplands;
- Improving livestock data collection with reporting done at dip-tank level rather than the current regional level;
- Improving data collection and reporting on the application of urea and lime in both commercial agricultural areas and subsistence agricultural areas/farms of the country;
- Establishing a platform for reporting in the hectareage of rice cultivation by farmers;
- Establishing a platform for reporting on the hectareage and yields of cultivation of other crops by farmers;
- Developing a tool and platform for data collection on manure management in the country;
- Undertaking local studies to determine local emissions factors rather than rely on South African (regional) factors.

3.9 WASTE

Emissions from waste contributed a total of 364.3 Gg to Eswatini's emissions in 2018 (Table 3-10). The most significant source of emissions in the sector is solid waste disposal (SWD) which contributed 49% to total emissions from the sector (Figure 3-16). This was followed by wastewater treatment (28%), open burning (23%), biological treatment of waste (1%), and incineration (0.04%).

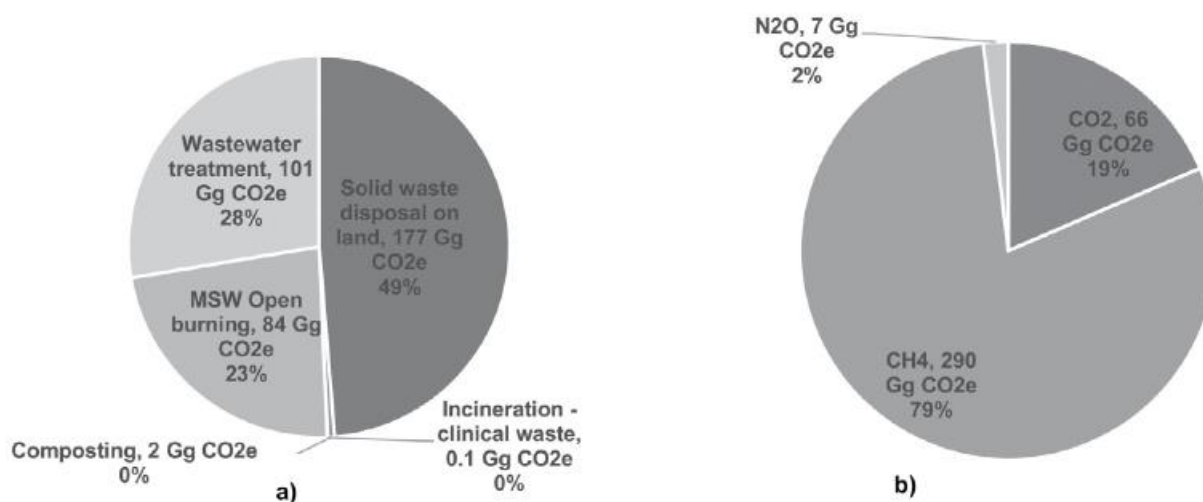


Figure 3-16. National GHG emission shares in the waste sector shown by a) sub-category and b) gas for 2018.

Table 3-10. Summary table for sub-category emissions in the waste sector for 2018.

Greenhouse gas source and sink categories	Total GHG	Net CO ₂ Emissions/ removals	CH ₄	N ₂ O	CO	NO _x	NMVOCs	SO _x
4. Waste	364.31	68	289.78	7	NA	NA	NA	NA
4A. Solid Waste Disposal	177.41	NA	177.41	NA	NA	NA	NA	NA
4A1 Managed Waste Disposal	177.41	NA	177.41	NA	NE	NA	NE	NA
4A2 Unmanaged Waste Disposal Sites	NE	NA	NE	NA	NE	NA	NE	NA
4A3 Uncategorized Waste Disposal Sites	NE	NA	NE	NA	NE	NA	NE	NA
4B. Biological Treatment of Solid Waste	2.13	NA	1.13	1.00	NA	NA	NA	NA
4B1 Composting	2.13	NA	1.13	1.00	NA	NA	NA	NA
4C. Incineration and Open Burning of Waste	84.16	67.56	12.38	4.22	NA	NA	NA	NA
4C1 Waste Incineration	0.14	0.13	0.00	0.00	NA	NA	NA	NA
4C2 Open Burning of Waste	84.03	67.43	12.38	4.22	NA	NA	NA	NA
4D. Wastewater Treatment and Discharge	100.60	NA	98.85	1.75	NA	NA	NA	NA

Greenhouse gas source and sink categories	Total GHG	Net CO ₂ Emissions/ removals	CH ₄	N ₂ O	CO	NO _x	NMVOCs	SO _x
1 Domestic Wastewater Treatment and Discharge	100.60	NA	98.85	1.75	NA	NA	NA	NA
2 Industrial Wastewater Treatment and Discharge	IE	NA	IE	IE	NA	NA	NA	NA
4E. Other	NO	NO	NO	NO	NO	NO	NO	NO

NO: Not Occurring; NA: Not Available; NE: Not Estimated

3.9.1 GHG TRENDS

Total GHG emissions from waste have been increasing across the time series, increasing from 238 Gg in 1990 to 364.31 Gg in 2018 (Figure 3-17). This is mainly due to the increased population across this period. The solid waste disposal emission trends have gradually increased over the years due to an increase in the national population. This is also the reason for the trend seen in biological treatment, open burning, and wastewater treatment.

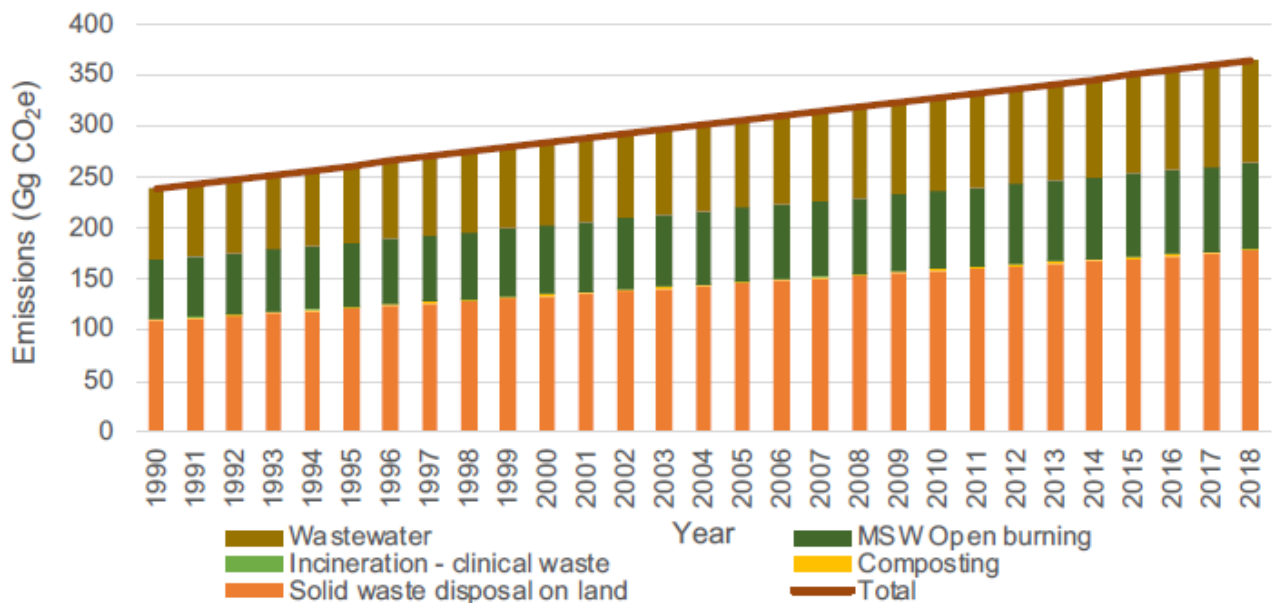


Figure 3-17: Total Waste Emissions by Category 1990-2018 (Gg CO₂e).

The emissions from the main gases emitted by the waste sector, these being CO₂, CH₄ and N₂O have shown a steady increase from 1990 to 2018. The emissions are presented in Gg CO₂e in Figure 3-18 CH₄ was the leading gas emitted by the sector estimated to be 186.98 Gg in 1990, 260.24 Gg in 2010, and 289.78 Gg in 2018. The second highest gas emitted by the sector was CO₂. In 1990 the CO₂ emitted was 47.03 Gg, 61.53 Gg in 2010 and was estimated to be 67.56 Gg in 2018. The least emitted

gas from the waste sector was N₂O with 4.85 Gg emitted in 1990, 6.35 Gg emitted in 2010, and 6.97 Gg emitted in 2018.

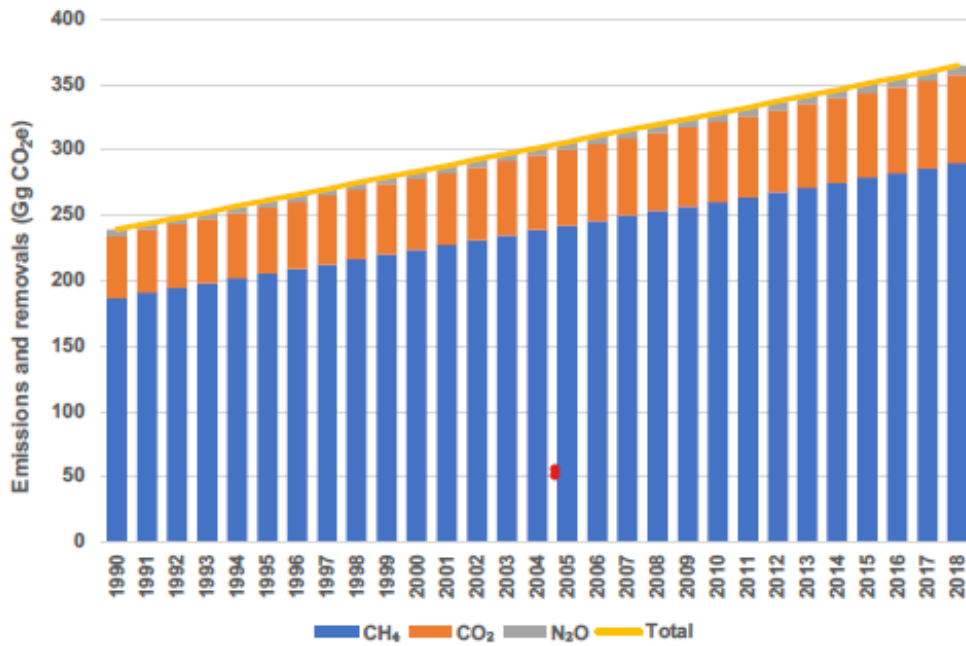


Figure 3-18 : Total Waste Emissions by gas 1990-2018 (Gg CO₂ e).

3.9.2 RE-CALCULATIONS

There were substantial improvements in the 2018 inventory to estimate waste sector emissions specifically for waste disposed in landfill, wastewater treatment, and open burning and incineration as shown in Figure 3-19. Updated population statistics from the central statistics office from 2007 to 2018 were used to compile a time series of population numbers between 1990 and 2018. Compared to the 2010 inventory, the population numbers used in the 2018 inventory were higher, which increased GHG emissions across all sub-categories. All other assumptions and characteristics of the waste management practices, and population distribution, were assumed to be constant across the time series. This resulted in the waste sector emissions trend being defined by the population trend. Emissions from incineration are estimated to be constant across the time series due to the assumption that there has been a constant number of hospital beds and thus hazardous waste output across the time series. In the previous inventory, the amount of clinical waste incinerated was based on a fraction of the total waste generated that was incinerated. In the current inventory, the number of hospital beds and the national rate of clinical waste generation per bed were used to estimate the amount of waste incinerated.

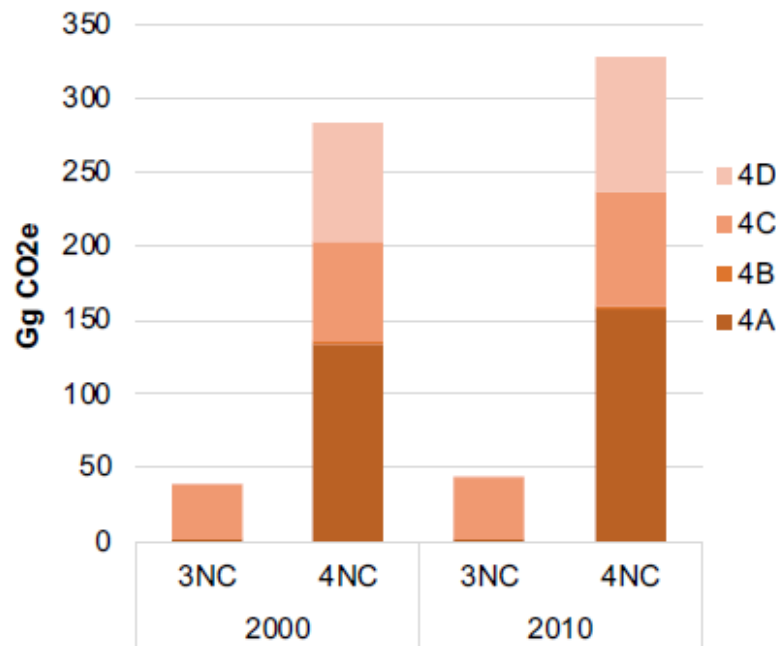


Figure 3-19: Comparison of estimated GHG emissions for 2000 and 2010 estimated in the 2010 inventory and the 2018 inventory.

3.9.3 IMPROVEMENTS SINCE THE 2010 GHG INVENTORY

For waste, changes to the data used to estimate clinical waste incinerated were made. A Tier 1 level was still used in this current inventory, and the increase in emissions observed relative to the TNC was linked to the change in data sources rather than an increase in population.

3.9.4 SCOPE FOR IMPROVEMENTS

The MTEA is responsible for the compilation of the Waste GHG inventory. The Eswatini Environmental Authority, Eswatini Ministry of Health Social Services, Eswatini Water Services Corporation and municipalities are responsible for the collation of activity data for the Waste GHG inventory. Planned improvements for the Waste GHG inventory include:

- Collecting country specific information for waste generated per capita, national specific waste composition to be used in the IPCC waste model;
- Collecting data on the quantity of waste produced in the country and the total amount of waste that is composted;
- For the biological treatment of waste, the need for country specific chemical oxygen demand (COD) and biological oxygen demand (BOD) data was identified. The total quantity and composition of clinical waste incineration and technologies used will also need to be collected.

Data on the percentage of national population practising open burning and country parameters composition burned waste also needs to be collected.

3.9.5 NATIONAL GHG INVENTORY TRENDS 1990-2018

Eswatini's GHG emissions from all sectors between 1990 and 2018 are depicted in Figure 3-20. The total GHG emissions have been steadily increasing since 1990 when the FOLU sector is included. This is related to the increasing emissions in the FOLU sector due to the deforestation of indigenous forests, harvesting timber in plantation forests, and dam infrastructure development.

Energy sector emissions increased between 1990 and 2018 but have remained relatively constant since 1994, peaking in 1999 due to the expansion of the Royal Eswatini Sugar Corporation's mill to accommodate sugar cane purchased from new independent cane farmers, which resulted in elevated demand for coal required to process this sugar cane. Total GHG emissions peaked in 2014, dipped in 2016, before increasing again over the last two years of the time series. The drop in emissions in 2016 is driven by an increase in the carbon sinks in 3.B.1 Forest Land.

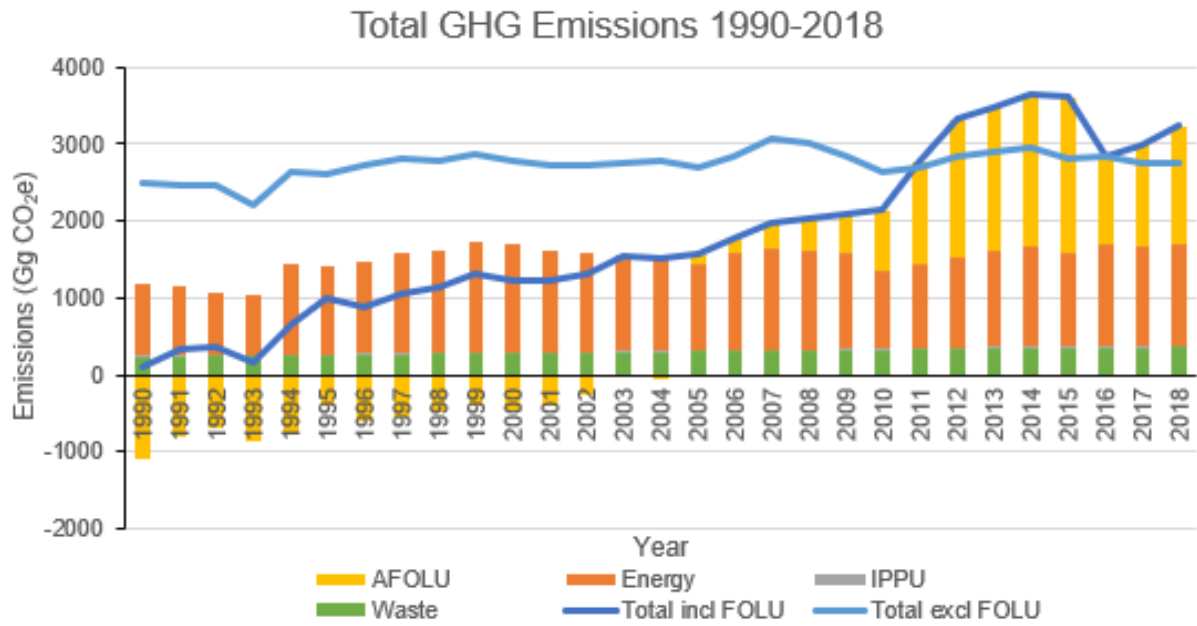


Figure 3-20: Time-series of total GHG emissions from 1990 to 2018 including FOLU and excluding FOLU.

Since 2011, CO₂ has been the most important GHG in Eswatini in terms of contribution to the national total. Prior to this, however, releases of CH₄ were the most important. This changing dynamic is primarily due to the decreasing influence of sinks and increasing emissions from 3.B.1 Forest Land. Releases of N₂O have remained relatively constant over the 1990-2018 time series. The release of F-gases has steadily increased since 1990, but their relative share of total GHG emissions has remained constant.

4 GENERAL DESCRIPTION OF STEPS TAKEN OR ENVISAGED TO IMPLEMENT THE CONVENTION

4.1 PROGRAMMES CONTAINING MEASURES TO FACILITATE ADEQUATE ADAPTATION TO CLIMATE CHANGE

In the 6th IPCC Assessment Report, it is highlighted that in the context of climate change, risk arises from the dynamic interactions between climate-related hazards, and the exposure and vulnerability of affected human and ecological systems (Figure 4-1). A hazard may refer to the climate signal (i.e., an extreme event or a trend) as well as climate-related direct physical impacts such as floods, erosion, and landslides. The vulnerability of exposed human and natural systems is a component of risk, and differs within communities and across societies, regions and countries, also changing over time. Adaptation plays a key role in reducing exposure and vulnerability to climate change. Interventions which enable adaptation or reduce climate risk should thus reduce vulnerability by reducing sensitivity and/or increasing coping capacity.

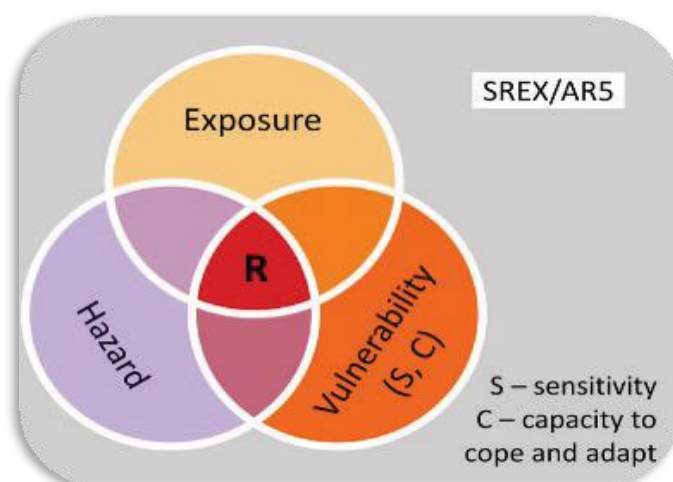


Figure 4-1: Risk emerges from the overlap of climate hazards, vulnerability, and exposure.

This section discusses current drivers of climate change exposure, vulnerability, and adaptation options in key sectors, as well as observed and expected impacts. The section builds on existing vulnerability and adaptation knowledge to assess, prioritise, and summarise climate change risks and vulnerabilities for the following key sectors:

- Infrastructure and built environment;
- Health;
- Tourism.

Since Eswatini's Third National Communication (TNC), the knowledge base on observed and projected impacts and risks across various socio-economic sectors has increased. The Eswatini First Adaptation Communication was developed in 2021 and provides updated information regarding

climate change impacts and prioritized adaptation actions for five sectors: water, ecosystems and biodiversity, health, infrastructure, and agriculture. An update on the State of the Environment in Eswatini was released in 2020 and reviews the latest information in terms of pressures such as population growth, urbanisation, depletion of water resources, soil erosion, land and water pollution, and loss of biodiversity in the context of climate change.

4.1.1 GENERAL METHODOLOGY

The climate model outputs used in this study span the historic and future climate period (1960-2100). The climate runs were done by the Council for Scientific and Industrial Research using computational resources from the Centre for High Performance Computing (CHPC) in South Africa.

The simulation was performed at a quasi-uniform 50 km horizontal resolution using the conformal-cubic atmospheric model (CCAM) developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) (McGregor, 2005; McGregor and Dix, 2001). CCAM is run with atmospheric greenhouse gas (carbon dioxide, sulphate and ozone) concentration trajectories under the Representative Concentration pathway 8.5 (RCP8.5) to represent the 90th percentile of the policy scenarios used in the Coupled Model Intercomparison Project – Phase 5 CMIP5 of the World Climate Research Programme (WCRP).

CCAM runs were coupled to the CSIRO Atmosphere Biosphere Land Exchange (CABLE) covering broad land cover classes to realistically simulate the climate system over Southern Africa. The CCAM-CABLE model was forced with bias-adjusted sea-surface temperatures (SSTs) and sea-ice concentration from six Global Climate Models (GCMs) as lower boundary forcings. Forcing data was used from the following GCMs: Community Climate and Earth-System Simulator (ACCESS1-0); National Centre for Meteorological Research Coupled Global Climate Model, version 5 (CNRM-CM5); the Geophysical Fluid Dynamics Laboratory Coupled Model (GFDL-CM3); the Max Planck Institute Coupled Earth System Model (MPI-ESM-LR); the Norwegian Earth System Model (NorESM1-M); and the Community Climate System Model (CCSM4).

The respective models were used in the Coupled Model Intercomparison Project Phase Five (CMIP5) and the Assessment Report Five (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The forcing CMIP5 models were chosen based on their ability to be a good representation of the El Niño–Southern Oscillation (ENSO) attributes (Engelbrecht et al., 2015). The CCAM-CABLE model, a variable resolution model, was used to further downscale from 50 km global outputs to 8 km over South Africa using a multiple-nudging strategy. The higher resolution simulation runs nudging was performed through application of a digital filter using a 600 km length scale applied at 6-hourly intervals from 900 hPa upwards. Precipitation and temperature outputs are bias-adjusted applying a delta bias-correction method to the Climate Research Unit (CRU) data following the method developed by Engelbrecht et al. (2015).

The departures of the future climate (2041-2070, 2071-2100) and the associated extremes relative to their baseline (1961-1990) patterns are also discussed for the country with reference to the

respective agro-ecological zones. Model daily timescale outputs for standard meteorological parameters such as maximum temperature (tasmax), minimum temperature (tasmin), and precipitation (pr) are aggregated over 30 years and anomalies for the projection period relative to the baseline period are calculated to indicate climate change for the historic and projected periods. The model uncertainty is reflected through the 10th, 50th and 90th percentiles of the ensemble.

Future changes in the annual average precipitation, the maximum and minimum temperature and precipitation, as well as changes of the climate extreme indices (Donat et al., 2013) are considered. The calculated extreme climate event indices are summarized in Table 4-1.

Table 4-1: Expert Team on Climate Change Detection and Indices (ETCCDI) extreme climate indices used for the NC4.

Definition		Units	Description
TXx	Annual maximum value of TX	°C	Annual daytime hottest temperature
TXn	Annual minimum value of TX	°C	Annual daytime coolest temperature
TX90P	Annual number of days when TX > 90th percentile	days	Annual number of hot days
TN90P	Annual number of days when TN > 90th percentile	days	Annual number of hot nights
TNx	Annual maximum value of TN	°C	Annual night-time hottest temperature
TNn	Annual minimum value of TN	°C	Annual night-time coldest temperature
DTR	The difference between daily maximum and minimum temperature	°C	Diurnal temperature range
Heat Waves	Prolonged periods, of at least 3 or more consecutive days, in which temperatures exceed 5°C above the average maximum temperature of the hottest month.	Days	
Prcptot	Annual total precipitation when daily precipitation >1 mm	mm	Annual total precipitation on wet days
rx1day	Annual maximum 1-day precipitation	mm	Highest daily rainfall per year
Rx5day	Annual maximum 5-day precipitation	mm	Highest five rainfall days per year
r20mm	Annual count of days when precipitation ≥ 20mm	days	Annual number of days with moderate to high rainfall
CWD	Maximum number of consecutive days with precipitation ≥ 1mm	days	Annual maximum length of wet spell
CDD	Maximum number of consecutive days with precipitation < 1mm	days	Annual maximum length of dry spell

The general methodology entailed a meta-analysis of literature on climate vulnerability and adaptation, with a focus on publications post-TNC. Stakeholder engagement and involvement of interested parties within Eswatini were key to inform the vulnerability analysis. Sectors were characterised according to the core components of risk, i.e., exposure and vulnerability (sensitivity and coping/adaptive capacity) to climate hazards. The risk and vulnerability assessment follows the approach adopted in the IPCC Fourth Assessment Report, which describes vulnerability as a function of exposure, sensitivity, and adaptive capacity.

Projections of the potential impact of climate extremes on the infrastructure, health, and tourism sectors were made by selecting appropriate climatic indicators and assessing changes in these between baseline (1961-1990) and future (2041-2070, 2071-2100) periods (described in detail in Section 2.5). These changes were determined under a low mitigation scenario for six climate models, with the median of these models then being assessed in analyses.

4.1.2 CLIMATE CHANGE SCENARIOS

4.1.2.1 CURRENT CLIMATE AND PROJECTED CHANGES

4.1.2.1.1 A SPATIAL PATTERN OF BASELINE TEMPERATURE OVER ESWATINI

Figure 4-2 suggests that the seasonal daytime average temperature during the summer and winter seasons has an east-to-west gradient. This is a signature of the region's proximity to the east coastline which is warmed by the Agulhas current that flows southwards from the equator along the east coast of Africa. The Lowveld, in the east, has the highest temperatures while the Highveld, in the western part of the country, is characterised by relatively lower temperatures. Average maximum temperatures over the Lubombo mountains are lower than the neighbouring Lowveld region also due to the elevation. Country wide, the rainy summer seasons October–November–December (OND) and January–February–March (JFM) periods during the 1961–1990 timeframe remained warmer than the June–July–August (JJA) season.

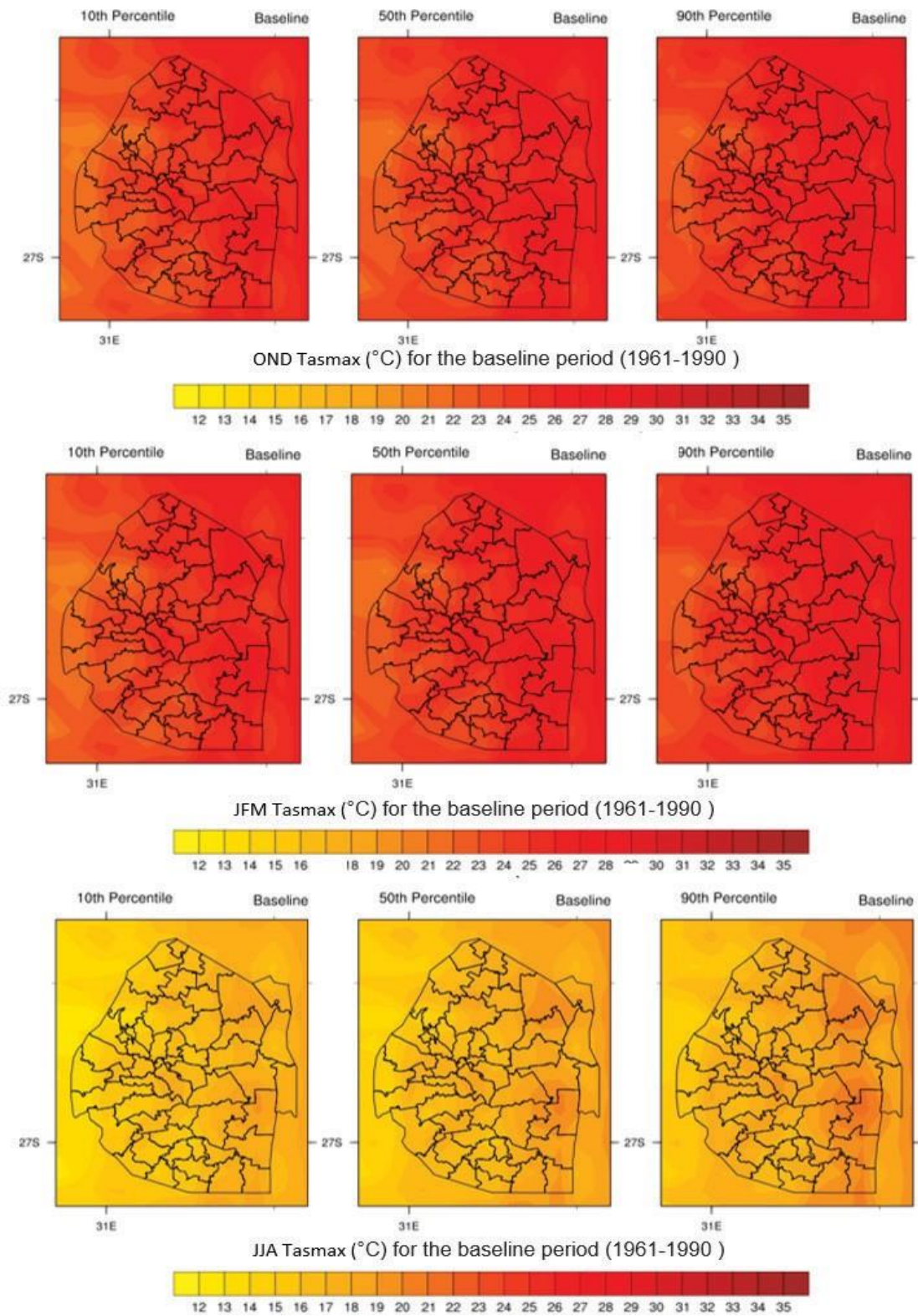


Figure 4-2: CCAM dynamically down-scaled baseline period (1961-1990) OND, JFM and JJA mean maximum temperature (°C) under RCP 8.5.

4.1.2.1.2 A SPATIAL PATTERN OF BASELINE PRECIPITATION OVER ESWATINI

Model projections of change in precipitation and other indices derived from the GCMs and their downscaling have a distinct uncertainty and, therefore, should be interpreted with great caution.

Typical sources of uncertainty identifiable from ensemble models are: (a) scenario uncertainty, (b) model structural uncertainty, and (c) natural variability (Wootten et al., 2017). Scenario uncertainty arises from the choice of scenario or model parameterization. Structural uncertainty in dynamically downscaled models lies in the choice of regional and global model pairing, and how the models simplify various aspects of the climate system such as convection, topography, and cloud microphysics. The natural variability uncertainty comes from the effect of the application of downscaling upon the representation of natural variability. Consequently, because of uncertainty, GCMs capture local or regional scale patterns of rainfall with significant biases. On the other hand, GCMs satisfactorily capture shifts in large-scale processes in the future (Barnes and Polvani, 2013). It is, therefore, instructive to explore how well local scale precipitation changes because of shifts in large-scale circulation changes.

Precipitation in Eswatini, as can be seen in Figure 4-3, is characterised by substantial year to year variations and is strongly influenced by the internal variability of the large-scale rain-bearing system over Southern Africa. The country is located within part of the subcontinent that receives about 80% of the precipitation in the summer months (from mid-October to mid-April) through convective and tropical storms rains. The observed annual rainfall accumulation, (Figure) shows ensemble median ranged from 250 mm to 1 200 mm over the baseline period. The ensemble members suggest that, during the period, the western Highveld received relatively higher precipitation ranging between 700 and 1 300 mm. The models show that the Middleveld is drier with an annual rainfall ensemble median ranging from about 550 to 850 mm. The hindcast portrays the Lowveld as having been the driest and hottest with average annual precipitation, with the ensemble median ranging from 250 and 600 mm. The Lubombo Range and the Middleveld received similar annual rainfall. The Highveld rainfall ranges between 700-1 550mm, which is higher than the model climatological estimates.

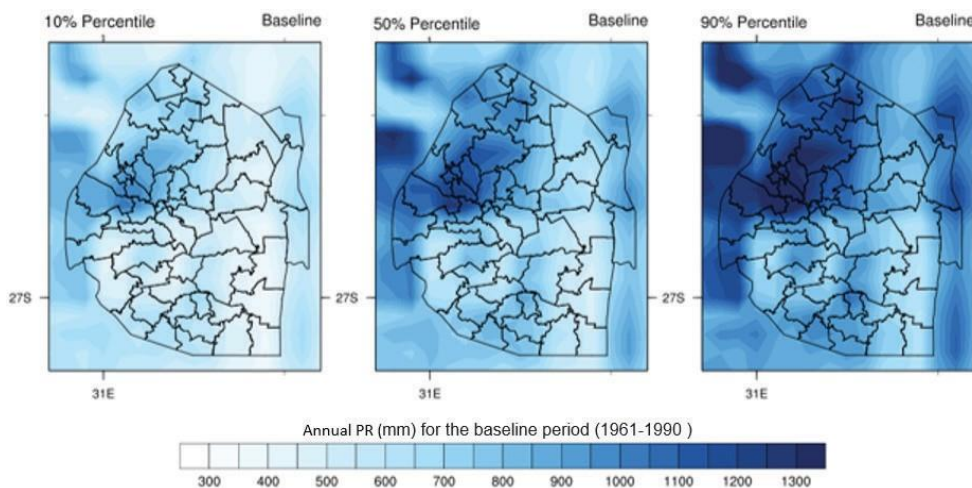


Figure 4-3: Downscaled baseline period (1961-1990) projected changes in mean annual precipitation totals (mm) under RCP 8.5.

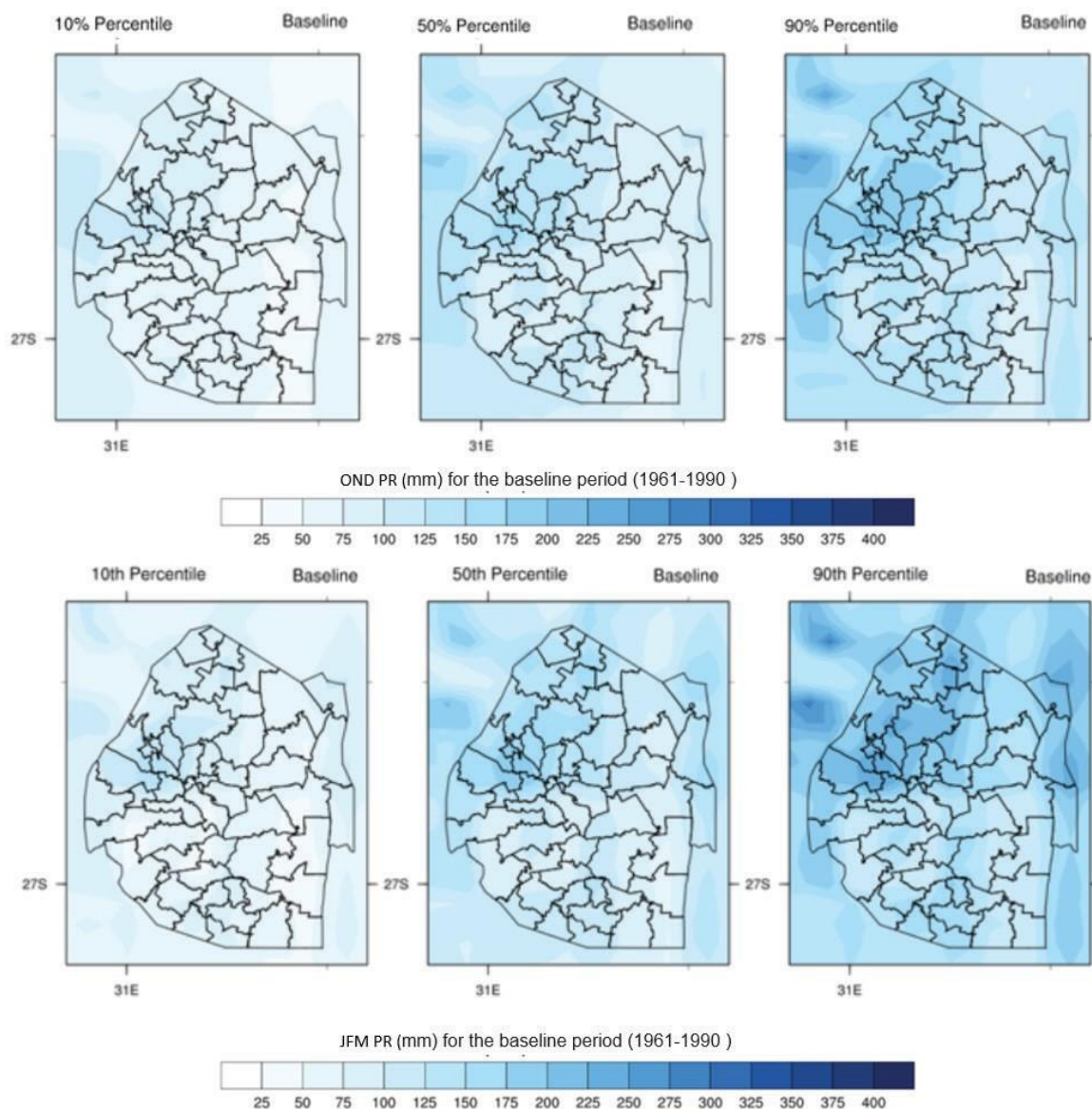


Figure 4-4: Rainy seasons (OND and JFM) baseline period ensemble percentiles of CCAM downscaled mean annual total precipitation (mm) under RCP 8.5.

4.1.2.1.3 STORMS AND LIGHTNING

Data on the occurrence of storms in Eswatini is not widely available. However, available information on lightning frequency and windspeed indicates a high storm damage risk in several parts of the country, with particularly storm (lightning) hotspots in rural areas (Dlamini, 2021), the southwestern part of the country as well as parts of the Middleveld and Lubombo Plateau.

The annual average lightning fatality rate was one of the highest recorded in the world in 2009 (Dlamini, 2021). Lightning fatalities occurred from September to May mainly in the afternoon (14:00-18:00) in rural areas, affecting both human and livestock. Timber highlands, the Lubombo Plateau, Cattle and Maize as well as the moist Middleveld zones are particularly at risk of storm impacts. Extensive damage occurred to plantation forests and crops, infrastructure such as human settlements and power (electrical) infrastructure.

4.1.2.2 PROJECTED ANNUAL AND SEASONAL CLIMATE FUTURES FOR ESWATINI

4.1.2.2.1 TEMPERATURE ANOMALIES

Examination of ensemble projections in Figure 4-8 suggests that the Highveld are most likely to see more pronounced warming, followed by the north-eastern Lowveld. The model projections are consistent on the sign of change relative to the 1961-1990 baseline period. However, when comparing the 10th and 90th ensemble percentiles for the central and southern parts of the Lowveld during the 2041-2070 period, significant differences can be seen in the pattern of warming differences. Model consistency on the spatial pattern of warming improves towards the end of the century, revealing much stronger warming of the night-time temperature extremes for the entire country.

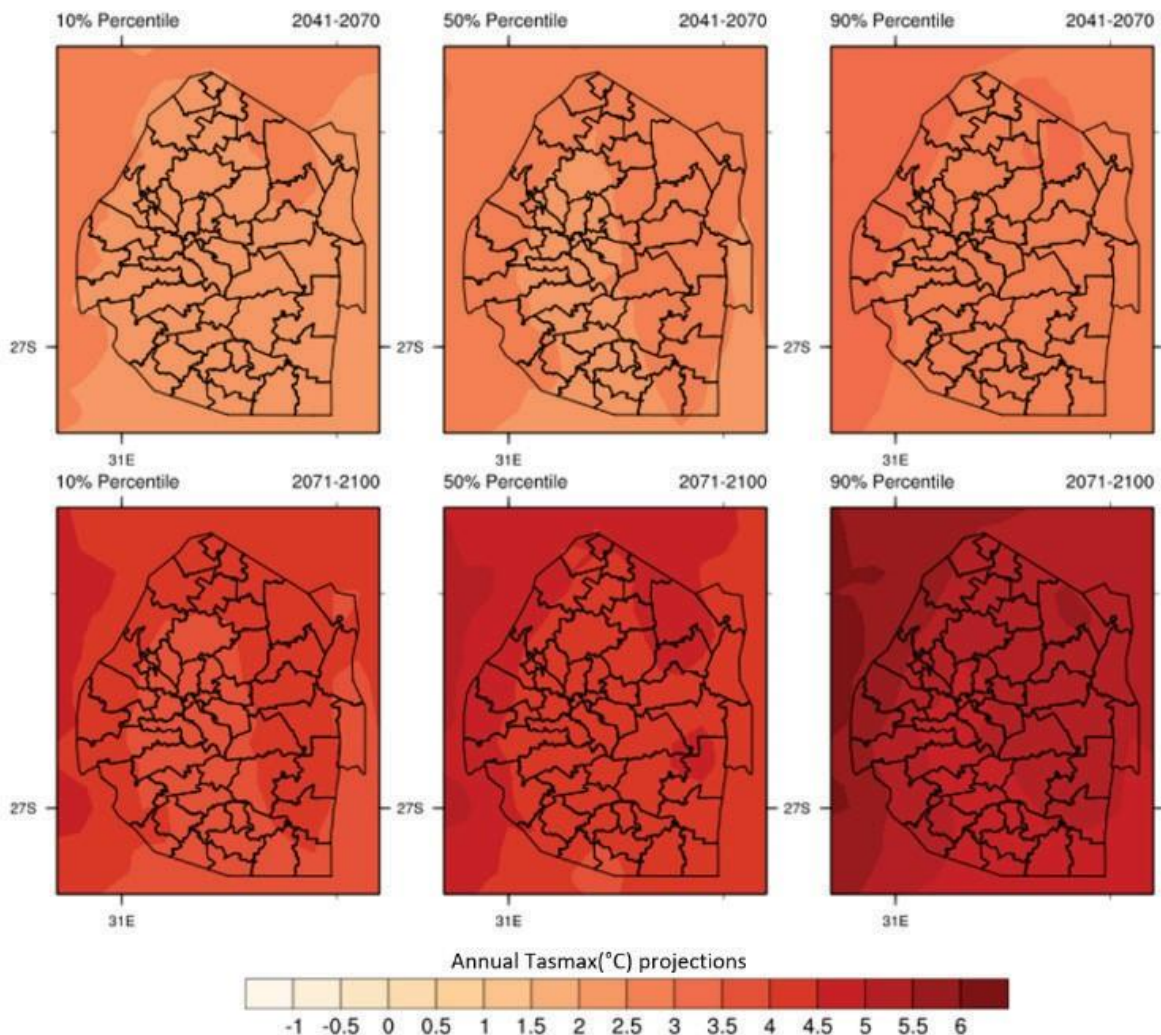


Figure 4-5: The ensemble percentiles of CCAM downscaled annual maximum temperature ($^{\circ}\text{C}$) under RCP8.5 for the periods 2041-2070 and 2071-2100

The warming in minimum temperature ranges between 2.0-2.5 $^{\circ}\text{C}$ across the country as portrayed in Figure 4-6. Average night-time temperature change relative to the baseline period does not show a distinct spatial pattern of change during the 2041-2070 period. However, towards the end of the century (2071-2100), the Lowveld and parts of the Western Highveld reflect much more pronounced

warming relative to the rest of the regions.

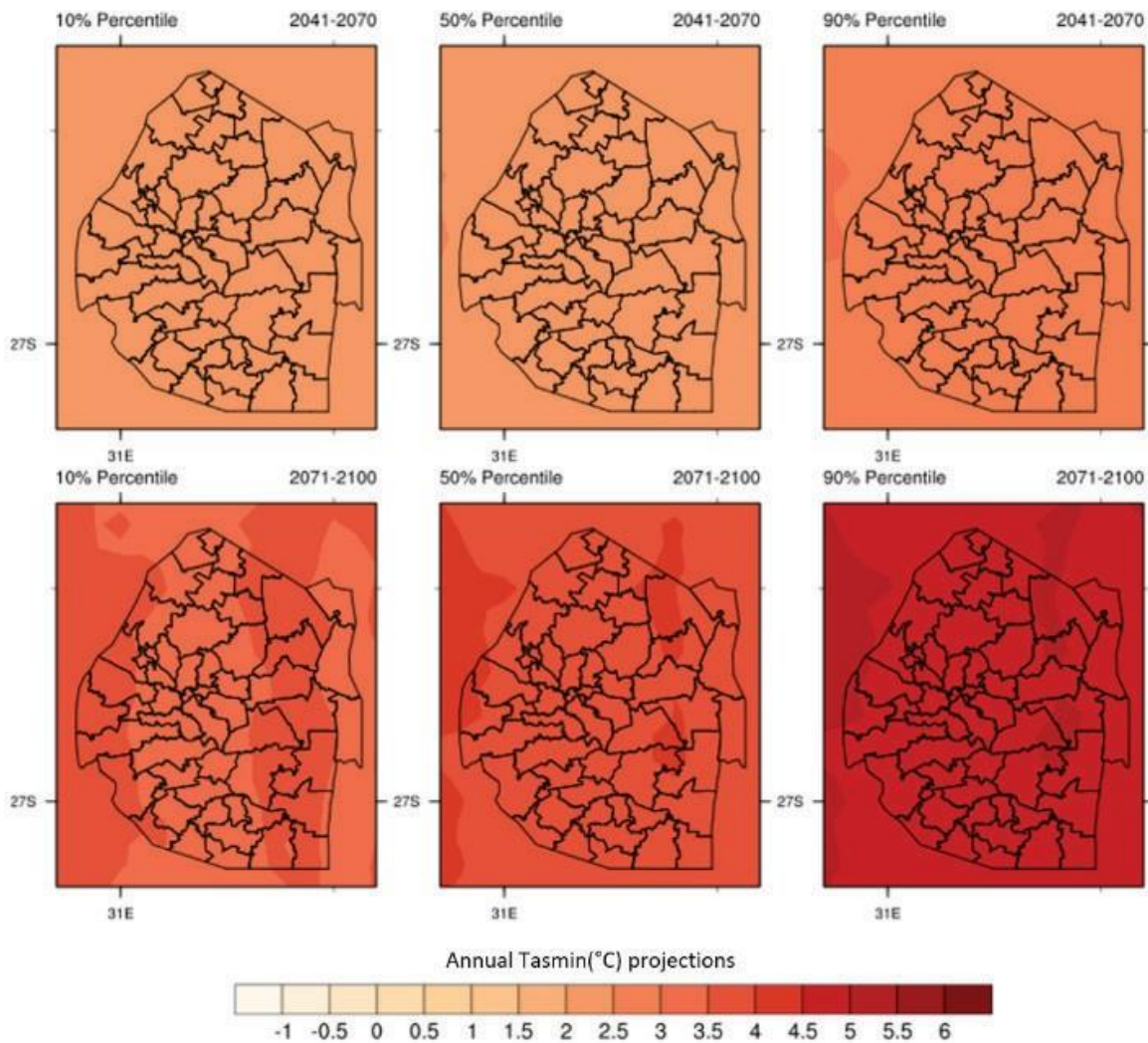


Figure 4-6: The ensemble percentiles of CCAM downscaled annual mean maximum temperature (°C) under RCP8.5 for the periods 2041-2070 and 2071-2100.

4.1.2.2.2 PRECIPITATION ANOMALIES

4.1.2.2.2.1 PRECIPITATION PERCENTAGE CHANGE

Figure 4-7 reflects that towards the mid-future period (2041-2071), under RCP8.5, most ensemble members are suggestive of a decrease in rainfall over the western part of Eswatini as was also the case in the World Bank report (2021). There is a noticeable disagreement among ensemble members over the eastern parts of Eswatini, particularly over the Lubombo mountains where the median and 90th ensemble percentiles suggest no change and the 10% percentile a slight increase. Going into the far future (2071-2100), the ensemble is consistent in suggesting a drier future over the high-lying areas starting at the Upper Middleveld to the Highveld. The rest of the region has a weak signal which can be translated as suggestive of no change. The projection suggests that while the

Eswatini region will be getting drastically warmer, the Western Highveld and Upper Middleveld has the potential to become drier toward the end of the century.

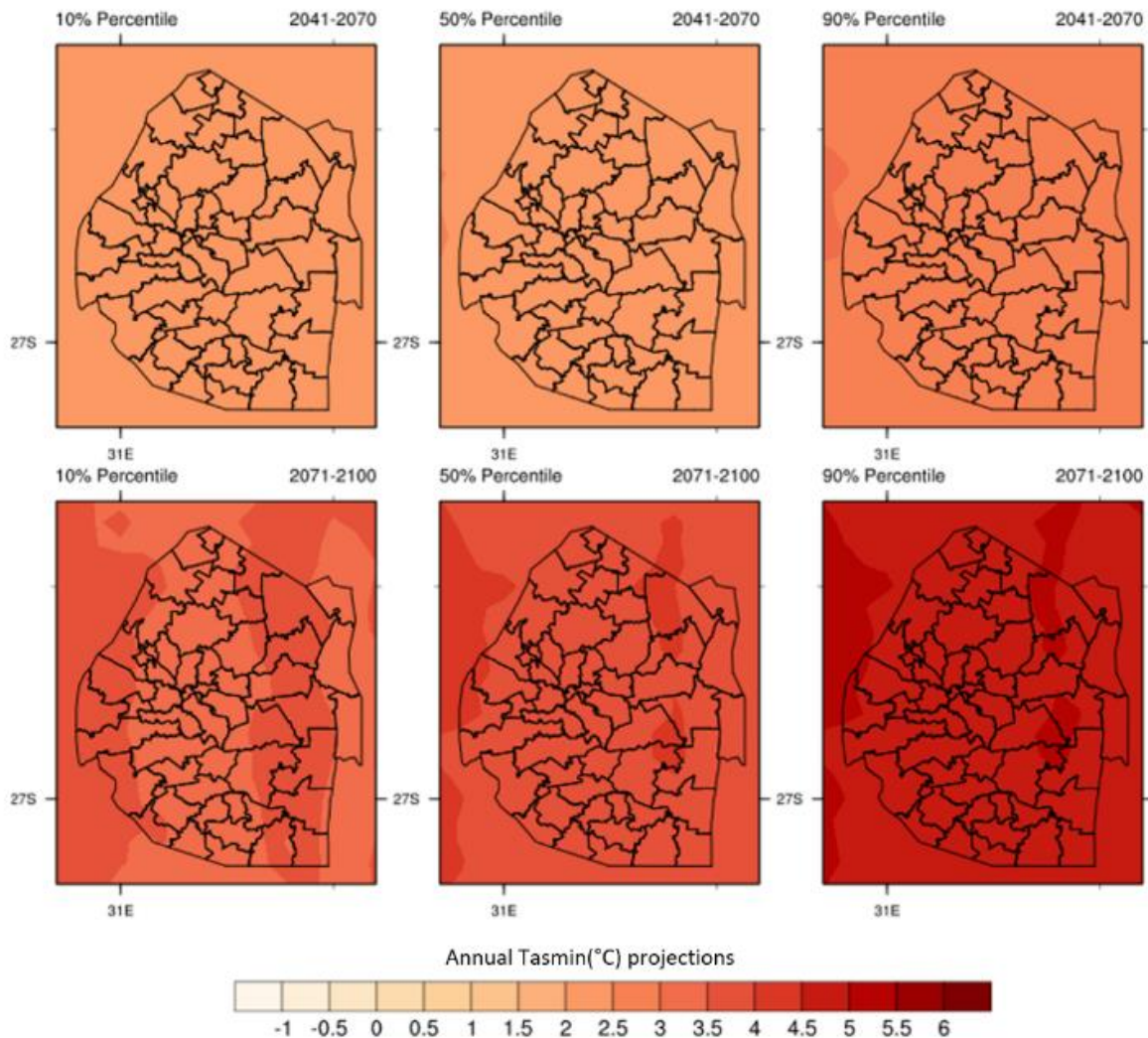


Figure 4-7: The ensemble percentiles of CCAM downscaled projected changes in annual precipitation total (%) under RCP8.5 for the periods 2041-2070 and 2071-2100 relative to the baseline.

4.1.2.3 CLIMATE EXTREME INDICES AND THEIR PROJECTIONS ACCORDING TO ECOLOGICAL ZONES

4.1.2.3.1 HEAT EXTREMES

Looking at the ensemble 10th, 50th, and 90th percentiles plot in Figure 4-8(a), the models consistently depict significantly warming of Eswatini over the reference period 1961-1990. Across the region, the annual temperature of the hottest days (TXx) ranges between 23 and 31°C. The TXx index reaches its highest value in the eastern Lowveld region of the country. This is also an area projected to experience a TXx increase of 2°C or higher during 2041-2071 relative to that of the reference period under RCP8.5, as shown in Figure 4-8(b). The annual temperature of the hottest night (TNx) reflects an east-to-west gradient ranging from 6 to 14°C. By the end of the century, both TXx and TNx are projected to attain ensemble median change above 3°C, relative to the baseline period, under

RCP8.5. The changes in heat extremes are likely to lead to devastating impacts on human health, temperature-sensitive sectors of the economy, and infrastructure.

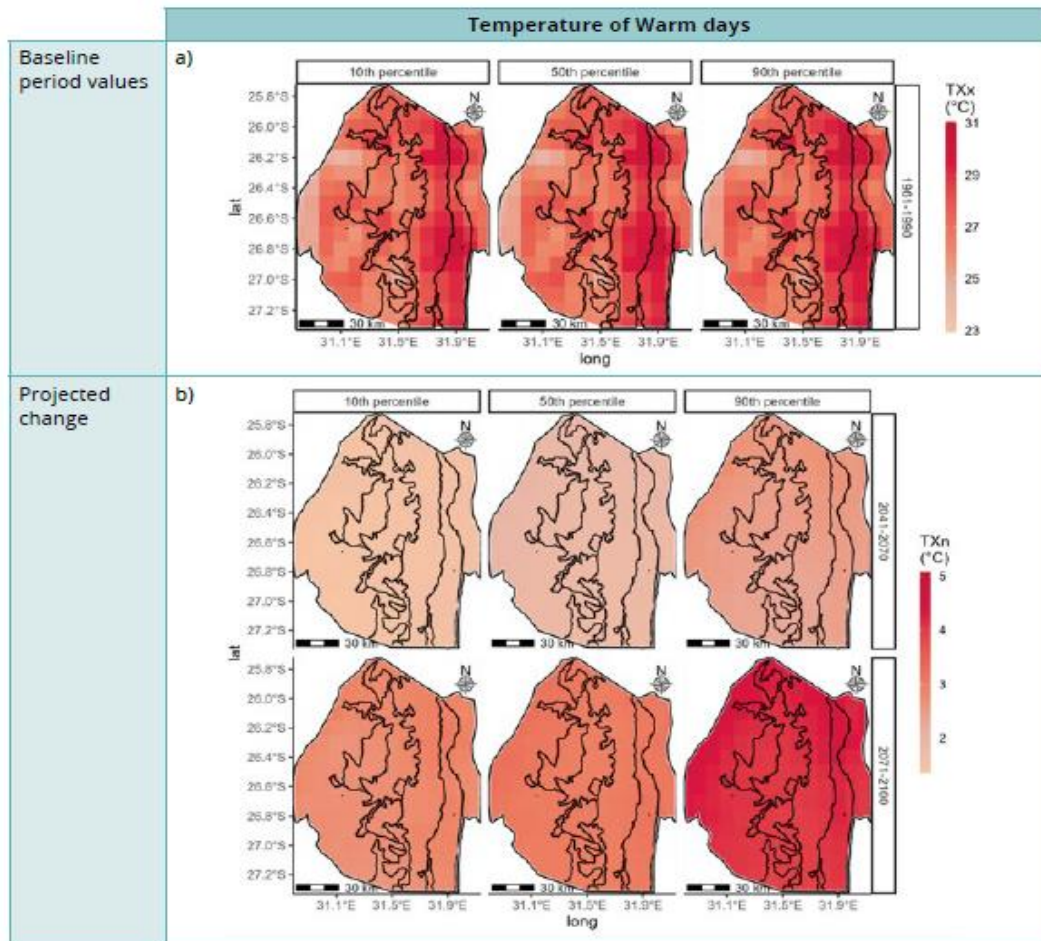


Figure 4-8: Downscaled annual mean of the maximum of maximum temperature (°C) (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.

4.1.2.3.2 HEAT WAVES

Across Eswatini, mean annual heatwave days range from 0.5– 2.5 during the reference period. This is depicted in Figure 4-9(a). The heatwaves are reflected at a relatively higher frequency over the Lowveld and Lubombo mountains. Towards the end of the century, the mean annual heatwave days are projected to increase drastically above 10 with the western parts of the country seeing the strongest changes. The spatial pattern of the heatwave days is consistent across the ensemble quantiles; however, there is a big difference in the projected magnitude of change between the 10th and 90th percentile suggesting that there is a difference in how the ensemble members capture the heatwave events. In summary, all the models depict that, for the low mitigation scenario (Figure 4-9(b)), with the warming of temperatures over Eswatini, the number of heat wave events during the projection periods are likely to substantially increase.

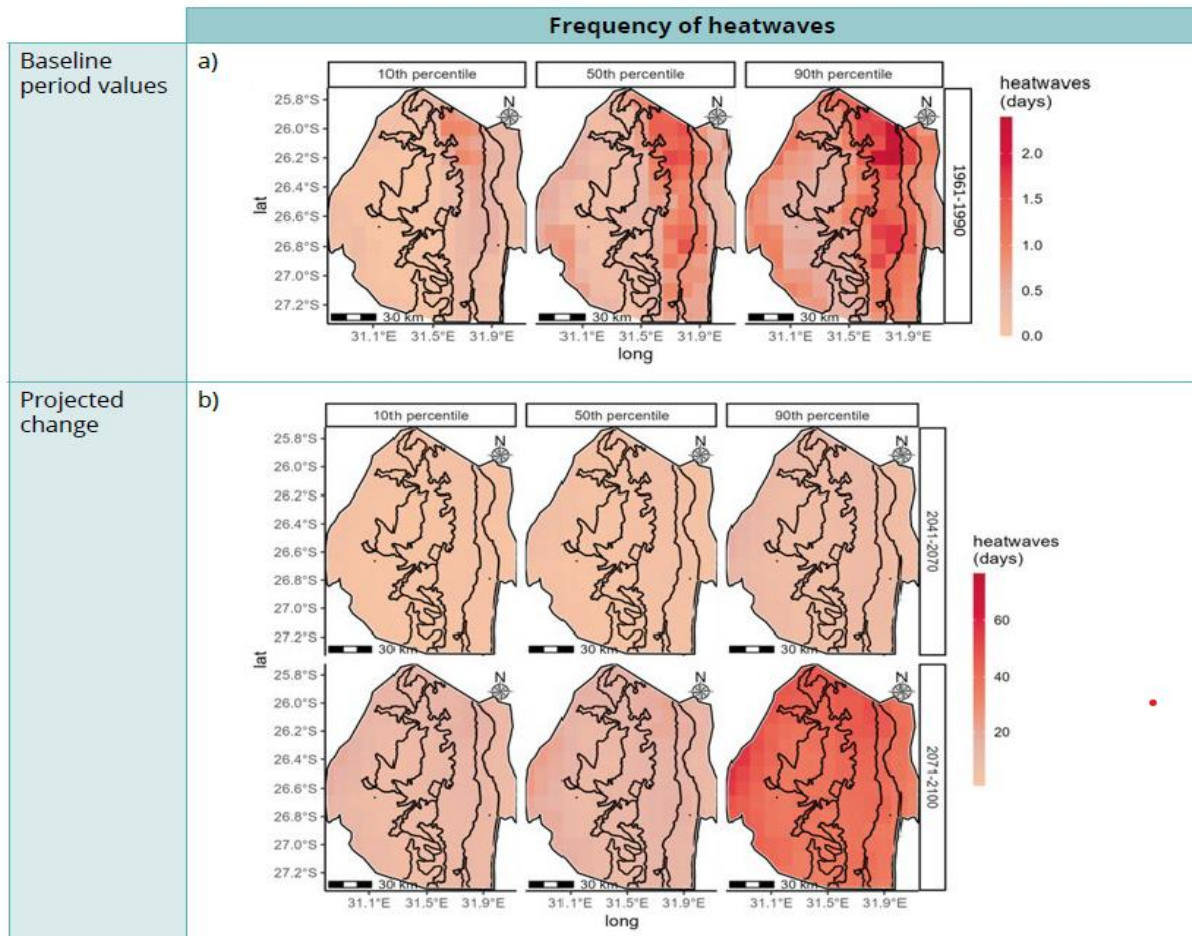


Figure 4-9: Downscaled annual mean of the count of heatwave days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.

4.1.2.3.3 WET EXTREMES

Rainfall variability is known to be connected to the El Niño-Southern Oscillation (ENSO) phenomena. Much of the Southern Africa summer rainfall regions, which include the Eswatini territory, experience dry (wet) summer conditions during the warm (cool) ENSO events. The Inter-Tropical Convergence Zone (ITCZ) and its interaction with the Botswana upper high (anticyclone centered over Botswana) are other important determinates of rainfall patterns in Southern Africa (Waliser and Gautier, 1993).

Figure 4-10 reflects the annual number of days with moderate-to-high rainfall (R20mm) for the baseline period. The R20mm index ranges from 3-15 during the reference period. The highest count of annual numbers with moderate-to-high rainfall is reflected over the central to northern parts of the Highveld, Middle and Lubombo Range. The projected signal of change in R20mm is weak (i.e., shows no drastic change in the index).

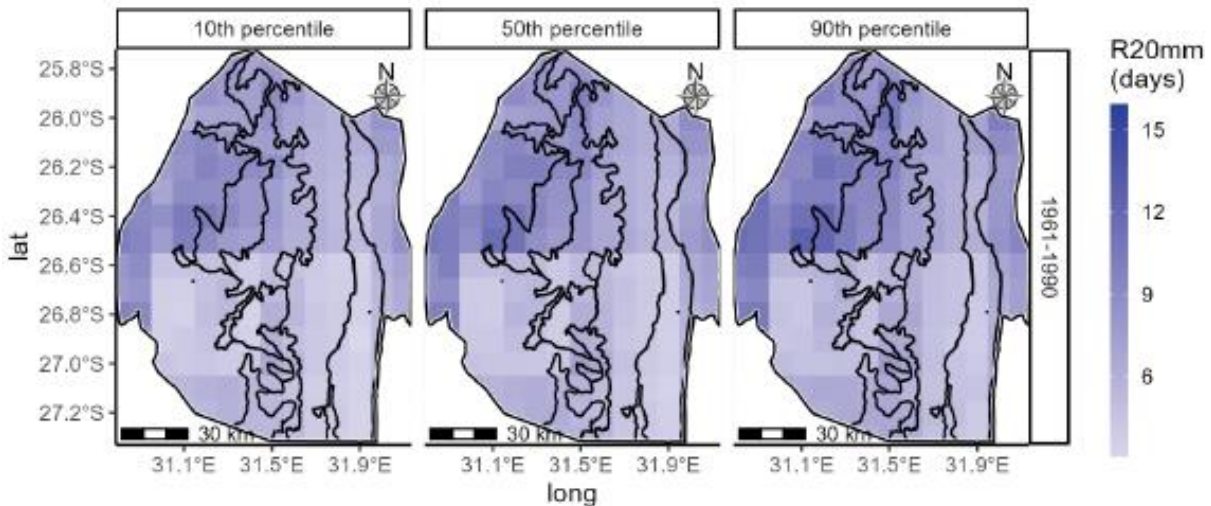


Figure 4-10: Downscaled annual mean of moderate to heavy precipitation days

Figure 4-11(a) shows the means annual consecutive wet days (CWD) range from 5–20 days. The highest CWD values are reflected over the Highveld extending to the southern high-lying Middleveld areas where extreme convective rainfall events are also predominant under the low mitigation scenario.

Figure 4-11(b), shows that the mean annual CWDs are projected to decline by almost all ensemble members. While CWDs is projected to decrease, the amount of precipitation contributed by the five consecutive days with the highest rainfall per year is projected by most ensemble members as likely to increase during the future projection period particularly for the central parts of the Highveld, Upper Middleveld, Eastern Lowveld, and Lubombo Range. The shift could also be associated with delays in the onset of seasonal rainfall, or an increase in inter-annual rainfall variability.

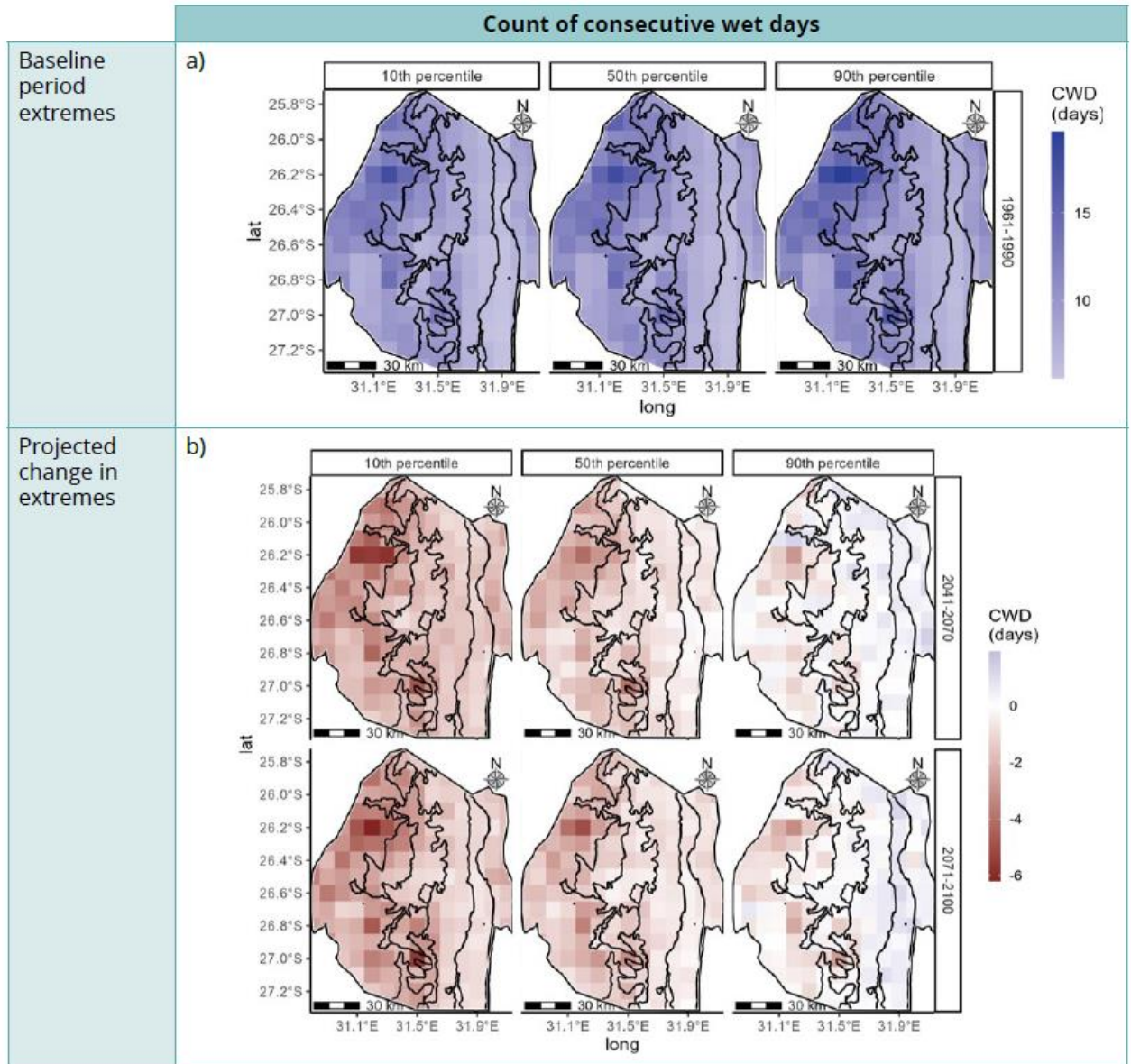


Figure 4-11: Downscaled annual mean of the count of consecutive wet days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.

Figure 4-12 reflects that there is a general increase in the highest five-day rainfall per year for parts of the Middleveld, Lowveld, and Lubombo ranges. The increase in the highest five-day rainfall in relation with a decline in the frequency of wet days shown in Figure 4-12 suggests the possibility of a shift in the temporal distribution of precipitation, particularly towards the end of the century. A future during which precipitation accumulation for 5 days is close to that of a season during the baseline period would be highly undesirable especially when followed or preceded by a dry spell.

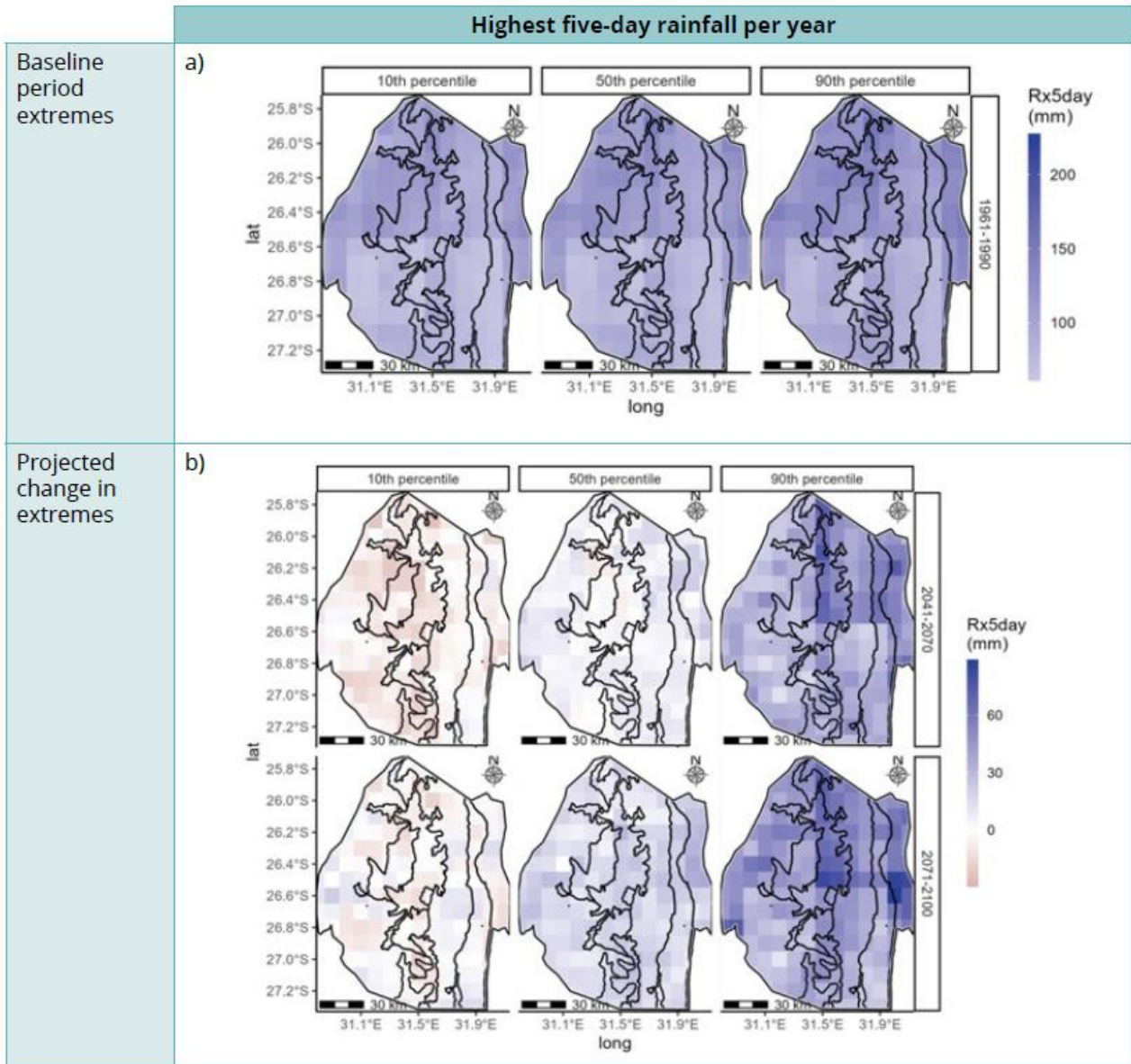


Figure 4-12: Downscaled annual mean of the highest five-day rainfall per year (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2071 and 2071-2100.

4.1.2.3.4 DROUGHT

Drought is an inherent feature of the current semi-arid climate of Eswatini, drought is an inherent feature. Consecutive dry days (CDDs) are often used as an effective measure of extreme precipitation and seasonal droughts (Duan et al., 2017). Looking at Figure 4-13(a), the CDD index recorded its lowest value over parts of the central-to-northern Highveld and western Middleveld. In Figure 4-13(b) under the low mitigation scenario during the period 2041-2071, the ensemble members do not agree with the direction of change. Towards the end of the century, there is a projected increase in CDDs except for the central-to-northern Highveld and that of the western Middleveld. It is worth noting that CDDs do not directly incorporate the impact of elevated evapotranspiration, due to the warming, but simply capture the duration of precipitation absence. The projected change in CDD suggests a change in inter-seasonal precipitation patterns leading to

dry spells of longer duration or frequency.

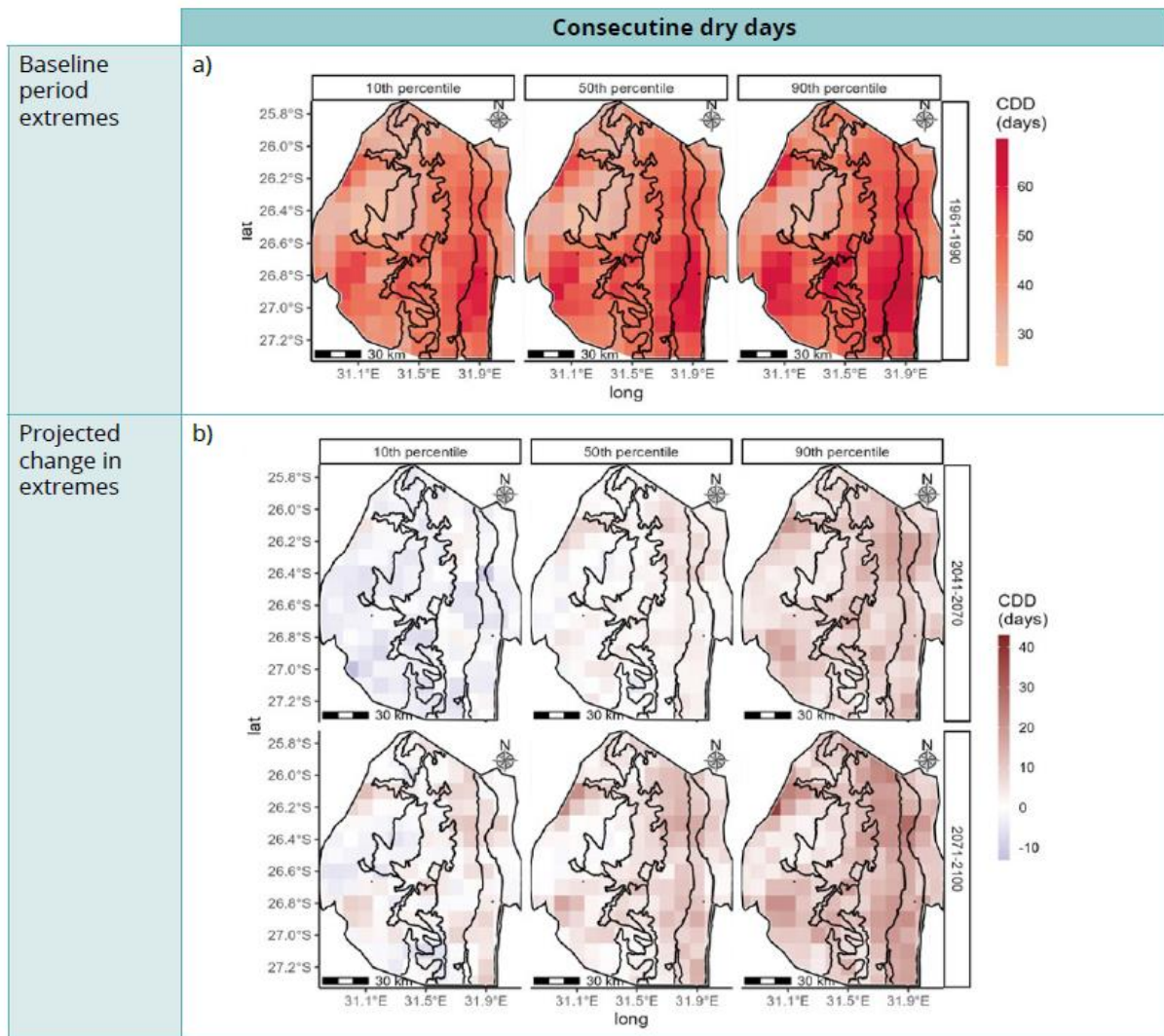


Figure 4-13: Downscaled annual mean of the count of consecutive dry days (a) baseline values and (b) projected changes under RCP 8.5 for the period 2041-2070 and 2071-2100.

4.1.3 SECTORAL ANALYSIS

4.1.3.1 INFRASTRUCTURE AND THE BUILT ENVIRONMENT

4.1.3.1.1 INFRASTRUCTURE AND CHANGES IN THE CLIMATE SYSTEM

Changes in the climate system will cause new risks to vital infrastructure for energy supply, water supply, transportation system, public infrastructure, and communication systems/ ICT. Climate change will affect infrastructure provision and operation, lifespan, effectiveness, and operating costs. An important feature of modern-day infrastructure systems is that they are also components of a larger interconnected system with co-dependencies. Critical infrastructure is often clustered in proximity, which can concentrate impacts and complicate emergency responses. Extreme events

are unlikely to affect one sector in isolation. A disruption in one infrastructure type can lead to a cascade of failures with consequences for other infrastructures, with impacts on communities and the broader economy (EU-CIRCLE, 2019). The efficient functioning of the energy sector is key to the functioning of the transport sector, ICT, water supply and sanitation, as well as agriculture. Other interdependencies in Eswatini relate to dams that are used as reservoirs for supplying water to the population, agriculture, and industry. The dams are also used for the generation of electricity through hydropower.

Impacts of changes in climate on infrastructure will also depend upon trends in economic development, population changes and technological changes. While infrastructure networks will be affected by the physical impacts of climate variability and change, it will also play an essential role in building resilience to those impacts

4.1.3.1.2 POLICIES, STRATEGIES AND LEGAL FRAMEWORKS

Several policies and frameworks have been developed within Eswatini, which directs the country's approach to mitigate risk in the infrastructure sector and reduce vulnerability. An important policy in this regard is the National Development Plan that was released in 2019 where one of the priority outcomes is an efficient economic infrastructure network. Emphasis is on better access and availability of affordable communication services, augmentation of domestic power production through renewable sources, improved road and rail networks and better access to water and sanitation. Another key policy document is the Kingdom of Eswatini Strategic Plan 2019-2022 which aims to create an enabling environment to foster private-sector led growth through policy and infrastructure, and outlines the delivering of adequate infrastructure as one of its priority areas.

In the Nationally Determined Contributions, measures such as building capacity and implementing climate-smart town planning for urban resilience and enhancing adaptive capacity of urban dwellers and implementing integrated waste management for resilient ecosystems were aligned with the Water Policy (2018), National Climate Change Policy (2016), the National Health Sector Strategic Plan (2014-2018), and the Integrated Development Plan City of Mbabane (2019-2024) (GoE-MTEA, 2021b).

The National Climate Change Policy (2016) and National Climate Change Strategy and Action Plan aim to support programs to help Eswatini adapt to climate change. The Kingdom of Eswatini Energy Masterplan (2034) is a key strategy document for the energy sector which projects outcomes of the current and planned policies in the energy system to 2034.

4.1.3.1.3 VULNERABILITY AND RISK ASSESSMENT

4.1.3.1.3.1 INTERGRATED INFRASTRUCTURE VULNERABILITY AND RISK

The Tinkhundla of Ludzeland and Lobamba have the highest risk to climate change due to the density and amount of infrastructure, high population concentration, and potential exposure to flooding and land degradation. Other areas of concern are in the north-eastern Highveld region and the Tinkhundla of Ngwempisi, Mahlangatja, as well as areas around Hluti and Hlatikulu. These areas

are at higher risk mainly due to land degradation, unpaved roads, and potential exposure to flooding (Figure 4-14).

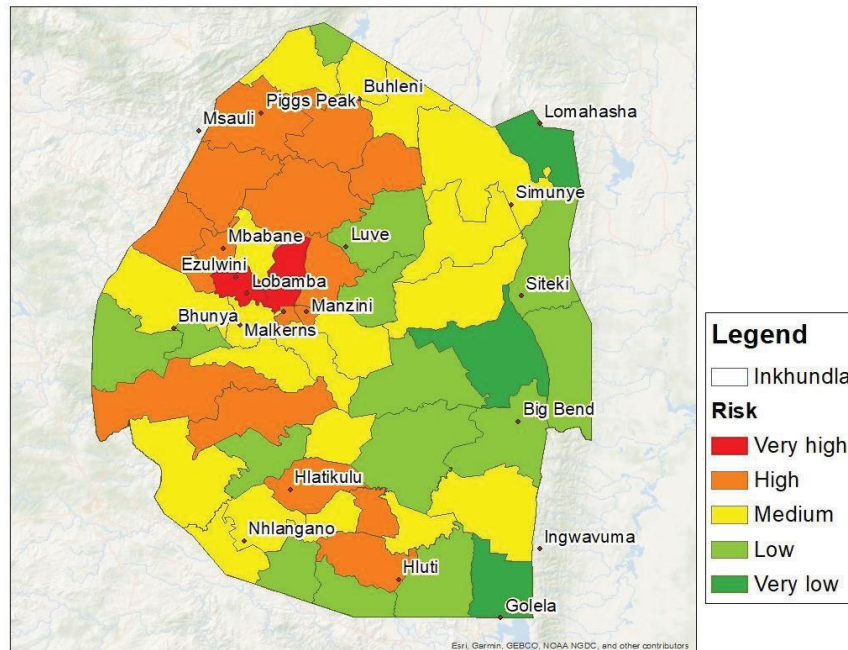


Figure 4-14: Risk of built environment infrastructure susceptibility to future climate change at Inkhundla level.

4.1.3.1.3.2 ENERGY SECTOR VULNERABILITY RISK

The main pressure on the energy sector in Eswatini is the country's heavy reliance on power imports from South Africa, which makes up approximately 80% of its total electricity use (IRENA, 2014). This contributes to energy supply challenges, in terms of both supply security and price shocks. South Africa is experiencing significant challenges of its own in power generation with insufficient generating capacity to fulfil its domestic demand. Eswatini, therefore, needs to reduce its dependence on South Africa for electricity supply. Although Eswatini does employ hydropower, the supply thereof is seasonal and is not available in sufficient quantities to meet national demand. Solar electricity is only available during sunshine hours and thus requires huge storage capacity. Eswatini is, therefore, planning to supplement power supply through Eswatini's extensive biomass resources.

Electrical power supply is strongly intertwined with weather variability and potential impacts of climate extremes vary across energy generation, transmission, and distribution infrastructure (Majodina et al., 2018). In Eswatini it was observed that electricity distribution lines are more frequently impacted by severe weather events, compared to transmission infrastructure. Extreme weather events, such as floods and strong wind, can physically damage overhead lines, towers, poles, and substations, while lightning and fires can lead to electrical faults on distribution lines. A combination of projected dry and hot conditions in future will increase the frequency of high fire-danger days across Eswatini. Distribution lines in the Highveld area with its vast forest plantations and grasslands are especially at risk of fires which can directly damage distribution poles and other electricity infrastructure. These events may also delay repair and maintenance work.

Dry spells and droughts followed by flooding lead to the accumulation of silt in Eswatini's dams. Sedimentation reduces dam storage volume, increases the chance of algal blooms, increases the proportion of water lost to evaporation, and ultimately reduces the potential for hydro-electricity generation. This challenges the long-term sustainability of multipurpose reservoirs and increases operational costs.

The government of Eswatini plans to expand the existing Maguga hydro power plant by 10MW, and the existing Maguduza hydro power plant by 13MW. Both expansions would be through water cascade systems. Projections of a general drying trend and increasing water demands from other industries in Eswatini would, however, decrease hydroelectric power potential and only be available during normal rainfall seasons. Hydroelectric power plants are sensitive to the volume and timing of stream flows. Low water levels in reservoirs during drought conditions can reduce the energy that can be generated by hydroelectric dams and algal blooms in reservoirs, which may challenge the long-term sustainability of multipurpose reservoirs and increase operation costs.

Energy infrastructure is the sector with the most interdependencies with other sectors of critical infrastructure. Without energy, most of the other sectors cannot operate properly. For example, during disaster events such as tropical cyclones which are predicted to occur more frequently in Eswatini, massive failures in power supply cause serious damage to wireless and internet infrastructure which limits communication in emergency situations. Water purification and distribution, and wastewater pumping and treatment are also dependent on the supply of electricity.

4.1.3.1.3.3 TRANSPORT SECTOR VULNERABILITY ASSESSMENT

Roads provide the dominant form of transportation and account for at least 86% of the trade logistics, which adds to pressure on the road network. Most district roads (about 2 055km) are unpaved and in poor condition, which adds to the risk of road accidents. Eswatini's paved road network has not improved to a level that is proportionate to the additional number of vehicles using the roads daily. As a result, many people must travel on unsafe roads. The networks in the urban centres, particularly those servicing commercial and industrial hubs, are increasingly becoming congested and, thus, require expansion. Public transport is not sufficient and only around 30% of people own private cars. Public rail transport faces bottlenecks such as the absence of a central train planning office to control train movement.

Although mean annual rainfall is projected to decline over Eswatini, an increase in the intensity of high-rainfall events is projected to occur. As the intensity of floods increases, road infrastructure that is already in a poor condition will become increasingly unsafe for public transport. Any heavy rainfall event may cause additional damage to transport infrastructure posing a threat to human safety, and leading to increased immobility of whole communities, reducing access to medical care, and other basic services. Poorly maintained roads and bridges that are exposed to more extreme precipitation events can be washed away, or rendered impassable. This is especially the case in Manzini, where there is serious road degradation in both rural and urban areas. Specific high-risk areas are Manzini-Nhlangano, Motshane-Piggs Peak, and Manzini/Sikhuphe roads.

Flash flood events, which are expected to occur more frequently in future, are associated with major impacts, especially in urban areas owing to the high proportion of impermeable surfaces that prevent the infiltration of water into the soil. During intense rainfall events, the accumulation of overland flow can overwhelm drainage systems, while debris can also block drains and cause substantial damage to roads, pavements, bridges, property, and electricity supply. While floods have many direct impacts, the indirect impacts such as disruption to traffic flow, business interruption, and limited freight transport are detrimental to society and the economy.

4.1.3.1.3.4 WATER SECTOR VULNERABILITY AND RISK

Key challenges, apart from climate change, facing the water supply and sanitation sector include high growth in urbanization, aging water services infrastructure, lack of water supply and sanitation infrastructure in rural areas, and uneven spatial distribution of water cross the country. Moreover, the five river basins in Eswatini are shared with the neighbouring countries of Mozambique and South Africa, which has led to tension among the three countries in some areas.

Urban population is expected to continue to grow in the future, which will add pressure on urban areas to provide water infrastructure. Environmental degradation is contributing to water problems through water pollution and wetland degradation. Water pollution reduces the amount of potable water for human use, and reduces water available for hydropower production.

In the Mbabane area there has been progressive transformation of the watershed from rural to urban land uses. More than 50% of the City of Mbabane is built on the biggest wetlands in the country. Degradation of natural flood retention systems such as wetlands significantly increases the impact of extreme rainfall events, leading to flash floods. There have been several cases of flash flooding in Mbabane over the years, which resulted in significant loss and damage to property. Poor drainage systems further contribute to the severity of flash floods when their operational capacities cannot cope with excessive surface runoff.

Over the past decade, Eswatini has made some progress in improving water and sanitation delivery. According to projections by the World Health Organization and UNICEF (Ratsiu et al., 2022) around 69% of Eswatini's population have access to basic water services, while 58% have access to sanitary services. There is especially a huge need for the expansion of water supply and sanitation in the peri-urban and rural areas of Manzini. Ageing water infrastructure and poor maintenance makes it more difficult to cope with the increased demand, putting it at risk of failure.

Key hazards to water infrastructure in Eswatini relate to overall warming and increased aridity, with a greater frequency and intensity of droughts as well as floods. Future occurrence of droughts and dry spells threaten sustainable supply of water, with implications to the people and economy of Eswatini. Drought conditions lead to decreased water supply, increased gap between the increasing water demand and available water, and competition between water dependent sectors and community needs. As water volumes decrease, raw water quality is also degraded, causing increased concentration levels of contaminants, pollutants, sediments, and solid waste.

Given the existing shortfall in water supply in Eswatini, in relation to demand, as well as the increase in population growth, there will be significant impacts on water security, water supply and wastewater infrastructure by creating higher sedimentation rates. This creates blockages and lower dilution rates that risk water quality, as well as increased strain on pumping mechanisms, leading to breakdowns (EU-CIRCLE, 2019). These challenges point to a need for timely and efficient infrastructure maintenance.

The high rainfall areas near rivers in the western part of the country have an elevated flood risk. Many of Eswatini's rivers originate outside of its borders and land-use changes, water extraction, and erosion in the neighbouring countries impact downstream users of Eswatini.

4.1.3.1.3.5 PUBLIC INFRASTRUCTURE VULNERABILITIES AND RISK

Infrastructure such as public and private (including businesses) property, health services, and education facilities are mostly located in urban or peri-urban areas and may be exposed to hazards such as fires, flash floods, and storms. The susceptibility of these structures is accentuated by changes in landcover, urbanization, and land degradation around settlements. Changing climate conditions are expected to modify the complex interactions between water, vegetation, and soil, resulting in changes in hydrology, soil quality, and nutrient cycling. These bio-physical changes associated with climate change are expected to be even worse in urban areas where human activity puts additional pressure on the natural environment with implications for water provision, fire risk, and biodiversity in urban areas. Increasing population, the expansion of the urban/wildland interface, and land use change enhance vulnerability to floods and fires.

The high-flood-risk areas in the country are in the western high-rainfall areas near major rivers and waterways. The prevalence of floods is expected to increase due to additional factors such as increase in impervious surfaces that is influenced by urbanization, vegetation fragmentation, and general land degradation. Other flood risk areas include low-lying areas in the Middleveld and Lowveld that are the recipients of inflows from the high-altitude areas.

The occurrence of fires in both rural and urban areas hold a significant risk to property and associated infrastructure. The Highveld region of Eswatini tends to be the most affected by veld fires due to the large forest plantations that characterize the area and pose serious risks to humans because they increase the severity of wildfires near densely populated areas.

The Lubombo Plateau, the Cattle and Maize zones, as well as the moist Middleveld are particularly vulnerable to storm impacts due to lightning which can cause extensive damage to infrastructure such as power (electrical) infrastructure (Dlamini, 2021).

The associated risks are accentuated by changes in landcover, urbanization, and land degradation around settlements. Changing climate conditions are expected to modify the complex interactions between water, vegetation, and soil, resulting in changes in hydrology, soil quality, and nutrient cycling. These bio-physical changes associated with climate change are expected to be even worse in urban areas where human activity puts additional pressure on the natural environment with

implications for water provision, fire risk and biodiversity in urban areas. Increasing population, the expansion of the urban/wildland interface, and land use change enhance vulnerability to floods and fires.

4.1.3.1.3.6 INFORMATION AND COMMUNICATION TECHNOLOGY VULNERABILITIES AND RISKS

Information and communication infrastructure that can be affected by climate change includes transmission infrastructure (cables and cell towers), wireless signals, system devices (computers, mobile phones, radios), and buildings and equipment. The information and communications sector are heavily reliant on other critical infrastructure sectors to operate effectively. Climate change will primarily impact on ICT through changes in the electricity and energy sector, as none of the active communications sector equipment can operate in the absence of a power supply. Other climate-related impacts on components of infrastructure include service disruption, infrastructure degradation, and changes in service quality and availability. Impacts vary considerably for below-ground infrastructure, above-ground infrastructure, and wireless-, radio-, or satellite-based services.

Communication and information sharing in many areas of Eswatini depends on fixed upper ground terrestrial infrastructure. These cables, switches, towers and antennas are susceptible to hazards such as strong winds, lightning, and fires as they are located just above ground. Copper cables, which are designed to conduct electricity, make copper internet more susceptible to lightning and fires. Below-ground infrastructure could be impacted by flooding, especially in urban areas such as Mbabane where central nodes for data transmissions or redistribution are located. These impacts can increase operation and maintenance cost of infrastructure and undermine economic activity, emergency response, and social connectivity.

4.1.3.1.4 PRIORITISED ADAPTATION ACTIONS

Understanding potential future impacts is essential for informing and developing adaptation strategies and actions. As with vulnerability, the process for assessing potential adaptation measures started by identifying the 'generic' measures and were then narrowed down and prioritized based on the climate risks identified for each infrastructure sub-sector. Climate change adaptation options for various kinds of infrastructure must also consider the multiple interdependencies between sectors. A holistic or coordinated approach to climate adaptation is, therefore, required to identify instances where multiple potential points of failure exist; and to take steps to prevent these failures from occurring. Adaptation interventions for the infrastructure sector that decrease the susceptibility of the sector to climate hazards can be divided into hard adaptation options such as the raising of dam walls, building new power generation facilities, reinforcing infrastructure, relocating critical infrastructure and structural modification of systems. Non-structural or soft adaptation refers to the spatial planning (including plans that assess the vulnerability of new infrastructure), monitoring, and maintenance components of infrastructure. Specific soft adaptation options of importance in Eswatini are the development of climate-sensitive policies, legislation, and development plans that reference resilience to protect infrastructure from known and anticipated climate risks. Other soft adaptation options include the development of appropriate monitoring and evaluation system to assess the effectiveness of adaptation measures,

improved weather forecasting capability, and implementation of multi-hazard early warning systems, as well as more frequent and enhanced inspection of affected sites.

Prioritized adaptation interventions across multiple components of the built environment include:

- Adaptation strategies that have a focus on designing multipurpose projects that rehabilitate or integrate existing infrastructures and be of advantage across multiple sectors. Collaboration between owners to work towards a collaborative model for interdependent infrastructure would be of advantage to government. This would save costs associated with duplication of developmental projects, streamlining of activities, and higher likelihood of success due to amplification of synergies (Mpandeli et al., 2018).
- Identifying interdependencies among infrastructure systems; for example, highway is connected to the airport, schools, hospitals, business area, etc. When flood occurs, these infrastructures will be affected simultaneously, causing losses in various sectors (tangible and intangible).
- Identifying and prioritising protection of disaster response infrastructure across settlements. These types of infrastructures are critical for response during disaster events and include important access and escape routes, ICT, electricity components, social facilities such as town halls, clinics, and hospitals.
- Improved prediction (longer lead time) of severe weather events integrated into multi-hazard early warning systems. Development of a drought monitoring tool to improve resilience of sensitive sectors.
- Stakeholder participation, engagement, and support—encouraging stakeholder involvement with climate adaptation needs and building resilience.
- Improved monitoring and evaluation of the condition of critical infrastructure to ensure timely maintenance.
- Given the interconnectedness of infrastructure systems, there should be better transparency and coordination between different infrastructure sector departments.
- Decentralizing bulk infrastructure systems to ensure that when there is a failure within a critical infrastructure system the entire network is not affected.
- Limiting the development of bulk infrastructure in high-risk areas. Land use and spatial planning tools should identify

and capture these areas.

- More detailed identification of vulnerable areas where existing critical transmission and distribution infrastructure is located.
- Maintaining and rehabilitating ecological infrastructure. Well-functioning ecosystems provide better flood control, improved water and soil quality, and lower temperatures. It reduces the costs of implementing hard adaptation measures to protect infrastructure. Many impacts on infrastructure can be mediated by adaptation interventions aimed at restoring biodiversity, catchments, and wetlands through ecosystems-based adaptation.
- Restoring and protecting natural features and re-greening areas of the urban environment are critical elements in adapting to climate change and increasing the resilience of communities. Elements such as sustainable urban drainage systems protect communities from flooding.

4.1.3.1.5 GENDER AND CLIMATE RESILIENT INFRASTRUCTURE

Climate change vulnerability is influenced by various socio-economic factors, including gender. Men and women have different infrastructure needs (Organisation for Economic Co-operation and Development OECD, 2018). In societies where women typically collect water, access to piped water will significantly assist with female empowerment, enabling them to spend their time on other activities. Women and men will also be affected differently by climate change impacts, such as disruption to infrastructure due to flooding. Systematic consideration of the needs and perspectives of women during decision making is, therefore, imperative to ensure that adaptation actions contribute to the resilience of communities.

4.1.3.1.6 SUMMARY OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE BUILT ENVIRONMENT

Table 4-2: Climate Hazards, Associated Risks, and Adaptation Strategies for Communication and Information Infrastructure in the Built Environment


Communication and information infrastructure				
	Hazard	Impact	Areas at risk	Adaptation
	Flooding and storms	Service failure and lack of communication during disaster events could amplify the impact of the disaster and cause more lives to be lost.	Urban areas in Hhohho (Mhlangatane, Madlangampisi), Manzini (Mhlambanyatsi, Lamgabhi), Lubombo (Nkilonko)	Decentralize essential equipment, so that a disaster event does not prompt overall network failure. Protect and prioritize power supply to key equipment in case of extreme events.

Table 4-3: Climate Hazards, Risks, and Adaptation Options for Transport Infrastructure in the Built Environment


Transport				
	Hazard	Impact	Areas at risk	Adaptation
	Increase in fire danger days	<ul style="list-style-type: none"> Reduced visibility along roads, increasing risk of accidents. Direct damage to transport infrastructure.	Dense vegetation growth on road reserve. <ul style="list-style-type: none"> Wildland/ urban interfaces. Afforested areas of the Highveld region	Reducing fuel load next to road and railway infrastructure Reducing fuel load at the wildland urban interface.

Table 4-4: Climate Hazards, Risks, and Adaptation Options for Water Supply and Sanitation Infrastructure





Water supply and sanitation infrastructure				
	Hazard	Impact	Areas at risk	Adaptation
	Extreme temperature and drought	Increased water demand and concomitant decline in water availability. Increased frequency of algal blooms and eutrophication in surface water sources.	Western Highveld and North-eastern Lowveld	Improve water use efficiency, especially in the agricultural sector. Regular maintenance and monitoring of water pipes for leaks.
		Reduced water security. Higher sedimentation rates in water supply and wastewater infrastructure.	The increase in droughts in a future climate will be most pronounced in the east of the country.	Better cooperation on adaptation projects between water and energy sectors. Wetland restoration and alien vegetation removal.

Table 4-5: Climate Hazards, Risks, and Adaptation Options for Public Facilities and Buildings

Public facilities and buildings				
	Hazard	Impact	Areas at risk	Adaptation
	Flooding	Damage to critical facilities such as hospitals, clinics, community halls, education institutions, old age homes etc. Loss of life	Urban areas in Areas close to rivers	Invest in flood early warning systems. Increased emphasis on nature-based solutions and green infrastructure
	Fire danger days	Damage to buildings and loss of lives.	Higher risk for damage to infrastructure is associated with wildland/ urban interfaces.	Reducing fuel load at the wildland urban interface is a critical component of fire management adaptation

Source: The Fourth National Communication

4.1.3.1.7 BARRIERS

Some key barriers that slow or halt progress on adaptation in the built environment sector of Eswatini include lack of knowledge on where to access funding, lack of access to relevant information on specific climate impacts to key infrastructure, as well as organizational, political, and governance challenges. Another complicated factor is the attribution of climate change as the driver of impacts. Climate change is characterized by high uncertainty and the ambiguity of various models to confidently predict changes (e.g., in rainfall) causing hesitance in making long-term investments. It may also cause some institutions to choose ineffective adaptation options.

Institutional challenges relate to coordination of various government ministries that are involved in decision making and implementation of adaptation interventions. Built infrastructure consists of various sub-sectors, governed by different ministries, which complicates the coordination, planning and implementation of adaptation actions. However, since these infrastructures have several interdependencies, the focus should be on cross-sectoral engagement and cooperation when designing adaptation strategies.

Considerable international funding and support is available to government for addressing adaptation needs, but there is often a disjunction between identifying support needs and accessing relevant funds. Local government in Eswatini should, therefore, be informed of the available mechanisms and programs through which adaptation funding can be accessed. This also includes tools and frameworks that have been developed to guide adaptation in the built environment sector.

4.1.3.1.8 CONCLUSION

The built environment sector of Eswatini faces several vulnerabilities in the face of climate change. These relate to the ageing condition and deterioration of critical infrastructure such as road networks, energy, water, and sanitation infrastructure, and an overreliance on coal-based energy from its neighbouring countries. These vulnerabilities are compounded by the steady increase in population and urbanization which places additional pressure on urban areas to supply food, water, and energy. In rural areas, limited access rates to electricity, water, and sanitation and mobile data contribute to vulnerability.

Changing climate conditions will cause direct impacts on the built environment, through damage to infrastructure facilities and indirect impacts through rising costs associated with maintenance and rehabilitation after severe events, as well as interruptions to services. Due to the interconnectedness of critical infrastructure systems, failure of one component will have consequences along a network of built environment types. Eswatini's transport sector will be most at risk of flooding, the water and sanitation sector mainly at risk of droughts, energy supply particularly at risk of drought and fires, while the ICT sector is especially at risk of flooding and fires. Adaptation interventions should include various approaches, ranging from protecting critical infrastructure, proper routine maintenance and upgrading of infrastructure, improving multi-hazard early warning systems, implementing public-private sector partnerships, and increased focus on nature-based solutions.

Future human vulnerability will continue to concentrate where the capacities of local, municipal, and national governments, communities and the private sector are least able to provide infrastructure and basic services (high confidence). Under the global trend of urbanization, human vulnerability will also concentrate in informal settlements and rapidly growing smaller settlements. In rural areas, vulnerability will be heightened by compounding processes including high emigration, reduced habitability, and high reliance on climate-sensitive livelihoods (high confidence). Key infrastructure systems including sanitation, water, health, transport, communications, and energy will be increasingly vulnerable if design standards do not account for changing climate conditions (high confidence).

4.1.3.2 HEALTH

4.1.3.2.1 HEALTH AND CHANGES IN THE CLIMATE SYSTEM

Climate change may impact on health both directly and indirectly. Its effects have been most noticeable during extreme weather events such as heat waves, floods, droughts, and storms. Climate change and climate-driven hazards and diseases can put additional pressures on already strained healthcare resources. These events, therefore, affect people's access to health care, as well as the functioning of health facilities. Health impacts associated with climate change will, in the short-to-medium term, be determined mostly by population vulnerability, their resilience to current climate change, and the pace and extent of adaptation (WHO, 2018). In the longer term, actions to reduce emissions and avoid the crossing of critical temperature thresholds will increasingly

determine associated effects.

Climate projections for Eswatini indicate the potential for record high temperatures, including increased night-time temperatures, which reduces natural cooling and affecting comfort and, potentially, health (World Bank, 2021). The impact of heat waves (consecutive days with high temperatures) can contribute to health issues in various vulnerable groups. Within Eswatini, exposure to these climate scenarios may result in increased deaths. Natural hazards such as floods, and vector-borne diseases such as malaria, are some of the climate hazards that may contribute to increased morbidity and mortality. Exposed households with co-morbidities, such as HIV/AIDS, are especially vulnerable. The health sector in Eswatini is, therefore, directly impacted by extreme weather events such as heat waves, floods, droughts, and storms. The sector is also influenced by the impacts of climate change on the other sectors such as agriculture (increased food insecurity), water (water quality and quantity), biodiversity and ecosystems sectors. This may, in turn, affect sectors such as tourism. However, few studies on climate change and health have been conducted in Eswatini.

4.1.3.2.2 HEALTH POLICIES, STRATEGIES AND LEGAL FRAMEWORKS

Eswatini has adopted several health policies and strategic plans to guide action and strengthen the sector's capacity to respond to climate change (Ministry of Economic Planning and Development, 2019). Some of these are the National Health Policy of Eswatini (2017), the Third National Health Sector Strategic Plan (2019-2023), and the National Health Financing Policy (2017); however, none of them explicitly recognize the nexus between climate change and health, despite their influence on the health and well-being of the population (GoE-MTEA, 2021). While the National Health Policy is the government's overarching policy instrument and is being implemented in part through the National Health Sector Strategic Plan 2019-2023, the lack of policies, strategies, and plans for mainstreaming climate change in the health sector is one of the biggest barriers impeding the health sector's adaptation to climate change (Ndlovu et al., 2022). Key legislation to be enacted includes the Health Bill, Nutrition Council Bill, Pharmacy Bill, and National Health Insurance Bill (NHSSP, 2019).

The National Climate Change Policy (2016) recommended policy statements to climate change-related health issues. Policies for climate-induced risk maps such as heatwaves are needed, since adaptation in health is currently reactionary, and these policies need to receive similar attention as that given to policies for the eradication of Malaria, for example (GoE-MTEA, 2021). The National Malaria Elimination Strategic Plan (2017-2020) is geared towards achieving elimination of malaria (MTEA, 2021). A gap analysis for the health sector (Ndlovu et al., 2022) highlighted a need for the sector to establish policy frameworks and collaboration mechanisms to provide the guidance and support required to mainstream climate adaptation into the health sector. Enhancing the legal, policy, and institutional framework was one of the adaptation goals for the health section in the country's revised NDC, in addition to capacity building, leveraging the use of technology to help the health sector adapt to climate change, and enhancing the sectors adaptive capacity (GoE-MTEA, 2021). The sector's response to climate change can also be supported through the development of a health national adaptation plan for the sector. Research data for climate change-related impacts in Eswatini is often lacking and, therefore, there is a need to strengthen scientific research in the health sector and, in particular, in relation to climate change (Ndlovu et al., 2022).

The National Development Plan (2019/20-2021/22) devotes a section on health, highlighting achievements as well as challenges. Reference is made to the Poverty Reduction Strategy and Action Programme (PRSAP), and several grants for social protection intended for vulnerable groups, including elderly and children. The Persons with Disabilities Act 2018 and the Sexual Offences and Domestic Violence 2018 have been implemented, and policies that support social assistance and social security policies developed. The Plan also mentions efforts to rehabilitate the houses of disaster victims, and train community volunteers on risk reduction and response.

4.1.3.2.3 VULNERABILITY AND RISK ASSESSMENT FOR HEALTH SECTOR

The vulnerability of the health sector to climate change was reviewed and assessed in terms of health resources such as health infrastructure and health workforce, and the health and well-being of the Eswatini population.

4.1.3.2.4 HEALTH SECTOR EXPOSURE TO CLIMATE HAZARDS

Exposure to climate hazards and direct climate impacts that were considered include temperature, extreme winds, floods, droughts, and wildfires as described in Section 4.3 and listed in Table 4-6 gives an indication of the number of people affected by natural hazards as reported in the Emergency Events Database (EMDAT) and Disaster Inventory System (DisInventar) databases.

Table 4-6: Natural hazards reported in the EMDAT database for Eswatini (1981 to 2021) and reported in the DisInventar database for Eswatini (2011 to 2020) (source: Dlamini, 2021).

Hazard	Frequency	Number of people affected	Number of people directly affected	Number of people indirectly affected	Number of people killed	
	EMDAT	EMDAT	DisInventar		EMDAT	DisInventar
Drought	7	2354000		598727	500	
Epidemic	3	3677			142	
Flood	3	274900			11	
Storm	4	639425	2035	5094	54	2
(Wild)fire	1	1500	22	26	2	
Hailstorm			245	267		
Tropical cyclone			13	83		
Windstorm			170	2637		1

The selected indicators used to assess exposure of health facilities to climate hazards are listed below:

- Extreme wet conditions;
- Hot days, heatwaves, and warm nights;
- Drought.

Climate hazards were overlaid spatially with the health facilities to assess health facility exposure to baseline and projected climate scenarios.

4.1.3.2.4.1 BASELINE EXPOSURE

4.1.3.2.4.1.1 BASELINE EXTREME PRECIPITATION EXPOSURE

Health facility location in relation to altitude and rivers is shown in Figure 4-15. The baseline for the maximum precipitation over a 5-day period and the number of very heavy precipitation days are shown in Figure 4-16 (a) and Figure 4-16 (b).

Figure 4-16 (b).

Eswatini altitude variability and health facility coverage

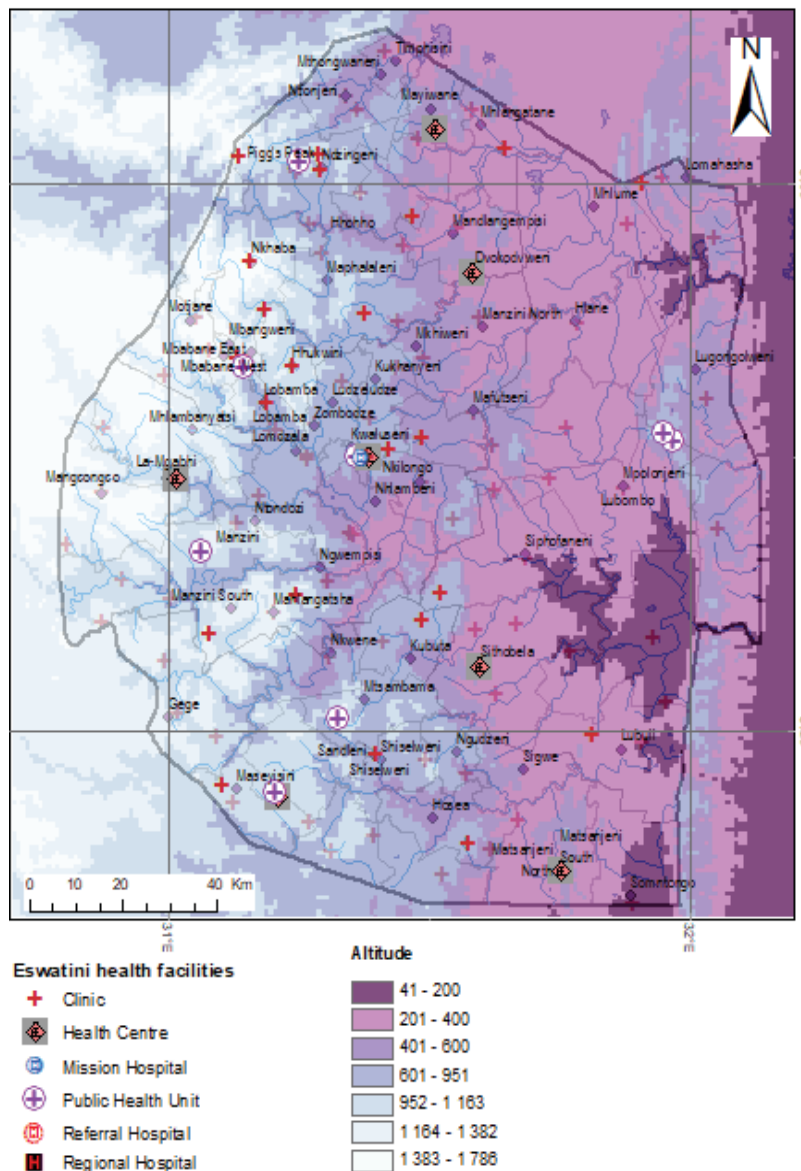


Figure 4-15: Variability in altitude and health facility coverage.

Health facilities that may be at a higher risk if they are exposed to high precipitation due to their low altitude and proximity to water bodies are concentrated along the eastern

border of the country (

Figure 4-16).

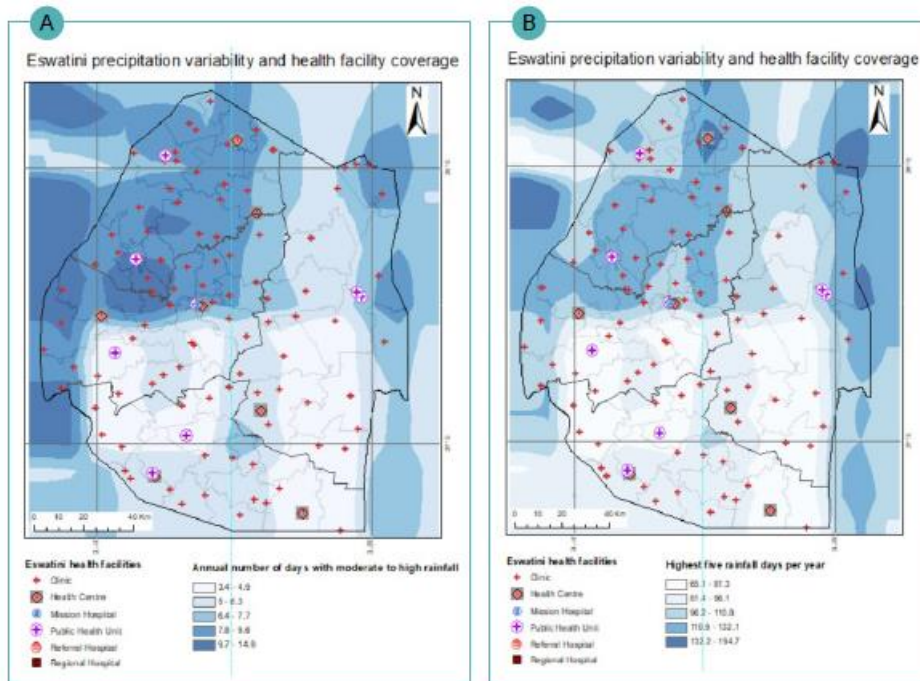


Figure 4-16: Health facility location in relation to baseline for a) the annual number of days with moderate to high rainfall and b) the highest five rainfall days per year.

Health facilities in the northwest and west and in the north-east and east are more likely to be exposed to heavy precipitation.

4.1.3.2.4.1.2 BASELINE HEAT EXPOSURE

Health facility location in relation to baseline hot days, extreme heat, and heat waves is shown in Figure 4-17a-c.

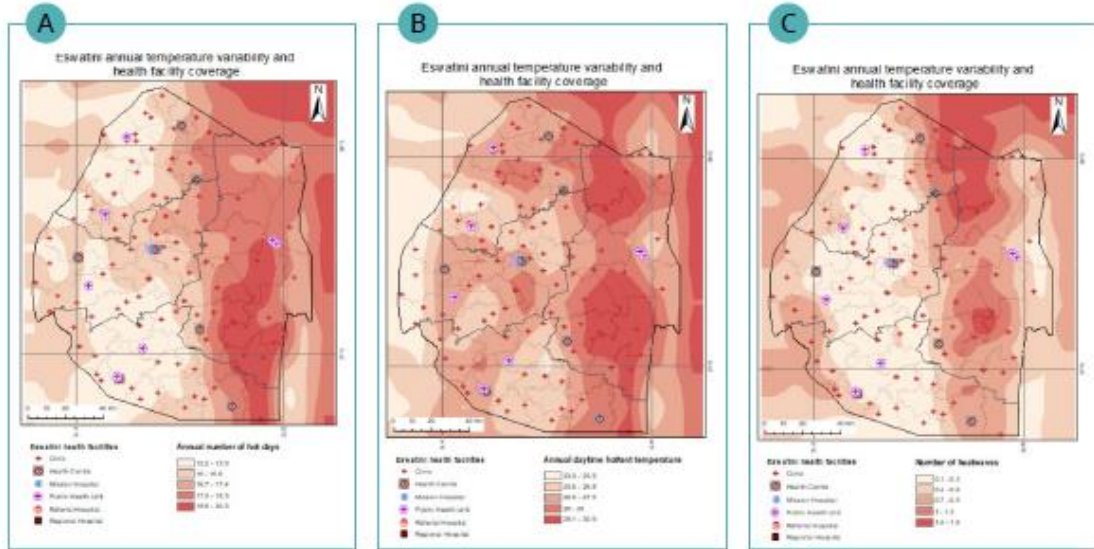


Figure 4-17: Baseline exposure of health facilities to a) hot days, b) extreme heat and c) heatwaves.

According to the baseline, health facilities in the north-east and east of the country are more likely to be exposed to high temperatures. Areas particularly at risk of heatwaves are those rural areas with more land and less protection from vegetation as well as densely populated and built-up areas, especially in the east of the country (Dlamini, 2021).

4.1.3.2.4.1.3 EXPOSURE TO BASELINE DRY SPELLS

Health facility location in relation to baseline for the maximum number of consecutive dry days is shown in Figure 4-18.

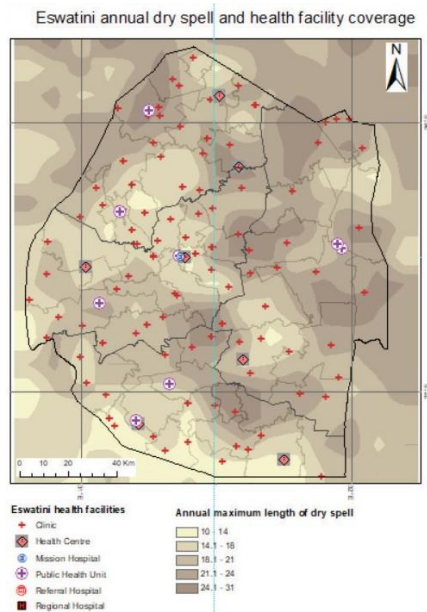


Figure 4-18: Health facility location in relation to the baseline for the annual maximum length of dry spell days.

Facilities that may be exposed to dry conditions are dispersed across the country.

4.1.3.2.4.2 PROJECTED CLIMATE EXPOSURE

4.1.3.2.4.2.1 EXPOSURE TO PROJECTED EXTREME PRECIPITATION

Health facility location in relation to projected precipitation over a 5-day period with the highest annual five rainfall days for 2041-2070 and 2071-2100 are shown in Figure 4-19(a) and Figure 4-19(b). The facilities with the highest risk due to precipitation using this indicator are shown in Table 4-7.

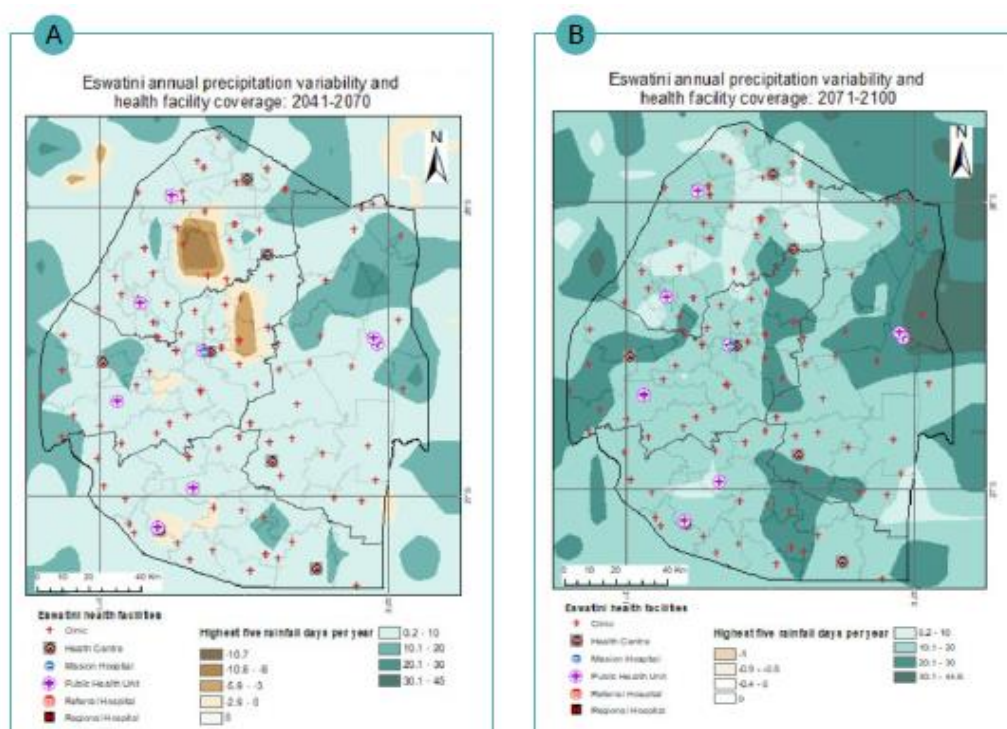


Figure 4-19: Health facility location in relation to projected precipitation, showing the highest annual five rainfall days for a) 2041-2070 and b) 2071-2100

Table 4-7: Health facilities with the highest projected 5-rainfall days, 2071-2100.

District	Inkhundla	Health facility
Hhohho Region	Lobamba	Satellite Clinic
	Piggs Peak	Regina Mundi Clinic / Mondiclinic
Lubombo Region	Lubulini	Ikwezi Joy Clinic
	Lugongolweni	Sitsatsaweni Nazarene Clinic
Manzini Region	Mafutseni	Hluti Clinic Mafutseni
		Nazarene Clinic
		Mangcongco Clinic

Shiselweni Region	Mangcongco	Dwalile Clinic
	Mtfongwaneni	
	Ngwempisi	Musi Clinic
	Hosea	Dwalile Clinic
	Ngudzeni	Musi Clinic

4.1.3.2.4.2.2 EXPOSURE TO PROJECTED HOT DAYS

Health facility location in relation to future (2041-2070 and 2071-2100, respectively) hot days is shown in Figure 4-20a and Figure 4-20b.

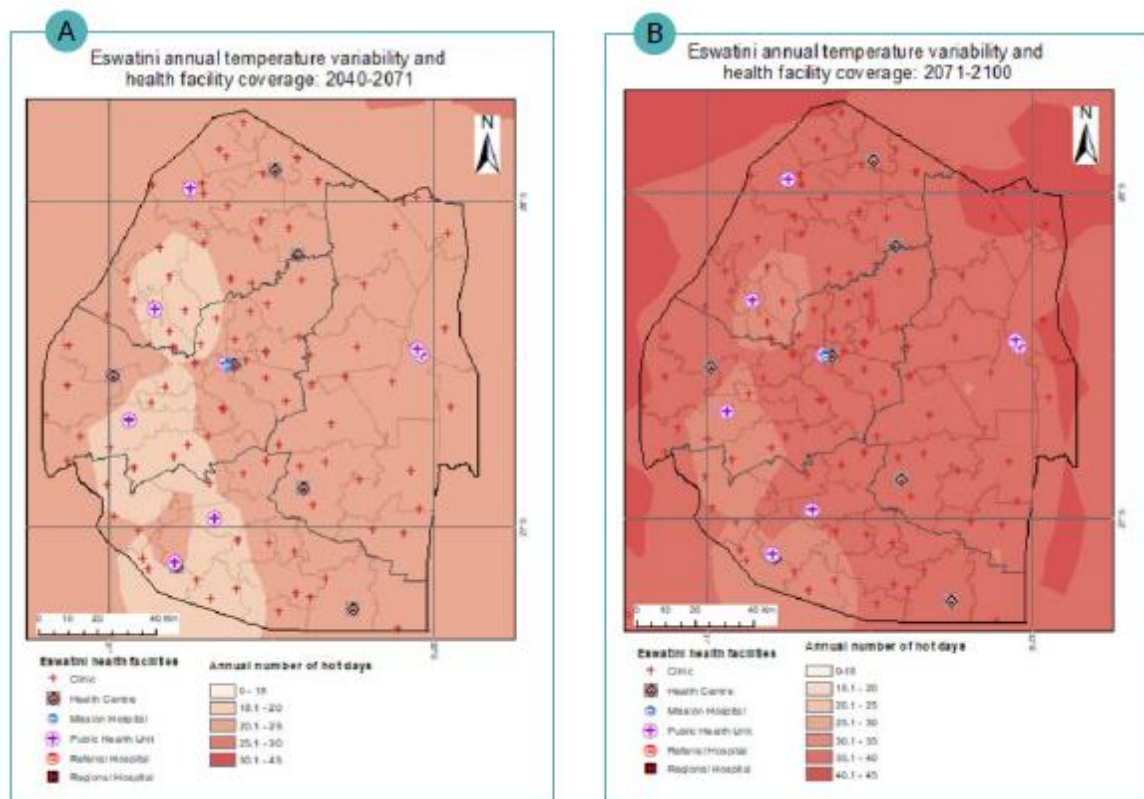


Figure 4-20: Exposure of health facilities to projected hot days, a) 2041-2071 and b) 2071-2100.

The health facilities with exposure to the highest number of hot days for the 2071-2100 projections are shown in Table 4-8.

Table 4-8: Health facilities with exposure to the highest number of projected hot days (2071-2100).

Region	Tinkhundla	Health facility
Hhohho Region	Ndzingeni	Bulandzeni Clinic
	Maphalaleni	Ekuphileni Clinic
	Piggs Peak	Regina Mundi Clinic / Mondi

		clinic
	Lobamba	Lobamba Clinic
Lubombo Region	Dvokodvweni	Manyeveni Nazarene
Manzini Region	Mthongwaneni	Ngculwini Nazarene Clinic
	Mkhiweni	Mliba Nazarene Clinic
Shiselweni	Matsanjeni	JCI (Mphelandzaba) Clinic

4.1.3.2.4.2.3 EXPOSURE TO PROJECTED DRY SPELLS

Health facility location in relation to the future annual maximum length of dry spell days, for a) 2041-2070 and b) 2071-2100 is shown in Figure 4-21(a) and Figure 4-21(b). Health facilities with exposure to the highest number of dry spell days, are shown in Table 4-9.

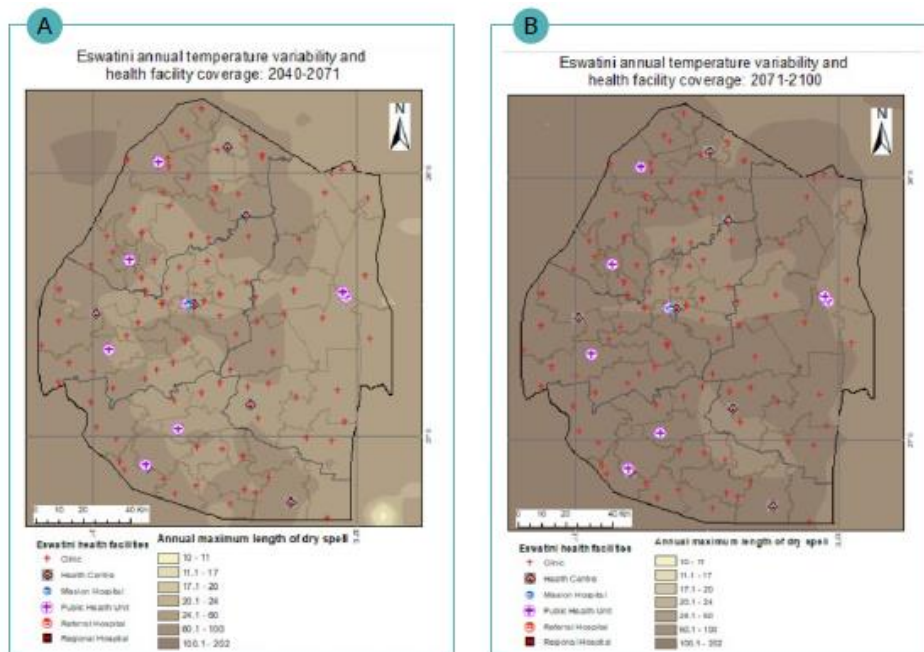


Figure 4-21: Health facility location in relation to the projected annual maximum length of dry spell days, for a) 2041-2070 and b) 2071-2100.

Table 4-9: Health facility location with the highest projected annual maximum length of dry spell days (2071-2100).

Region	Tinkhundla	Health facility
Shiselweni Region	Gege	Gege Clinic
		Mashobeni Clinic
		Magubheleni Clinic
	Maseyisini	Tfokotani Clinic
Hhohho Region	Piggs Peak	Pigg's Peak Government Hospital

		Bulembu Clinic
	Siphocosini	Sigangeni Clinic
Manzini Region	Mahlangatja	Mahlangatja Clinic
	Mangcongco	Mangcongco Clinic
	Mhlambanyatsi	Mpuluzi Clinic

4.1.3.2.5 POPULATION AND HEALTH INFRASTRUCTURE VULNERABILITY

A recent assessment of the country's vulnerability profile indicates that 60% of the population has a medium to high vulnerability to climate-driven hazards (Dlamini, 2021). High vulnerability is most likely in the low-income rural and peripheral parts of the country, with Shiselweni and Lubombo regions highlighted as socio-economic vulnerability hotspots. Urban areas, protected areas, private ranches, forest, and sugarcane plantations had comparatively low vulnerabilities. When considering the livelihood zones of the country, the Lubombo Plateau, Cattle and Maize, Parks and Reserves, and the Middleveld zones were highly vulnerability and which indicated that the livelihoods of the people in these areas are susceptible to, or unable to cope with, adverse effects of climate change.

Stakeholders from the health sector in Eswatini identified the following climate hazards and their associated impacts on human health and wellbeing as important (Dlamini, 2021):

- Drought, resulting in a decline in food and nutrition security, a decline in hygiene and an increase in water-borne diseases;
- Floods, resulting in interrupted access to health facilities;
- Fires, contributing to a shortage of medical supplies;
- Storms, which may result in interrupted access to health facilities, increase in waterborne diseases, as well as a shortage of medical supplies;
- Heatwaves, which may increase the incidence of heatstroke, cardiovascular disease, cause dehydration, fatigue, contribute to increase in snake bites, and a general increase in morbidity.

These impact factors may also contribute to the vulnerability of the general population (either through sensitivity or inability to cope or adapt). Vulnerability may depend on the climate hazard of concern. Generally, vulnerability aspects of importance for heatwaves, dry spells, and flood events may include:

4.1.3.2.5.1 SENSITIVITY

- Literacy/education population above 20 years old without secondary education;
- Age dependency elderly population and young

population;

- Population living in informal structures;
- Unemployed population, aged above 20 years;
- Family structure – women-headed and child-headed households;
- Household density – overcrowding;
- Disabled population – difficulty to walk, hear, see, communicate;
- Pre-existing health conditions such as HIV/AIDS, TB;
- Population on chronic medication.

4.1.3.2.5.2 COPING /ADAPTIVE CAPACITY

- No or limited access to electricity;
- No or limited access to information/communication methods (cell phones);
- No or limited access to open spaces/vegetation;
- No or limited access to refuse removal;
- No or limited access to clean water;
- Social cohesion;
- Limited access to, or being far from health facilities.

Factors that affect health facility and health workforce vulnerability (either its sensitivity or its ability to cope and/or adapt) may vary, depending on the climate hazard of concern. The risk and impacts of climate change on different aspects of the health sector are complicated by its inter-connectedness with other sectors. Factors of importance for heatwaves, drought, and flood events may thus include:

- Status of water supply quality and quantity as well as continuity;
- Water storage facility readiness;
- Health waste storage status;
- Stable energy supply to ensure the safety of both patient and medication;
- Cooling ability of infrastructure, e.g., wall and roof insulation, pavements;
- Status of the surrounding natural environment (e.g., vegetation for shade);
- Status of medical supplies for treating heat-related illnesses;

- Emergency and risk communication procedures (e.g., evacuation procedures);
- Access to early warning services;
- Location of facility in relation to flood plains, rivers and dams, steep slopes erosion and/or fire risk prone areas;
- Staff awareness, capacity, readiness, and support;
- Relationships with other entities such as other health facilities, local municipality, community organisations and local businesses, and relevant research organisations;
- Monitoring of the resilience of systems and resources.

Vulnerability data (geo-spatial and statistical) were acquired from a variety of data sources, including online data sharing platforms, relevant Government Departments within Eswatini, and other stakeholders working within the domain of climate risk, vulnerability, and adaptation. Data sources include:

- Central Statistics Office (CSO, 2017);
- Vulnerability Assessment Committee (VAC, 2022);
- National Development Plan (NDP, 2019);
- WHO Country cooperation strategy for Eswatini (WHO, 2019);
- Eswatini Health Facility Census, 2017;
- Eswatini State of Environment Report, 2020;
- Service Availability and Readiness Assessment (SARA, 2017);
- National Voluntary reporting;
- Humanitarian Data Exchange (HDX) which is an open data sharing platform managed by the United Nations Office for the Coordination of Humanitarian Affairs.

Pre-existing health conditions of concern which contribute to the vulnerability of exposed communities include a high HIV/TB co-infection rate (TB and AIDS being the top and second-highest cause of mortality, respectively), upper respiratory infections (being the top cause of morbidity); non-communicable diseases (NCDs) such as hypertension (third-highest cause of morbidity), and diabetes mellitus (8th-highest cause of morbidity). The incidence of NCDs is increasing. In addition, water and sanitation related diseases such as faecal-oral diseases are among the top five leading causes of morbidity in the country. The double burden of both communicable and non-communicable diseases adds to the pressure on health facilities. Assessment of diagnostic readiness of health facilities showed that most (72%) of the 327 health facilities had the capacity to diagnose HIV but only 53% could test for malaria (WHO-SARA, 2019). A low readiness of facilities was also

observed for the following non-communicable diseases that contribute to climate vulnerability (WHO-SARA, 2019):

- cardiovascular disease services (76%);
- diabetes services (72%);
- chronic respiratory disease services (70%).

Nutrition-related conditions contribute to vulnerability, with almost half of the population being overweight. On the other hand, food insecurity is also increased by fluctuating climatic patterns, poor planning, and policy initiatives with 22% of the country's population classified as food insecure and thus dependent on food aid while almost 40% of children under five years are malnourished and stunted. Food insecurity showed a decrease after the El-Nino drought in 2016 (from 25% in 2016 to 14% in 2018) but then increased again to 22% in 2019. Estimates for June to September 2022 indicated that 16% of the population will be facing acute food insecurity (VAC, 2022), with 11% of rural households facing severe hunger. Shiselweni has the highest proportion of households facing severe hunger (15%).

A safe and sustainable supply of water supply is essential during and following climate events such as heat waves and flooding, which can also significantly increase the risk of diseases such as cholera, typhoid, and schistosomiasis (VAC, 2022). Lubuli, Sigwe, Somntongo, and Hlane had the highest proportion of households that take above an hour to travel to a water source (CSO, 2017).

Children are especially at risk, with more than half of all children younger than 17 years in Eswatini classified as orphaned or vulnerable (OVC), with Sandleni having the highest proportion of children under 18 years that have lost both parents.

Climate-driven diseases in Eswatini include malaria and neglected tropical diseases. Malaria was found to be high in the northern and eastern areas of Hhohho and Lubombo districts, with the populated and low-lying areas of Manzini and Shiselweni districts also affected (Dlamini, 2021). Malaria cases peak in January due to imported cases, and from September to December due to local cases (Nkya et al. 2021 in Dlamini, 2021). External travel, specifically to Mozambique, has been found to be the primary risk factor for malaria infection in Eswatini (Tejedor-Garavito et al. 2017 in Dlamini, 2021). The livelihood zone at highest risk is in the Lubombo Plateau, followed by peri-urban and urban areas, with less risk in parks, reserves, and sugarcane areas. Neglected tropical diseases such as bilharzia (schistosomiasis) and intestinal worms have also been increasing. In addition, the Neglected Tropical Diseases (NTD) sector has not been prioritised, resulting in an increase of these diseases as well as other challenges such as weak coordination mechanisms for NTDs control program and a lack of strong partnership for the control, elimination, and eradication of targeted NTDs in the country (NHSSP, 2019).

Neuropsychiatric conditions, which rank high, contribute to the mental health burden. Mental health is an important health concern in Eswatini in the context of climate change, with pre-existing mental health conditions both contributing to climate vulnerability and manifesting as an impact

due to climate change. There is a disproportional distribution of mental health services particularly between urban and rural settings. In response, the country has a draft Mental Health Policy which was developed through an extensive consultation process with relevant stakeholders. However, it has remained a draft since 2013 (NHSSP, 2019).

The relative distribution of social vulnerability indicators, used in the most recent census, indicates that Mpolonjeni, Ngudzeni, and Sigwe had the highest number of indicators in the high vulnerability range, followed by Mkhiweni and Shiselweni. In Shiselweni, the proportion of the population that are living below the poverty line has seen an increase, also having the most female-headed households and a household size above the national urban average. This region also has the highest proportion of disabled households. Although the overall dependency ratio has decreased, Madlangampisi in the north and several Tinkhundla in the south and east of the country have a relatively high dependency ratio.

Although the number of healthcare facilities in the country has doubled (from 154 to 327) between 2010 and 2017 these are still concentrated in the urban areas. The quality of healthcare may also contribute to the vulnerability of the health sector to climate change impacts. The National Health Sector Strategic Plan (2019-2023) identified several such factors putting pressure on the health sector which can increase its vulnerability to climate change.

In terms of health financing, it has been recorded that available resource-use and allocation are inefficient and inequitable, with expenditure biased towards curative rather than preventative services.

There is a lack of guiding documents for planning and prioritizing the setting of new health facilities considering factors such as proximity to waterbodies, and accessibility of water and access roads. Water, sanitation, and hygiene at health facilities remain a challenge, with low access to clean drinking water especially problematic. Water and sanitation related diseases such as faecal-oral diseases are among the top five leading causes of morbidity in the country.

Assessment of health emergency preparedness and response showed that, in 2018, a multi-hazard national public health emergency or health preparedness and response plan had been developed and implemented in 50% of facilities. The capacity of health facilities to activate emergency operations was also at 50% in 2018. In 10% of health facilities, priority public health risks and resources were mapped and used, disaster/emergency preparedness and response plans were in place, and facilities able to handle emergencies.



Health education and awareness of the workforce remains a challenge, including the capacity of the health workforce at clinics to screen for health conditions e.g., NCDs. Other pressures on the ability of the health sector to respond to climate impacts include deteriorating infrastructure, old vehicles that are not optimally maintained (with only 55% of hospitals and health centres that had at least on ambulance with less than 5 years of service in 2019) (NHSSP, 2019).



Deteriorating health infrastructure, inadequate budget, and a chronic shortage of human resources

and skills in the public sector not only impacts on the health system but increases its vulnerability to climate change impacts (Swaziland NTD Plan, 2015-2020). These elements all contribute to the ability of the health sector to respond adequately during climate disasters.

4.1.3.2.6 MATRIX OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE HEALTH SECTOR

Table 4-10: Climate Hazards, Risks, and Adaptation Options for Health Facilities and Human Health

Health facilities and human health				
	Hazard	Impact	Areas and populations at risk	Adaptation
	Flooding Although annual precipitation is expected to decline, isolated heavy precipitation events leading to flash floods are expected to increase in severity. This is especially expected over the Highveld region.	Facilities: Infrastructure damage, facilities inaccessible, water sources polluted Communities: Direct impacts: Injuries, displacement, loss of crops and livestock (farmers) Indirect impacts: Water-borne diseases, food insecurity	Health facilities in low lying areas: Lubuli: Bholi Clinic Matsanjeni North: St. Phillip's Clinic, Hlane Clinic Siphofaneni: Ndzevane Clinic Nkilongo: Mangweni Clinic Madlangempisi: Mangwaneni Clinic Dvokodweni: Siphofaneni Clinic Sitsatsaweni Nazarene Clinic Homes in low-lying areas, near rivers. Communities: Young children, elderly, those with disabilities	Facilities: Emergency plan to protect patients and health workers, including volunteers to assist in case of emergency, provision of water and electricity, communication Information system for tracking and monitoring diseases after flood events. Training of staff to deal with injuries, occupational hazards during a flood Early warning of potential flood events Natural floodwater infiltration system to reduce risk of facility flooding Appropriately covered water storage tanks to prevent access or contamination, and safety located for flooding events Plan to provide and maintain adequate cleaning and disinfection supplies for water safety
	Extreme day temperatures sharp increases in temperature of between 2°C and 3.5°C for the midterm period (2040-2070), and between 3°C and 5.5°C for the long-term period (2071-2100).	Facilities: Increased need for water Patients experiencing heat-related conditions such as heat stress Elderly, children, disabled and those with co-morbidities are at particular risk Communities: Heat stress, aggravating mental health,	Health facilities: Timpisini: Vuvulane Clinic Sithobela: Tsambokhulu Clinic Lugongolweni: Nkalashane Community Clinic Mhlambanyatsi: Lomahasha Clinic Ndzingeni: Luve Clinic Hlane: Shewula Nazarene Clinic Siteki: Sitsatsaweni	Facilities: Plan to keep the facility environment cool Adequate roof and wall insulation; sufficient ventilation trees and leafy plants near windows natural cooling Coordinated plan with other stakeholders including government, NGOs, faith-based organisations Adequate water supply, including covered water tanks

		cardiovascular health impacts	Nazarene Clinic Community health: Children – also in schools People with disabilities, elderly, outdoor workers, farmers	Plan to identify and protect patients and health workers at risk of heat stress Community health educational programme to improve community health in the face of extreme temperatures
	High nighttime temperatures	Human health: Discomfort, sleep disturbance, aggravation of cardiovascular diseases Elderly, children, disabled and those with co-morbidities are at particular risk	Households in urban, built-up areas in dwellings with insufficient insulation and ventilation.	Awareness and education wrt: insulation and adequate ventilation of homes. -Access to clean drinking and cooling water
	Drought or dry spells Annual precipitation is expected to decline while a strong increase in temperature is expected under future climate conditions (2050-2100 climate), causing an increase in the frequency of droughts.	Health facilities and communities: Decrease in available water, resulting in less availability of water and sanitary services, which might lead to the increase of diseases like cholera Indirect: Loss of crops and livestock, food insecurity, malnutrition	Gege: Gege Clinic, Mahlandle Clinic Mhlangatane: Magubheleni Clinic Mkhiweni: Tfokotani Clinic Lubuli: Mashobeni Clinic Piggs Peak: Pigg's Peak Government Hospital Siphofaneni: Bulembu Clinic Mahlangatja: Mahlangatja Clinic	Awareness and education regarding water-wise practices, water quality Plan to coordinate and create awareness including stakeholders e.g., health facilities, government, farmers, schools, NGOs, faith-based organisations etc. Plan to conserve and manage water to reduce water usage Water storage/water harvesting, Exterior shading devices, e.g., trees that mitigate heat and dryness

4.1.3.2.7 ADAPTATION MEASURES HEALTH SECTOR

Adaptive capacity refers to the ability of a system to cope with, adjust, manage damages, and take advantage of opportunities resulting from exposure to climate variability/change. It also includes the ability of a system to reduce exposure to climate hazards (e.g., through the implementation of government programs and policies). Examples of indicators for adaptive capacity include access to financial resources, the distribution and state of health infrastructure (e.g., hospitals, clinics, ambulances), or access to technology (e.g., for cooling purposes).

Although Eswatini has not yet developed a health adaptation strategy for climate change, there are

adaptation measures that have been put forward and can already be implemented (World Bank, 2021). The priority adaptation measures for the health sector are outlined in the TNC and further developed and elaborated in the NDC. Investment in actions that increase the awareness and understanding of the health workforce about the relationship between climate change, vulnerability, and health impacts is an important starting point. This could include training that grows knowledge and skills on the prevention of diseases that are associated with climatic factors and build capacity to ensure mainstreaming of climate change into the national health policy and strategic documents. Ensuring that monitoring and surveillance systems operate at geographical and temporal scale will allow observations of trends and advance forecasts to design appropriate and effective interventions against climate sensitive diseases. These steps could form the basis of developing indicators that can be used to improve the ability of the health sector to respond to climate challenges.

The TNC identified adaptation measures that were already implemented in the health sector, although conceptualised outside the climate change agenda, and further proposed some adaptation actions that could be prioritised going forward. To date, there have been different fora and projects that attempted to refine the adaptation actions to ensure that the sector is taking on board the climate change agenda. These include work done under the NDC revision process and the recent ICAT project.

Table 4-11 summarises and compares the adaptation measures as articulated in the TNC and NDC, and aligns them to the NHSSP 2019-23, as well as track progress on the actions. The NHSSP prioritised some actions for the health sector, and it is important to track whether the priorities have the potential to meet the adaptation ambition in the sector.

Table 4-11: Comparison of adaptation measures identified by the NC3TNC, NDC and some strategies and priorities in the NHSSP 2019-23

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
Build capacity and other institutional and systemic shortcomings that include the health system's severe human resource constraints.	Strengthening capacity of healthcare workers on the adverse impacts of climate change	<ul style="list-style-type: none"> The Epidemiology and Disease Control Unit, as well as the National Health Research and Innovations Department are key role players in building capacity and conducting research, in collaboration with health partners and higher education institutions. There is no coordinated effort to build capacity on climate change within the sector, however, the climate change unite (MTEA) has engaged and involved key officers in the health sector on climate change related trainings and workshops. 	<ul style="list-style-type: none"> Strengthen systems for planning and provision of pre-service and in-service training to ensure quality and needs-based training of health workers. Strengthen delivery of community health services
Strengthen research and (local, regional, and international) knowledge generation on climate change and health impacts relative to Eswatini.	Promoting capacity building through research and development, education and awareness, and training in climate change related issues.	<ul style="list-style-type: none"> Epidemiology and Disease Control Unit conducts research. National Health Research and Innovations Department also facilitates research within the sector 	<ul style="list-style-type: none"> Develop a governance model appropriate to the management of research in the sector. Strengthen and sustain the health research system. Strengthen the use of evidence to inform decision making, policies, guidelines, and interventions
Promote institutional development and inter-sectoral collaboration and cooperation.	Improving and integrating the health management information system with	<ul style="list-style-type: none"> Establishment of the Health Management Information System (HMIS) unit and the Client Management Information System (CMIS) to improve data 	<ul style="list-style-type: none"> Build and maintain a single integrated health information system. Improve data quality, security and use at all levels for policy

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
Adopt an intersectoral and integrated approach, and improve information collection, management and sharing.	other systems from relevant sectors to achieve a centralized MRV system.	collection and capture and thus facilitate the ease and efficiency of data sharing with other relevant sectors.	decision making
Increase focus on women and children due to their socio-economic weaknesses which makes them vulnerable to climate change.	Mainstreaming gender responsive climate policies and emphasize special efforts to support vulnerable groups (women, youth, and children) in climate change adaptation efforts within all sectors of the economy.	<ul style="list-style-type: none"> • There are no specific climate policies that are gender responsive; however, there are efforts by the Ministry of Health to target vulnerable groups e.g., through such programmes as: • The Sexual Reproductive Maternal New-born Child Adolescent Health and Nutrition (SRMNCAH&N), • People living with HIV/AIDS, • School Health Programme, • Integrated Management of Childhood illnesses, • Public Health Programme. 	
Mainstream and embed climate change adaptation into the national health planning processes	Mainstreaming climate change into the national health policy and other strategic documents.	<ul style="list-style-type: none"> • Not mainstreamed yet, however, some ad hoc adaptations are ongoing and implemented as per the NHSSP 2019-2023. • Review cycle of policies and strategies presents an opportunity for mainstreaming adaptation. 	

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
<p>Heat-Health Warning System (HHWS): Develop and design. Strengthen and institutionalize</p> <p>Surveillance (Improved risk-indicator and disease surveillance specific to known climate change related risks and diseases such as Malaria and HIV and AIDS).</p> <p>Early alert systems for impending extreme weather events.</p>	<p>Establishing a multi-hazard early warning system to trigger prompt public health intervention when certain variables exceed a defined threshold.</p>	<ul style="list-style-type: none"> Multi-stakeholder forum for weather forecasting Epidemiology and Disease Control Unit and the National Malaria Control Programme participate in seasonal and monthly meetings for weather forecasting with the National Disaster Management Agency and the Meteorological Services Department (MTEA). National Malaria Control Programme has eight (8) automatic weather stations set up in clinics in the four regions of the country. 	<ul style="list-style-type: none"> Scale up and enhancement of Integrated Disease Surveillance and Response (IDSR) Development of multihazard National public health emergency preparedness and response plan
<p>Disaster preparedness (INGC 2009) and inter-sectoral capacity to deal with the aftermath climate change related extreme weather events.</p>	<p>Strengthening the preparedness and resilience of the health sector to respond to climate related emergencies and illnesses through preparedness plans and programs.</p>	<ul style="list-style-type: none"> Prevention – Motor Vehicle Accident Fund hosts a programme to prevent accidents, raise awareness, and conduct health facility and community preparedness. Response to emergencies – provision and use of 112 national emergency reporting health line. Collaborating with rural health motivators to build emergency preparedness capacity in communities. 	<ul style="list-style-type: none"> Vulnerability and risk analysis and mapping Country preparedness Strengthen multisectoral cooperation and coordination for emergency response

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
Enhanced infectious disease control programmes (vaccines, vector control, case detection and treatment). Community-based neighbourhood support/watch schemes (e.g., for elderly, children).	Improving basic public health programmes that address vulnerability to climate change induced infections/ Strengthening climate-informed disease control programs	<ul style="list-style-type: none"> • There are several programmes addressing impacts of climate change on health but mainly responsive and include, among others: • National Malaria Control Programme • Neglected Tropical Disease Programme • Epidemiology and Disease Control Unit • Environmental Health Programme • National Nutrition Council (Nutrition Programme) • Eswatini Antivenom Foundation. 	<ul style="list-style-type: none"> • Different strategic priorities for the different programmes are articulated in the NHSSP 2019-23 • Build a robust, integrated, and reliable surveillance system. • Strengthen epidemiological surveillance capacity. • Timely response to events of public health concern and emergencies. • Accelerate efforts towards environmental and vector control, and Harness Research and Innovations towards the attainment of NTD-free status.
Awareness raising: Inform, educate, and empower the public, policymakers, and other stakeholders about health risks of climate change	Educating and informing the public of the needed measures to protect health from the adverse impacts of climate change.	<ul style="list-style-type: none"> • No climate change education to the public yet but the Health Promotion Unit presents education opportunities in various platforms such as the national radio and these could be used to educate the public on climate change. 	
	Adopting sustainable climate smart technologies to enhance the resilience of health care facilities to the adverse effects of climate change.	<ul style="list-style-type: none"> • Provision of a sustainable water supply is currently being undertaken through Microprojects funding where boreholes are installed in rural clinics to ensure safe and reliable water supply. • A World Bank-funded project is being implemented by the health sector and includes utilisation of energy efficient and sustainable technologies to improve service delivery in health facilities. 	

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
	Promoting environmentally friendly waste management practices.	<ul style="list-style-type: none"> • A few programmes are designed to promote environmentally friendly waste management practices such as: • Open Defecation Free Project 2016. • Waste and livelihoods project implemented by UNDP. • Project to develop National Integrated Waste Management Pollution Prevention and Control Policy. 	<ul style="list-style-type: none"> • Accelerate sanitation and hygiene coverage through participatory approaches. • Ensure and maintain environmental integrity and safe working environment in health facilities
	Developing resilient / climate proof WASH infrastructure	<ul style="list-style-type: none"> • At present, 65 % of the population use improved sources for drinking water, meaning that the water is piped water, tube well/ borehole, protected well, protected spring, and rainwater harvesting. • A few projects are ongoing to address the WASH. • World Vision WASH programme which has improved access to clean water and basic sanitation facilities. • Environmental Health Programme and UNICEF implementing the Open Defecation Free Project since 2016 to ensure that every household has and uses a toilet by 2023. 	

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
		<ul style="list-style-type: none"> • National Sanitation and Hygiene Policy 2019 • Waste and livelihoods project implemented by UNDP. • Project to develop National Integrated Waste Management Pollution Prevention and Control Policy. • A national WASH financing study conducted by ESARO in 2019 resulted in the development of a budget brief to assist in influencing planning and advocacy activities to support more effective allocation and coordination of WASH services funded by government ministries, donors and other financiers engaged in delivering, operating, and maintaining WASH services. 	
	Financing health actions to address inequities and climate related vulnerabilities	<ul style="list-style-type: none"> • The Health System Strengthening for Human Capital Development in Eswatini Project, 2020 is providing finance for the health sector to address inequities and some climate related vulnerabilities. • The Eswatini COVID-19 Emergency Response Project, also funded by the World Bank, is providing funding to Ministry of Health to strengthen the country's national systems for public health preparedness. 	

Adaptation measures from TNC	Adaptation measures from NDC	Progress /status of action	Some strategies and priority interventions for emergencies (NHSSP 2019-23)
		<ul style="list-style-type: none"> • End Malaria Fund 2019. 	

4.1.3.2.8 PRIORITISED ADAPTATION ACTIONS FOR HEALTH SECTOR

The vulnerability of human health to climate change is aggravated by its linkages with the other sectors, and an understanding of these linkages is essential to use the co-benefits of adaptive actions and mitigation initiatives in other sectors to improve human wellbeing and health. However, in-country research to understand the linkage between human health and climate change is limited and, therefore, it is essential that the country focuses on research as well as closing the gaps that are already apparent when looking at where the health sector is going strategically, and the ambitions set out in the NDC. This means that one of the key actions to focus on is implementing the adaptation measures identified in the updated NDC and their clear articulation in the overall health country strategy. True community health resilience in the face of large-scale changes such as climate change is built on functioning health care systems and capabilities that support physically, mentally, and socially healthy individuals and communities (Wulff et al., 2015).

Some specific actions may include:

- Prioritise the most vulnerable households in terms of immediate humanitarian assistance (VAC, 2022).
- Strengthen the protection of livelihoods through innovative and cost-effective ways to improve food diversification, e.g., through small-scale backyard gardens, accompanied by increasing nutrition awareness among households' members (VAC, 2022).
- Increase the proportion of public facilities that can provide both diagnosis and treatment of malaria, e.g., by facilitating PHU to begin offering RDTs and first-line malaria treatment options for the disease; establishment of a constant supply of antimalarial drugs at all public and, if possible, private not-for-profit facilities by the Malaria Control Program; increasing the number of trained staff and availability of guidelines at the health facilities to improve their

readiness to provide malaria services (WHO-SARA, 2019); and improving community health outreach initiatives.

- Strengthen the health system to improve its preparedness, surveillance, and response on emerging pandemics (VAC, 2022) through:
 - the delivery of decentralized health care services;
 - pursuing public-private partnerships as a mechanism for providing some services in which the private sector has a comparative advantage over the public sector;
 - a properly maintained database of extreme weather losses from past events in the region and/or by facility;
- involvement of frontline workers in the development of plans and responses, and participation in local and regional initiatives around mitigation and adaptation including the development and communication, as well as practice of emergency procedures such as evacuations, ensuring continuity of communication, energy systems and water supply;
 - Rigorous measuring and monitoring of the specific indicators set to significantly improve the capacity of health facilities to handle health emergencies (NHSSP, 2019).

Gender and inclusion principles should be incorporated into all these actions (VAC, 2022).

The MoH participates in a Multi-Hazard Early Warning System forum which has been introduced (Ministry of Economic Planning and Development, 2019). Overall, education, awareness-raising on climate change mitigation, adaptation, impact reduction, and early warning should be actioned by the health sector.

4.1.3.2.9 DIFFICULTIES AND BARRIERS TO, AND ASSOCIATED NEEDS FOR ADAPTATION FOR THE HEALTH SECTOR

Needs stemming from the gaps and challenges associated with climate risk assessment in the country (Mhlanga-Ndlovu and Mhlanga, 2019 in Dlamini, 2021) include:

- Acquisition and further development of equipment, skills, information, knowledge, and local capacity as well as baseline information to model, analyse or interpret climate impacts. Mechanisms for information access, management,

and dissemination.

- Awareness and understanding, human and technological capacity for developing and implementing the NAP, including the benefits of having the NAP.
- Improvement and enhancement of the adaptation prioritization process in the country.
- Increased capacity of the coordinating institution.
- Improvement of the institutional and technical capacity for the different thematic areas of the national communication.
- Linked and cross-referenced existing climate change adaptation data across various organisations to reduce data fragmentation.
- Capitalisation on the desire across institutions to develop a clear database with clear data sharing protocols to optimise the use of (currently limited) climate projection data for planning purposes.
- Improved standards and establishment of a permanent institutional framework to improve reporting requirements and sustainable and quality reporting.
- Climate change forecasts to inform local climate change adaptation strategies including farming system option selection.
- Adequate Early Warning information.
- Long-term investment in research, development, and innovation including research on vulnerability and adaptation to build capacity.
- Financing strategy for research and development created in partnership with all stakeholders to ensure sustainable funding and technological support for climate change research.
- Available trend of disease/ pest outbreaks due to climate variations.
- An accurate and improved drought forecasting system to enable the country to plan for persistent drought episodes that result in mass starvation and negative impact on the economic performance of the country.
- Capacity building in data analysis, management, information sharing, and climate research and modelling.

- Down-scaled global and regional models to the national and local context to improve understanding of climate knowledge.
- For malaria, improving community health outreach initiatives; increasing the proportion of public facilities that can provide both diagnosis and treatment of malaria, e.g., by facilitating PHU to begin offering RDTs and first-line malaria treatment options for the disease; ensuring a constant supply of antimalarial drugs at all public and, if possible, private not-for-profit facilities by the Malaria Control Program; increasing the number of trained staff and availability of guidelines at the health facilities to improve their readiness to provide malaria services (WHO-SARA, 2019).
- In addressing the burden of communicable and non-communicable diseases, reduce prevalence and incidence in morbidity and mortality through expanding responsive and client-centred services; improved diagnostic capacity; controlling of risk factors; and scaling up of preventive efforts related to life-style interventions (NHSSP, 2019).
- Empowerment of community health workers (e.g., rural health motivators) (Walker et al., 2020), through:
 - Training and supervision for activities,
 - Managing of community expectations beyond formally endorsed tasks,
 - Promoting increased health-seeking behaviour of men, and their acceptance of health messages by men.

4.1.3.3 TOURISM

4.1.3.3.1 TOURISM AND CHANGES IN THE CLIMATE SYSTEM

Evidence of shifts in the climate and the associated extremes in Eswatini already exist (World Bank, 2021; Government of Eswatini, 2016). Detrimental climate change due to these shifts have impacted on the tourism sector over recent years. For instance, the 2015-2016 drought period resulted in the implementation of water restriction measures affecting the occupancy of tourists in accommodation facilities. Overall, a significant decline of over 10 500 international tourists was observed during the drought period (TNC, 2021). With future potential impacts of climate change in the sector, socio-economic implications, and shocks both in Eswatini and globally are of greater concern; hence, the importance of accelerated adaptation strategies coupled with better marketing and advertising strategies.

The international tourist arrivals trend per month in Figure 4-22 shows that (prior to COVID-19 restrictions) Eswatini received its highest visitations during the summer season especially in January and December, ranging between 141-525 in December and 127-540 visitations in January. The peak visit during these months is supported by several factors including school holidays, the festive season and, most importantly, the hot Eswatini summers that easily accommodate the vast outdoor recreational activities in the tourism sector. According to the Eswatini Tourism Research Annual Report (2021), only 0.3% of the visitors complained about the weather in Eswatini, while 0.1% complimented the nice weather conditions. With future potential climate change impacts, tourist arrivals in Eswatini as well as their perceptions of the weather conditions during their stay are highly likely to change for the worst.

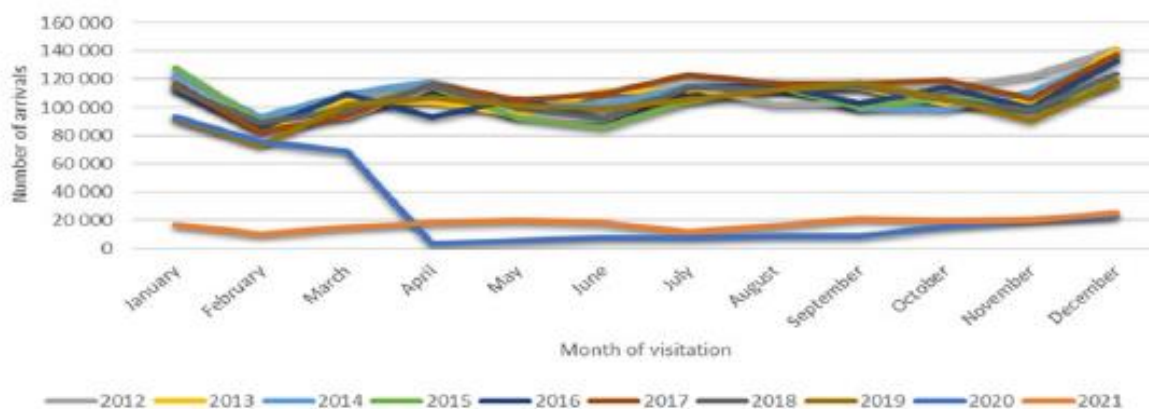


Figure 4-22: Trend of Eswatini international tourist visitations by month between 2012 and 2021.

4.1.3.3.2 POLICIES, STRATEGIES AND LEGAL FRAMEWORKS FOR TOURISM SECTOR

The government of Eswatini recognises and acknowledges tourism as a crucial engine for economic recovery and national development, as well as the global and regional importance of tourism in the attainment of the SDG 8. This is reflected in the 2019-2022 Strategic Roadmap and National Tourism Policy (2019). In this regard, the Government of Eswatini has declared Tourism as one of the five pillars to drive economic growth over the next 5 years ending 2023 as outlined in the Kingdom of Eswatini's 2019-2022 Strategic Roadmap, and is part of Priority 1: 'The ease of doing businesses'. The first National Tourism Strategy was adopted in 1999 and revised in 2011, and the first National Tourism Policy was adopted in 2000 and revised in 2010. The country's National Tourism Policy of 2019 recognizes tourism as a priority economic activity that has the potential to sustainably contribute to national development.

The tourism industry is largely based on the unique biodiversity of the country. A majority of the Eswatini population depends on biodiversity for a variety of practical uses including food, traditional medicine, fuelwood, and cultural ceremonies (UNDP, 2012). For this reason, the natural environment, rural landscapes, and livelihoods are interlinked forming a significant component of the country's tourism industry (Du-Pont and Sacolo, 2019). Scaling up actions and investments in

ecological infrastructure will translate to socio-economic benefits by safeguarding the livelihoods of communities relying on farming and tourism for income. Development policies such as the Strategy for Sustainable Development and Inclusive Growth (SSDIG) (2017) have prioritised rural development and broad-based participation in economic growth. The Eswatini Tourism Authority (ETA) commissioned marketing and product development strategies (2013) through the Commonwealth Secretariat (Chaitoo and McGinn, 2022).

The Second National Biodiversity Strategy and National Plan (2016) advocates for strategic measures to reduce direct pressures on biodiversity by controlling pollution, and prescribes conservation of land that provides essential ecosystem service. This plan supports measures such as reducing pressures driving biodiversity loss (e.g., deforestation, human settlements) to improve carbon sinks and promote eco-tourism. The Ministry of Agriculture's Strategic Plan 2018-2023 also promotes sustainable management of grazing land.

Policies such as the Post COVID-19 Economic Recovery Plan (2020-2022) prioritise the agriculture, tourism, and environment in its plan and aims to assess impacts and identify ways to integrate climate change into Eswatini's economic recovery plan within the context of the national development planning and budgeting process.

4.1.3.3 VULNERABILITY AND RISK ASSESSMENT FOR TOURISM SECTOR

The Eswatini tourism sector exposure to climate change was analysed by looking at spatial and temporal datasets (<https://data.humdata.org/dataset/geoboundaries-admin-boundaries-for-kingdom-of-eswatini>). Protected areas shapefiles were accessed from Explore the World's Protected Areas (protectedplanet.net). Raw agro-ecological zones data was received from the Eswatini team which were then classified in accordance with Remmelzwaal (1993). Most of the temporal datasets were acquired through integrating recent Eswatini Tourism Research Annual Reports (i.e., ETA, 2017; 2018; 2019; 2020; and 2021) which consist of statistical datasets collected by the Eswatini Tourism Authority (ETA). Tourism statistics (i.e., number of tourist visitations per country, entry port, year or month, etc.) were collected from 2015 to 2021. The reports and other datasets were accessed from <https://www.thekingdomofeswatini.com/eta-resources/research/>. More temporal data including the number of accommodation facilities, restaurants, tour operators, travel agencies and tour guides, transport providers, different types of attractions and activities, as well as annual events were accessed from the Eswatini Development of a Strategy for Sustainable Tourism draft report by the Chaitoo and McGinn (2022).

The Eswatini tourist website (<https://www.thekingdomofeswatini.com/>) and the Eswatini National Trust Commission (<http://eswatininaturereserves.com/>) were used as key sources of information in getting about specific locations of the attraction's key cultural activities, as well as lists of all documented accommodation facilities. The lists were then reconciled with those that were recently populated by Chaitoo and McGinn (2022) which provided an additional 135 accommodation establishments (resulting in a total of 236 facilities). To allow for development of GIS spatial overlays of climate information and the impacted activities and attractions, Google-Maps were used to spatialize attractions and tourism facilities locations. About 82 tourism attractions and activities were

recorded, and 101 accommodation facilities were mapped. The tourist attractions and activities cover the following categories: adventure, agriculture, arts and craft, care centre, commercial, community tourism, conservancy, culture, health, leisure, nature reserve, religion, scenery, school, sport, travel, volunteering, and wildlife.

Matrices considered for the respective elements of vulnerability analysis were informed by an approach by Alvaro and Sasanne (2008). For the sensitivity factor, the physical characteristics (or geographical location of tourism attraction and activities), tourism perceptions, and the condition of infrastructure are investigated. Based on a literature survey and expert knowledge, the impacts of heat and wet extremes, the origin of tourists, and perceptions are studied to evaluate national and regional sensitivity levels. The capacity of the Eswatini Tourism sector to adapt to climate change focused on management capacity and institution support. In the case of management capacity, ownership of establishments was used to make inferences on financing access and marketing. Institution support for operation early warning systems' access by all communities in the tourist industry informed the analysis of coping capacity.

The climate model outputs covering hindcast and projections of temperature and precipitation informed climate hazards for the infrastructure sector. Hot days, hot nights, and the highest five-day precipitation amount were used as proxies for assessing changes in tourism sector temperature hazards during the baseline (1971-2000) and future (2011-2040) periods. These changes were determined under a low mitigation scenario for six climate models, with the median of these models being used to reflect the ensemble central spatial pattern.

Exposure analysis focused on local infrastructure that supports tourism such as local ports of entry, transport, water, and energy infrastructure. To inform the tourism population's exposure to the extremes, geospatial overlays of the frequency of tourists visits per year were plotted against the frequency of temperature extremes. The game and nature reserve locations were used to understand the exposure of biodiversity locations against the projected precipitation and temperature extremes. Expert judgement and perception gathered through questionnaires circulated to targeted stakeholders are used in conjunction with collected data exposure, hazards, sensitivity, and capacity evidence to conclude on the levels of vulnerability over the respective elements of the tourism sectors' value chain.

The diagram below (Figure 4-23) captures and summarises the different focus areas that were used to measure vulnerability to climate change over the Eswatini Tourism sector. Risk is calculated by considering hazard, exposure, and vulnerability. The study assessed vulnerability for various elements of the sector, in the face of specific climate hazards, by looking at the levels of sensitivity and adaptive capacity. Sensitivity analysis is informed by the degree of protected areas and type, and status of tourism supporting infrastructure. Similarly, the tourism sector's adaptive capacity was looked at, focusing on management areas, technology, etc. Some data gaps existed on whether some tourism facilities are privately or government owned. Data and information gaps also existed when it comes to the management of visitors, carrying capacity of land, conservation protection projects, education, and climate awareness of the hospitality industry workforce. The study also focused on climate hazards exposures on tourism sector infrastructure, population, and the specific

attractions. Measures of vulnerability in summary looked at the types of hazards that influence the tourism sector, their intensity and frequency, locations of attractions, and facilities.

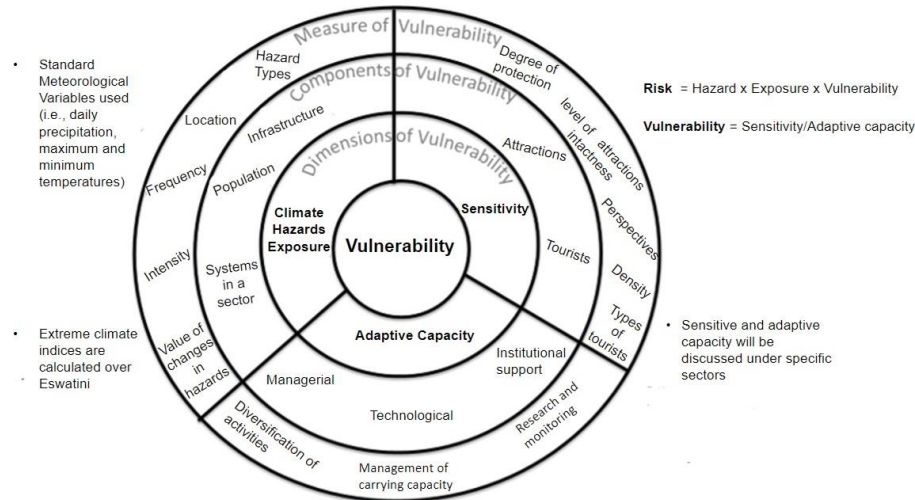


Figure 4-23: Diagram showing the methodology used for the vulnerability and risk assessment.

The travel and tourism sector plays a significant role in the socio-economic development of a country and has the potential to lead to the United Nations Sustainable Development Goals (UNE, 2022). Because of the sector's connection to the environment, tourism is on a similar footing to agriculture, transportation, and energy in its climate-sensitivity and, hence, vulnerability. While climate is an important resource for the sector, it is also a driving vulnerability as it determines operating costs such as cooling-heating, water supply, and insurance costs.

The projected changes in the climate system have huge potential for exposing the sector to the physical climate hazards associated with climate change. The model outputs suggest that the country is prone to hydrological extremes such as droughts and rainfall extremes that lead to floods, as well as extreme temperatures that often lead to heatwaves and wildfires. Drought stands as one of the high pathways for declines in biodiversity/ game sightings at nature/game reserves, and water scarcity. Prolonged drought leads to water restrictions at accommodation facilities (i.e., hotels, guest houses etc.). Exposure to extreme rainfall associated with occurrence of tropical cyclones and storms could negatively drive perceptions around safety, thereby elevating the sensitivity of the sector to climate change. These exposure and sensitivity factors will cause a general decline in tourist arrivals in general. Riparian zones, disturbed by flooding, are also vulnerable to invasion by alien plants (Dlamini, 2021). These plants can form impenetrable undergrowth that can hinder cultural activities such as recreational vehicle use and enjoyment of the bush, and obstruct waterways which may result in destruction of fish spots and increase the risk of drowning (Dlamini, 2021). It can also reduce the aesthetic value of an area.

4.1.3.3.3.1 HOSPITALITY INDUSTRY AND TOUR TRANSPORT OPERATORS

According to the Tourism Research Report (2017), most tourists visit Eswatini for outdoor activities specifically cultural (45%), adventure (44%), wildlife (37%), shopping (34%) and hiking (18%). The

vulnerability of the tourism sector under increasing temperatures is largely because tourism in Eswatini is dominated by the travel type of tourism and outdoor type of tourism activities.

With increasing temperatures over Eswatini, the dry spells are also projected to increase Figure 4-24. Droughts over Southern Africa are often accompanied by heat extremes in the form of heatwaves. Under the projected extremes, the tourism sector in the country is anticipated, for most parts of the country, to range between 2.4-4°C. Looking at the plot of change in maximum temperature displayed in (Figure 4-25), the most-visited districts (within the Highveld and Upper Middleveld) and towns (over the Highveld and north-eastern Lowveld) are likely to experience the highest increases in daytime temperatures. Notably the most-frequently visited towns in Eswatini already on average experience above 15 days of hot days in which daytime temperatures go above 90 percentile of temperature distribution for the 1961 -1990 baseline period. With warming in the climate over Eswatini, there is a projected increase in frequency of warm nights, which is likely to increase discomfort (Figure 4-26).

Looking at the existing shortfall in water supply in Eswatini in the context of the potential increase in local and tourism population growth, there will be significant impacts on water security across the country. For areas such as Mbabane and Manzini, which are the most populated, the growth of the tourism industry under climate change conditions is likely to push the existing facilities, which are already operated at full capacity, to their limits of risk and increased vulnerability. The projected heavy rains depicted in (Figure 4-27) in the western high-rainfall areas near major rivers and waterways are likely to negatively impact the integrity of roads. These heavy rains may cause damage and floods, leading to major delays and interruption or even inaccessibility of key attractions and sights.

4.1.3.3.2 CULTURAL EVENTS

As per the calendar of sports and cultural events in Eswatini, Umhlanga or the Reed Dance ceremony takes place in August or early September, while the 6-day Incwala or Kingship Ceremony takes place in December. During these periods, the main climate stressor of tourism-related cultural ceremonies are extreme temperature events like heatwaves and intense storms. The vulnerability of cultural ceremonies could be looked at from the adaptive capacity of responsible agencies, customer diversity for businesses dependent on the events, and community sensitivity to the impacts of climate change. Cultural ceremony-based tourism for local, national, and international participants relies heavily on transport and accommodation infrastructure; and its capacity to adapt to climate change ties to the economic status of the country. The outdoor nature and the range of cultural attire used during the ceremonies drive sensitive health hazards in the case of both precipitation and heat extremes. In Eswatini, tourism stands a chance to diversify by including creative arts and indoor activities to benefit the investment and businesses dependent on tourism, thereby reducing their vulnerability to projected changes in climate patterns.

During these periods (2041-2070, 2071-2100) the main climate stressor of the cultural ceremonies associated with tourism are extreme temperature events such as heatwaves and intense storms (Figure 4-24 and Figure 4-26). Changes in the intensity of the key climate stressors stand a chance to directly impact local, domestic visitors, and international tourists separately. Projected changes in

the stressors have both cultural, social, health(safety), and economic implications.

The cultural impacts will be felt in connection with the timing or even duration of the events in the face of an early onset of extremes or interruption of a series of events during the ceremonies. A coincidence of each of the ceremonies with the climate extremes could easily limit the effectiveness of social connections and unity-building targeted among the participating youth and adult population. The health and safety impacts on account of the projected increase in direct exposure to climate extremes, such as heat waves, or degradation of infrastructure from heavy rains leading to increasing likelihood of accidents especially in the case of damaged road infrastructure, are a major concern.

The economic impact will directly be felt by day-by-day tourism operations, multiday tourism trips, and accommodation facility operators. This could be in the form of increased maintenance costs on vehicles, and costs of cooling in the case of resorts. Natives in Eswatini's rural areas produce multiple cultural handicrafts and attire which are bought by tourists at markets and during cultural events. In return, the business contributes to income that supports livelihoods predominantly among poor community members (Masarirambi et al., 2010). The endangerment and extinction of raw materials due to climate change will thus impact the tourism sector revenue generation.

4.1.3.3.3 HERITAGE SITES

Eswatini is home to some of the climate-sensitive rock-art sites, namely the Nsangwini Cave paintings, Rock Art and wildebeest sites, Prince Fanyana memorial library, Khambi's Stone, and Lion Cavern. Heritage assets, such as rock art, are exposed to changes in humidity and temperature. Rock exposed variation in the atmospheric conditions and living beings are at risk of chemical, physical, and biological processes acting on the rock art inducing rapid degradation (Vasco, 2010). Globally, heritage sites are at risk of accelerated degradation due to climate change. Warming temperatures and shifts in rainfall patterns have been one of the key climate stressors of indigenous rock art in Australia in particular (Green et al., 2010).

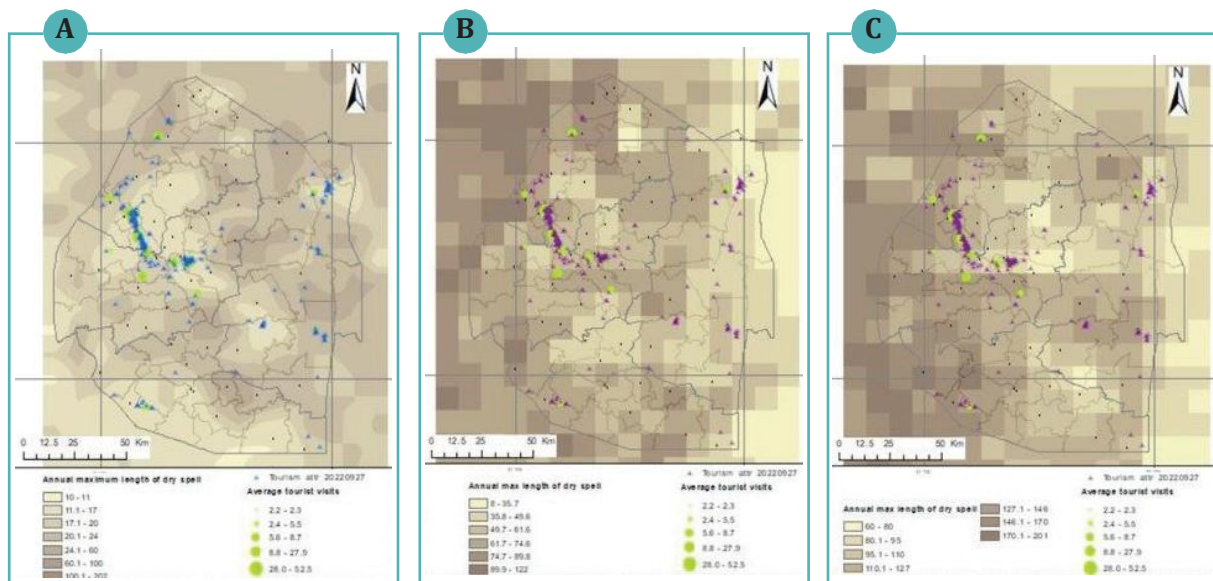


Figure 4-24: Most visited towns and tourism attractions plotted against, a) the baseline

(1961-1990) and, projected b and c) (2041-2070 and 2071-2100) dry spells

The projected increase in intense rainfall in the form of thunderstorms and elevated temperatures will accelerate the physio-chemical weathering of rock art at a risk of devaluation of rock art and other heritage assets.

4.1.3.3.4 NATURE RESERVES AND GAME RESERVES

Nature tourism is dependent on the local population and the supporting ecological infrastructure, and it is attractive by virtue of its ability to get people in contact with nature. Wildlife experience in a natural environment inherently necessitates that people get exposed to daytime heat, humidity, precipitation, or solar radiation. Hamilton (2003) found that wet days above 11.5 per month lead to a decline in tourism. According to a survey by Hamilton (2003), the optimal temperature for the German tourist market is 24°C, above which tourism both local and international drops. Related studies conducted in the United Kingdom (UK) (Maddison, 2001) and Netherlands (Wietz and Tol, 2002) established nature tourism optimal temperatures of 29°C and 21°C for travellers for the respective countries. Figure 4-25 and Figure 4-26 reflect a high frequency of hot days and warm nights.

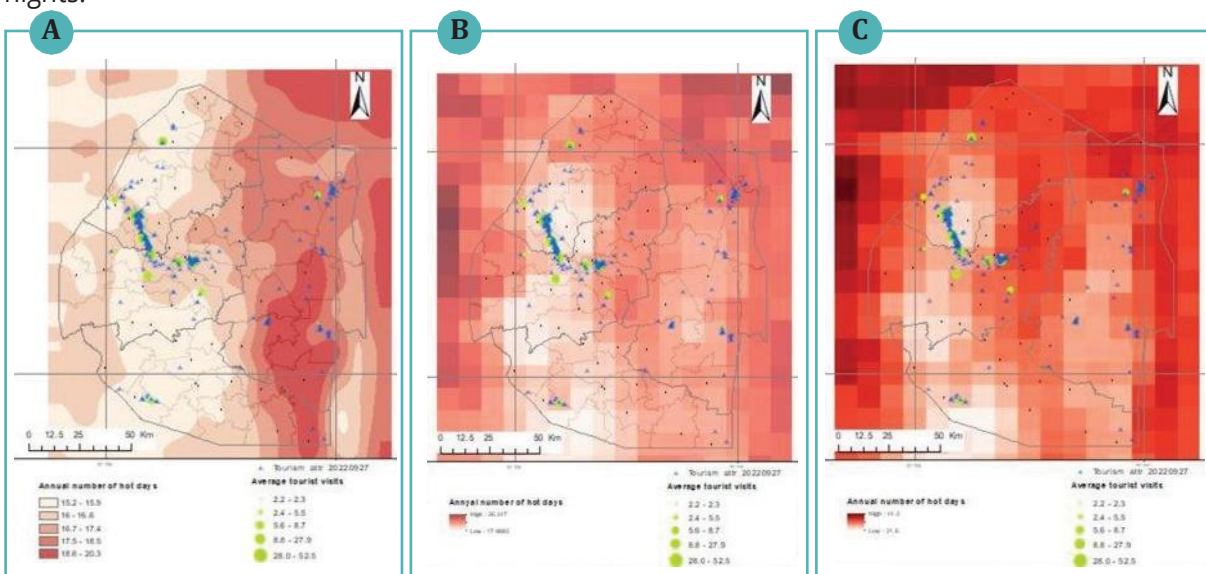


Figure 4-25: Most visited towns and tourism attractions plotted against annual percentage of hot days for a) the baseline (1961-1990) and projected change in b) 2041-2070 and c) 2071-2100).

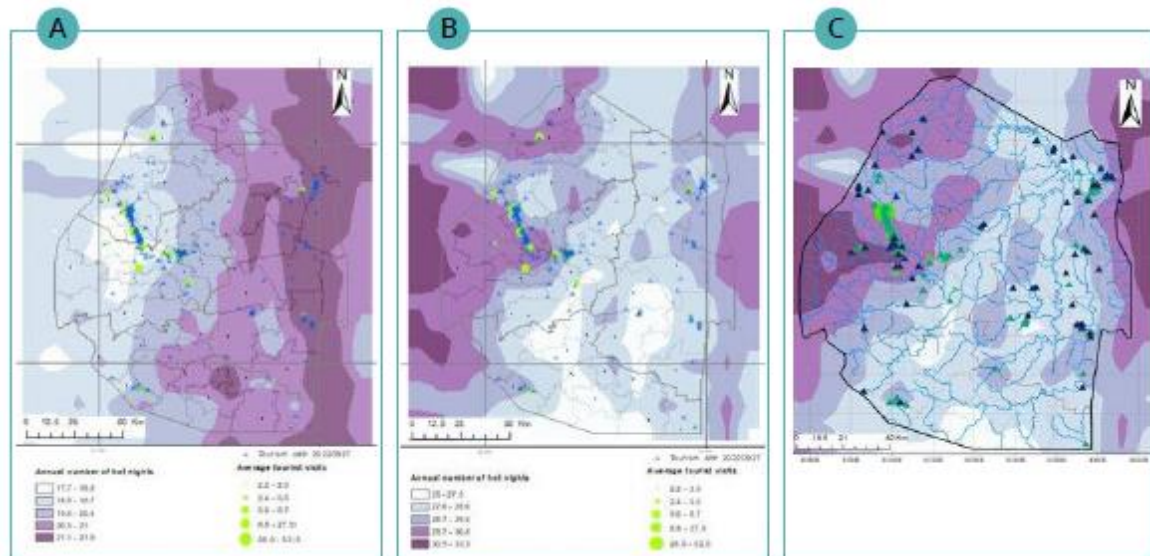


Figure 4-26: Most visited towns and tourism attractions plotted against the annual percentage of warm nights for, a) the baseline (1961-1990) and projected anomalies of b) 2041-2070 and c) 2071-2100).

Some of the extremes, such as tropical storms, will lead to impacts on electricity generation through damage to power cables and affect the power supply. This will have a significant impact on tourist experiences, especially for reserves with accommodation.

When it comes to nature tourism, hot days are a major concern for health and safety. Heatwaves may adversely affect employees, animals, and tourists. The associated heat will increase the evaporation rates and lead to the loss of some animal and bird species. Moagi et al. (2021) report that when temperatures are between 35°C and 40°C, birds reduce foraging efficiency, body weight, and breeding success. The risk of poor breeding of animal and bird species presents a threat of ecosystem imbalance and, hence, the sustainability of nature and game reserves. An increase in extremely hot weather has the potential to cause sleepless nights among employees, presenting the risk of poor productivity and degradation of working morale. High daytime temperatures also affect wild animal sighting, as temperature sensitive animals avoid the heat exposure by hiding under shrubs and trees. In Zimbabwe, a study on nature tourism at Hwange National Park found that tourists get temperamental during extremely hot days, while the demand for air conditioning increases (Mushawemhuka et al., 2018).

For Eswatini, an increase in temperature is likely to increase the sensitivity of the tourism sector once the optimal temperature for non-local travellers is reached. The tourists, local population, and the supporting ecological infrastructure stand a chance to get directly exposed. This will come through changes in the tourists' perceptions of the destination's weather and climate. The change in perceptions will directly lead to either a reduced tourist population, frequency, or duration of visits, particularly during the summer season.

4.1.3.3.3.5 SPORTS AND ADVENTURE

Options for sporting in Eswatini include hiking, golf, mountain climbing, and trail running. According to the Tourism Research Report of 2017, sports attract less tourism compared to nature tourism.

The sector has potential for growth if given sufficient investment. As a result, sports tourism could potentially lead to exposure of people to the projected climate extremes. The climate health risks associated with sports tourism are the same as those of the health sector, but are assessed from a tourism specific context. In the case of sports tourism, the vulnerable groups are not necessarily dominated by the elderly, youth, or people with co-morbidities. The vulnerable groups in tourism may include all sports and physically active age groups.

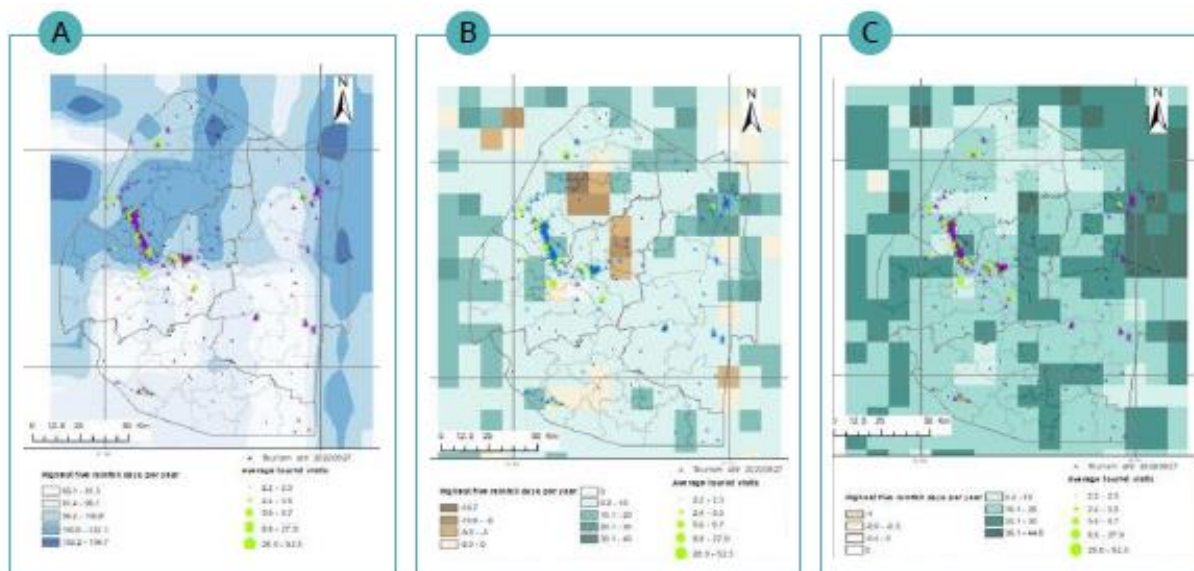


Figure 4-27: Most visited towns and tourism attractions plotted against, a) the baseline (1961-1990) and, b and c) projected (2041-2070 and 2071-2100) extreme precipitation.

Overall, the likelihood and eagerness of tourists to visit and part-take in the different and exciting outdoor activities such as hiking, rafting, the road runs, water rafting, etc. during these future potential extreme conditions would be accompanied by risk from physical climate hazards for tourists and service providers in the tourism sectors. In particular, the projected increase in very hot days, ultraviolet radiation, and heatwave days is likely to impact sports tourism by increasing sports-specific risks. Heatwaves could lead to incidences of heat stress, hyperthermia (including heat stroke, heat collapses), and skin diseases. When it comes to mountain hiking, tourism could be impacted by lightning strikes associated with convective rainfall and storms (Figure 4-27). During drought years, a decline in potable water may impact tourism through the proliferation of water and food-borne infections and other health risks associated with climate change. The projected southwards migration of the tropical cyclones will potentially damage and destroy road infrastructure, thus making it difficult to access tourist destinations, especially in more remote areas where there are gravel roads.

4.1.3.3.4 ADAPTATION MEASURES FOR TOURISM SECTOR

4.1.3.3.4.1 HOSPITALITY INDUSTRY AND TOUR TRANSPORT OPERATORS

The adaptive capacity of the sub-sector is relatively high as key attractions are owned by

government and private investors with relatively high potential for access to financing. Presently, the adaptive capacity is bolstered by the existence of an early warning system as implemented and supported by the National Meteorological Service. However, the impacts of the projected extremes in temperature and precipitation extremes necessitate the improvement of the uptake of early warning information and the operationalization of evacuation drills. Optimization of the adherence to the safety standards by all tourism operators in partnership with the relevant authorities such as the National Disaster Management Agency is crucial for the sustenance of the sector against the projected changes. It is important that tourism operators have access to finance to maintain safe working conditions for the local workforce and tourists under extreme temperature conditions. This could be achieved through heatproofing of tourism hospitality infrastructure, improved perception management (through targeted advertising), and strengthened employee capacity to run business under warming conditions. In the case of tropical storms, the establishment of government-operated calamity insurance may bolster the resilience of investors in the tourism industry. In summary, implementation of the adaptation interventions for built infrastructure will positively impact the tourism hospitality industry as well as the tour transport operators, thereby improving the resilience in the sector.

4.1.3.3.4.2 CULTURAL EVENTS

The strengthening of Eswatini early-warning system multi-timescale information development and dissemination is one key option worth considering. The Eswatini government has demonstrated high adaptive capacity during the cultural ceremonies by providing accommodation units (in the form of tents), health emergency response facilities, and water tanks, etc. The adaptive capacity for future impacts could be strengthened by integrating cultural ceremonies climate-change impact management plans covering all social, health, and economic dimensions of the impacts including development of instruments for increasing the adaptive capacity and absorption of shocks.

4.1.3.3.4.3 HERITAGE SITES

- Develop integrated rock art management strategies incorporating environment and stone-specific data.
- Empower heritage managers with scientific methods for preserving assets under projected future climate. The management practices could target, for example, reducing wind exposures, improving site drainage systems, and potentially reducing mobility of soil salts in the case of rock art.

4.1.3.3.4.4 NATURE AND GAME RESERVES

The recommended adaptation option includes:

- Regulate rangers' protection and safety standards against extreme heat (e.g., introduce a legal provision for rangers and tourists to be transported only on covered vehicles to minimize sun exposure);
- Introduce adequate renewable energy powered cooling mechanisms;
- Encourage investments in green buildings;

- Address energy efficiency through implementation of climate insulation of buildings;
- Staff and tourist accommodation should be adopted or retro-fitted according to the cooling demands of the present and future climate;
- Schedule sightings to avoid exposure to extreme temperatures, thereby avoiding heatstroke, sunburns, thermal stress, and other associated health risks.


4.1.3.3.4.5 SPORTS AND ADVENTURE



The climate risks associated with tourism and sports activities could be minimized by:


- Conducting sporting activities during evening and morning hours,
- Promoting intake of fluid before, during, and after sporting activities,
- Pausing sporting activities in the case of gastrointestinal illnesses,
- Regulating intake of alcohol or medication that influences the body's electrolyte balance,
- Ensuring that training is done under favourable conditions.

4.1.3.3.5 MATRIX OF POTENTIAL CLIMATE HAZARDS, RISKS AND ADAPTATION OPTIONS FOR THE TOURISM SECTOR

Table 4-12: Climate Hazards, Risks, and Adaptation Options for the Tourism Sector

Tourist attractions				
	Hazard	Impact	Areas at risk	Adaptation
	Flooding: Although annual precipitation is expected to decline, isolated heavy precipitation events leading to flash floods are expected to increase in severity. This is especially expected over the Highveld region.	Direct damage to tourism infrastructure such as accommodation facilities, hiking trails, and cultural sites increase costs associated with maintenance and rehabilitation. Extreme events will also impact on supporting infrastructure for tourism such as transport, power supply, water supply and telecommunication. This will lead to an increase in the cost of	Over the Highveld region Road network is critical for tourist transport in Eswatini. Vulnerabilities to the sector in the face of precipitation extremes may stem from poor accessibility to the destination sides on account of heavy precipitation damage to road infrastructure during storms.	Develop and operationalize early warning system, mud slides, and heavy precipitation response planes.

Tourist attractions				
	Hazard	Impact	Areas at risk	Adaptation
		tourist visits. Overflowing bridges and drainage channels and landslides could affect travel times or limit access while also putting the lives of tourism operators and tourists at risk.	Eswatini depends on South Africa for its electricity supply. More extreme events can impact on the assurance of power supply to the tourism industry.	
	Extreme temperature sharp increases in temperature of between 2°C and 3.5°C for the mid-term period (2040-2070), and between 3°C and 5.5°C for the long-term period (2071-2100).	Compromised tourist's comfort levels, operating costs and durations of visits, elevated chances of heat exhaustion and heat strokes in the case of climate sensitive tourism activities.	The impact of extreme temperature is likely to be felt throughout the country at varying intensity during future periods.	Diversity of tourism for heritage and cultural experiences to include activities within heat protected areas during extremely hot seasons OND and JFM.
	Drought Annual precipitation is expected to decline while a strong increase in temperature is expected under future climate conditions (2050-2100 climate), causing an increase in the frequency of droughts. Sub-tropical storms through the Mozambique channel	The bulk of Eswatini water resources is recharged by seasonal precipitation. Drought will cause a lack of drinking water and potential water restrictions for tourist facilities. This will likely affect the eastern parts of the country, such as Lowveld and Lubombo, where there is a projected decline in precipitation. Tropical storms are projected to migrate southwards of the Mozambique increasing chances of making landfall over Eswatini.	Frequent dry spells and prolonged drought at elevated temperatures could lead to dam levels going lower than operating thresholds, leading to water shortages. An increase in dry spells will cause general water scarcity with specific impacts on tourism activities such as hiking, fishing, and white-water rafting. With the projected increase in intensity of precipitation extremes, the tourism perception of safety may negatively affect tourism especially	Establish national calamity insurance to safeguard tourism investments against poor business during extreme drought years. Establish water saving education programs for the hospitality industry. Invest in advertised campaigns that help manage perceptions and give accurate information for building climate resilience by tourists and investors.

Tourist attractions				
	Hazard	Impact	Areas at risk	Adaptation
			during the second part of the rainy season leading to changes in tourism demand.	
	Fire danger days Likely increase in the frequency of fire danger across Eswatini due to an increase in temperature and greater variance in rainfall.	Western Highveld areas with tree plantations.	The projected increased temperature in connection with the declining precipitation are likely to simultaneous with fire outbreaks over vegetated areas.	Establish and maintain fire breaks to safeguard tourism attractions as well as emergency responses protocols.

4.1.3.3.6 BARRIERS, CHALLENGES AND ASSOCIATED NEEDS FOR ADAPTATION IN THE TOURISM SECTOR

Barriers and challenges to adaptation were consolidated through stakeholder consultation. The needs transpiring from the identified challenges include:

- Access to funding for climate proofing tourism establishments and to mainstream climate change issues included in the National Tourism Policy within the tourism industry.
- Access to severe weather early warning information and decision-support tools.
- Availability of, and access to, technology such as GIS and remote sensing to inform adaptation.
- Climate change education and awareness for employees, investors, and tourists through different media such as television, radio, and targeted workshops.
- Mainstream climate-informed tourism management practices.
- Strengthening of the technical expertise on climate change issues to ensure their inclusion in the tourism bill.
- Build the technical capacity of tour operators to understand and promote climate resilience.
- Invest in climate change-informed tourism practices to assist with managing the perceptions and expectations of tourists, and increase the sustainability of the Eswatini industry.

4.1.3.3.7 OPPORTUNITIES FOR ADAPTATION BY KEY TOURISM ACTORS

Table 4-13: Opportunities for Climate Change Adaptation by Key Tourism Sector Actors

Type of Adaptation	Tourism Attractions/ Business	Tourism Industry Association	Government and Tourism communities.	Private Sector involvement (Financial sector/ investors/ insurance)
Research	Undertake regular Site-specific climate risk assessments and communicate outcomes.	Undertake regular assessment of levels of climate change awareness and knowledge gaps for tourists and all investors and workforce within the sector.	Establish adaptation progress monitoring systems; Establish and maintain high performance computation infrastructure for forecast and climate modelling; Advance near real time weather prediction science through investments in RADAR systems near tourism relevant areas.	Undertake local extreme climate events exposure studies.
Managerial	All investors draft auditable water conservation plans, as well as product and business diversification strategies.	Promote climate change sensitive management through certification; Publish tourism tailored weather content through media; Sustain climate change training programmes.	Implement tourism shock absorption mechanisms or business interruption subsidies; Develop Climate change impact management plans covering all attractions.	In anticipation of the projected climate change, revise landing approaches; Review existing insurance policies and their premiums.
Policy	Establish Tropical Storms interruption guarantees or financial shocks (e.g., national calamity tourism insurance).	Engage in advocacy and lobbying for mainstreaming of adaptation, access to financial means of implementing adaptations intervention and projects.	Enforce building design standards in anticipation of tropical storms and heatwaves; Enforce implementation of safety protocols; evacuation routines, water and energy saving measures.	Mainstream climate change in credit risk and project finance assessments.
Technical	Cyclone -proof buildings and tourism infrastructure; Rainwater collection and wastewater Recycling system.	Proliferate adaptation information through their websites and social medial accounts; Support use and access of equipment such as radios.	Expand and avail free water infrastructure in anticipation of tourism and population growth in urban and rural areas; Sustain Weather and Seasonal climate Early warning systems.	Provide technical information to the tourism sector clients (e.g., heat and fire-resistant material); Required technological advances (renewable energy-based air conditioning); Building design standards for insurance.

Type of Adaptation	Tourism Attractions/ Business	Tourism Industry Association	Government and Tourism communities.	Private Sector involvement (Financial sector/ investors/ insurance)
Education	Water conservation for employees and guests. Run multi-hazards emergency protocols for operators.	Undertake regular publishing education campaigns (e.g., Keep Summer fun incidence free).	Lead water conservation campaigns during drought years.	Relay climate change adaptation information and educational content for existing customers.
Behavioural	Real time weather condition monitoring around tourism attractions and tourists' routes.	Advocate for behaviour that is in support of water, environment, and energy conservation.	Encourage extreme weather recovery among investors through targeted campaigns.	Implement climate change adaptation practices internally to set examples to customers.

4.1.3.3.8 CONCLUSION FOR THE TOURISM SECTOR

For Eswatini, the warming trends in temperature and declining precipitation pose substantial uncertainty when it comes to the tourists' climate preferences and destination loyalty. Changes in the length and quality of climate-sensitive tourism stand a chance to negatively impact the overall potential contribution of the tourism sector in Eswatini. The tourism sector may experience geographic and seasonal changes due to shifts in the comfort levels and accessibility of attractions (Grundling et al., 2022; Simpson et al., 2008).

The tourism sector of Eswatini faces several vulnerabilities in the context of climate change. On the part of the tourist population, vulnerabilities relate to the outdoor nature of the activities. The vulnerabilities are amplified by the sector being reliant on critical infrastructure such as road networks, water, and sanitation which are already ageing. The rate of diversification of aspects of the sector such as accommodation facilities in rural areas is limited by the low access to electricity, water, sanitation, and reliable communication facilities.

The projected climate change condition will likely impact the sector directly and indirectly. The indirect impacts will come through the stresses of the biodiversity of nature and game reserves which are vulnerable to the projected changes in temperature and the associated extremes. Prolonged dry spells extending into the rainy season stand a chance to drive the mortality of certain animal and bird species, while also limiting their reproduction. Failure of the natural systems or ecological infrastructure supporting the tourism sector will likely be accompanied by direct impacts through the risk of flooding or fires which will put employees and tourists at risk. Adaptation should be through an integrated approach that involves all role players in the sector such as tourism industry associations, government, the private-sector, and investors in tourist attractions. Interventions should include encouraging adaptation-inclined behaviour, appropriate climate resilience building education, policy interventions as well as management practices, and research that identifies and bridges adaptation knowledge gaps across the tourism value chain.

4.1.4 ADAPTATION CHALLENGES, NEEDS AND OPPORTUNITIES

Challenges to adaptation may include the following (Ministry of Economic Planning and Development, 2019):

- Climate change has not been directly mainstreamed into national budgets, and resources for effective implementation are thus limited.
- Adaptation and resource mobilization require capacities or skills to implement new tools and actions which can be costly.
- Timely and quality data are essential to ensure sound decision making and planning. Adaptation actions compete for resources with other country priorities which may delay the availability of critical data.
- Monitoring and evaluation tools to assess implementation progress may need to be strengthened.
- Support to ensure that identification and targeting of beneficiaries is done effectively and fairly may have substantial cost implications for government and thus, considering the limited resources, the benefits from such an investment should be positive with the cost of providing the service not outweighing the support. The Middle-Income Country (MIC) status of the country has resulted

in the inability to access some loans at favourable conditions. However, in the process of accessing loans, it is important to be aware of various ways through which international development funding may contribute to mal-adaptation (Ojha, 2021). Because vulnerability is very context-specific, projects that have been designed based on a shallow or insufficient understanding of the vulnerability context in Eswatini are likely to miss the root causes of vulnerability, or may even increase vulnerability. This may be even worse if those that are most vulnerable to climate change are not considered as equal partners and thus are not included in the process of adaptation project planning and management. Adaptation that is retro-fitted into existing development agendas, i.e., modifying existing adaptation actions without considering the local context, can have further unintended consequences. Inadequate engagement between funding organisations, northern-based experts, governments, and local people and professionals to define what 'adaptation success' means in specific contexts of project interventions may also contribute.

- No information and research are available on short-lived pollutants in Eswatini, which are responsible for more than 45% of global warming.

Key requirements across different sectors to strengthen adaptation measures, include (Dlamini, 2021):

- Evidence and hard, verified data on the impacts of climate change and hazards across all sectors, underpinned by effective data governance (data quality, data availability, data usability, data integrity and data security).
- Geographically based adaptation strategies, addressing underlying drivers of vulnerability/adaptive capacity, included as an integral part of spatial and land

use planning.

- Dedicated and mandated climate change adaptation focal points in place for each sector.
- Competent and qualified staff knowledgeable on climate change adaptation.
- Climate change adaptation operational procedures that consider cross-sectoral implications.
- Early warning systems that interact with the different sectors where appropriate.
- Improved education, awareness-raising on climate change mitigation, adaptation, impact reduction, and early warning.
- Key climate change adaptation stakeholders and research organisations that have been trained on the following:
 - Downscaling of meteorological data and climate modelling.
 - Use of statistical and dynamic crop and hydrological modelling scenario development in different sectors.
 - The use of different adaptation tools and methods applicable to different sectors including economic models, biophysical models, and cost benefit analysis.
- It is essential that, during the planning of mitigation and adaptation initiatives, the linkages and dependency of the different sectors should be considered and mapped to maximise co-benefits within the sectors and economic savings.

Ongoing initiatives by the National Disaster Management Agency that can strengthen adaptation across sectors include the following (MTEA, 2021):

- Tracking and quantification of disaster losses and damages;
- Annual reports on vulnerability, particularly food insecurity, produced by the Vulnerability Assessment Committee (VAC), which helps NDMA quantify and track disaster losses and damages;
- Drone technologies;
- The technical assistance will build capacity of NDMA staff on use of UAV and Remote Sensing Technology for DRR and vulnerability assessments including agricultural data collection, analysis, and interpretation for crop monitoring, yield predictions, and early warning alerts.
- NDMA has developed a mobile app called 'Phepha' (which means 'be careful' in the local siSwati language) to report hazards and disaster incidents and provide a live map with various features including verified incidents, location, and radius of affected areas, and relief zones such as health centres, police stations, and schools. Users can register and share their location and get push notifications if an incident has been reported and verified within a certain radius of their location (MTEA, 2021).

- The recently revived Sector Wide Approach (SWAp) intends to increase technical and allocative efficiencies, improve resource mobilization, and streamline monitoring and evaluation frameworks (NHSSP, 2019). Therefore, efforts for reviving the SWAP will be strengthened during the NHSSP 2019-2023 Strategic Plan.

4.2 PROGRAMMES CONTAINING MEASURES TO MITIGATE CLIMATE CHANGE

The Kingdom of Eswatini's National Climate Change Policy (2016) sets the basis for the country's response to climate change and the need to advance mitigation measures. The intent and ambition of these mitigation goals are outlined in the updated Nationally Determined Contributions (NDC) of the country, which sets an economy-wide target of reducing GHG emissions by 5% by 2030, compared to the baseline year of 2010. Opportunities for mitigation were previously discussed in the TNC chapter on mitigation measures. This chapter reports on the current status of implemented mitigation measures that were previously discussed in the TNC mitigation measures chapter, and which also appear in the NDC.

Since 2010, when the TNC was submitted, the GHG emissions of Eswatini have increased by 51.9% between 2010 and 2018. Sectoral emission contributions in 2018 are 40.2% from the energy sector, 0.6% from the IPPU sector, 11.2% from the waste sector, 33.2% from agriculture, and 14.7% from FOLU. The total GHG emissions have been steadily increasing when the FOLU sector is included. This is related to the increasing emissions in the AFOLU sector due to the deforestation of indigenous forests, harvesting timber in plantation forests, and dam infrastructure development.

4.2.1 BASELINE

The baseline year for the country's mitigation scenarios and projections is 2010. The GHG emissions in 2010 were re-calculated as part of the update to the National GHG inventory 2018. More detailed information about the National GHG Inventory of 2018 is provided in Chapter 3. In 2010, the main sources of GHG emissions were from the energy, AFOLU, and waste sectors as indicated by the sectoral totals in Table 4-14.

Table 4-14: GHG Sources and Sinks GHG emissions totals in 2010

GHG Sources and Sinks	GHG emissions totals in 2010	
	Total (Gg CO ₂ e)	Percentage (%)
Total National Emissions without FOLU	2622.50	-
Total National Emissions with FOLU	2133.38	100%
1 Energy	1018.87	48%

2. Industrial Processes	13.03	1%
3. Agriculture	1262.49	59%
4. Land-Use Change and Forestry	-489.11	-23%
5. Waste	328.12	15%

4.2.1.1 BASELINE EMISSIONS

The baseline emissions have been projected according to the business-as-usual scenario from the base year 2010 to the start and end year of the NDC mitigation implementation period of 2020 and 2030, which is shown in Table 4-15. Relative to the base year 2010, the total GHG emissions from all sectors are expected to increase from 2010 to 2020 and from 2020 to 2030. Net GHG emission removals decrease between 2010 and 2030 due to the loss of forestland area and related decline of harvested wood products.

Table 4-15: Aggregated business as usual (BAU) baseline from all sectors (Gg CO₂e).

Sectors	Sub-Sectors	2010	2020	2030
AFOLU	Agriculture	1262.49	1060.15	1015.49
	FOLU	-489.11	1033.44	3334.22
	Total AFOLU	773.38	2093.60	4349.71
Fuel Combustion Activities	Other sectors	218.63	436.24	427.23
	Manufacturing Industries and Construction	205.70	521.54	599.18
	Transport	572.10	933.31	1548.15
Energy Industries	Electricity Production	0.03	76.83	1399.66
Fugitive emissions from solid fuels	Coal mining and handling	22.40	20.91	225.78
Total Energy	All Sectors	1018.87	1988.83	4200.01
IPPU	IPPU	13.03	17.77	23.32
Waste	Waste	328.12	373.52	418.32
TOTAL emissions	TOTAL	2133.38	4473.71	8991.36

The mitigation actions prioritized in the Eswatini INDC included doubling the share of renewable energy in the national energy mix by 2030, relative to 2010 levels; introducing the commercial use of 10% ethanol blend in petrol by 2030; and phasing out the use of HFCs, PFCs, and SF₆ gases. Additional mitigation actions prioritized in the NDC update include improving energy access and energy intensity of the residential sector; reducing energy intensity of industrial, agricultural, commercial, and public services sectors; conducting studies to assess the adoption of electric mobility options; reducing GHG emissions in the waste sector by 2030 through improvements in waste treatment (including landfilling) across urban and rural areas; reducing land degradation through restoration including tree planting; and improving livelihoods through better livestock management. The proposed phase out of F-gases has been revised in the NDC update to address the phase out of HFCs only as per international commitments of the country to the Kigali

Amendment.

In the next section of the chapter, the status of planned and implemented mitigation measures is discussed. Implemented mitigation measures and the GHG emissions reductions achieved have also been assessed ex-post. The evaluation of achieved GHG emissions reductions for the reporting period 2010 to 2020 is described in relation to the baseline GHG emissions in the 'with policy' scenario for the period 2010 to 2030. Mitigation actions prioritized in the INDC and NDC were included in the ex-post assessment if implementation occurred prior to 2020, and there was sufficient activity data available from online publicly available reports. The mitigation actions considered in the ex-post mitigation assessment include doubling the renewable energy share in the energy mix; introducing a 10% ethanol fuel blend in petrol; reducing the energy intensity of the residential, industrial, agricultural, commercial, and public services sectors; reducing GHG emissions in the waste sector through improvements in waste treatment; and reducing land degradation.

The mitigation actions not considered in the ex-post mitigation assessment included improving energy access in the residential sector; commercialisation of 10% ethanol fuel blend in petrol; exploring electric mobility options; and the phase out of HFCs. The activity data collected to quantify GHG emission reductions ex-post were from government reports published on-line. For the next cycle of reporting, it is expected that the activity data to be used in mitigation assessments will be sourced from the operational MRV information system that is currently under development.

4.2.2 SECTORAL ANALYSIS

4.2.2.1 ENERGY

Relative to the 2010 baseline year, desired GHG emission reductions in the energy sector are expected to increase by 2356.26 Gg CO₂e in 2030. While actions have been identified across the supply and demand side, the major share of emission reductions shall be achieved through increasing electricity generation from renewables to 50%, and this involves considerable expansion of capacities from biomass, solar, hydro, and wind. Several policies have been institutionalized to initiate this transition and a synergetic approach with various stakeholders from the government and private sector will be required to meet the desired outcome.

Energy efficiency measures from residential, commercial, manufacturing, and agriculture sub-sectors contribute to the bulk of the desired emission reduction contributions at 82% in the energy sector for the 2010 to 2020 period. The ex-post assessment of mitigation measures indicates that both renewable energy generation and energy efficiency measures were important for mitigation, contributing to 59% and 41% of the total energy sector emission reductions, respectively. As shown in Figure 4-28, GHG emissions are lower in the ex-post 'without policy' scenario compared to GHG emissions in the NDC 'without policy' scenario from 2010 to 2016, since the actual annual GHG emission reductions achieved were greater than the desired annual GHG emission reductions.

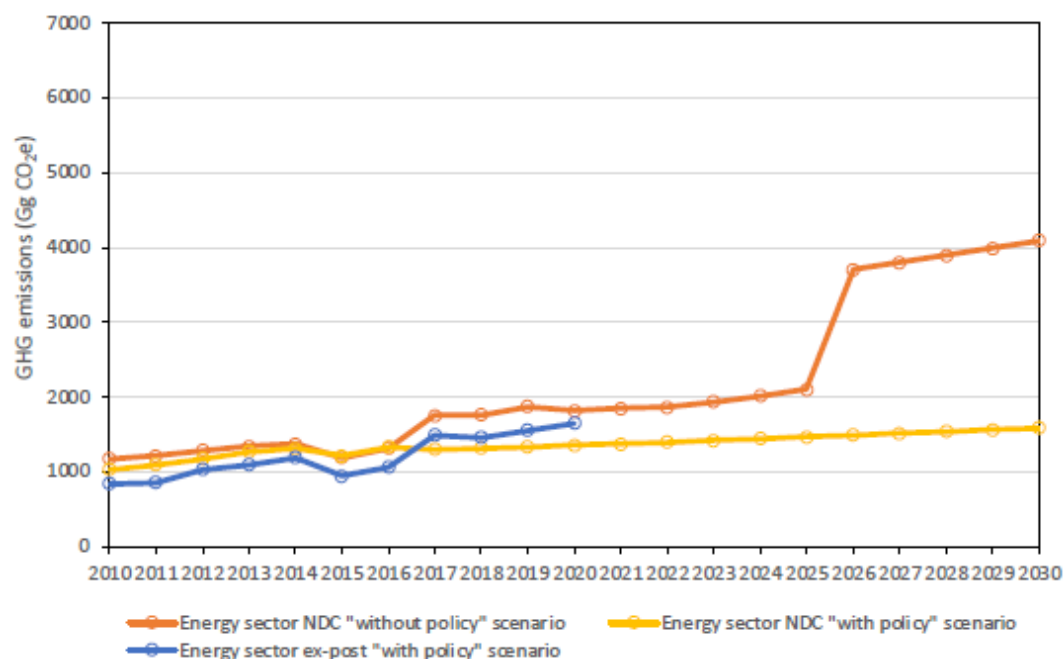


Figure 4-28: Annual GHG emission in the ex-post 'with policy' scenario of energy mitigation measures compared to the GHG emissions in the 'with policy scenario' and 'without policy' scenario of the NDC.

4.2.2.1.1 COMMERCIALISATION OF A 10% ETHANOL BLEND

Introducing a new petrol blend into the market for use in road vehicles is the only transport sub-sector action mentioned in the INDC. The target year for implementation of the mitigation action is 2030. To support the introduction of an ethanol fuel blend in petrol, several milestones have been achieved. The Eswatini Petroleum Company was established in 2012 and is tasked with the production of the ethanol fuel blend in petrol. Funding and infrastructure requirements for blending have been secured by the Eswatini Petroleum Company. A national standard for blending anhydrous ethanol in unleaded petrol has been developed. The Eswatini Revenue Authority approved a zero-rated VAT for fuel-intended ethanol. Discussions and consultation with the various distilleries occurred about the Petroleum bill enforcing mandatory blending, after which the Petroleum Act was introduced in 2020. Construction of the Strategic Oil Reserve Facility in Phuzumoya which will store blended fuel is ongoing.

4.2.2.1.2 CONDUCTING STUDIES TO ASSESS ADOPTION OF ELECTRIC MOBILITY OPTIONS

The introduction of electric vehicles into the domestic market is the only new action for the transport sub-sector mentioned in the updated NDC. The exploration of electric vehicle options in Eswatini to support the uptake of efficient vehicles is on-going as a research and development measure.

4.2.2.1.3 ELECTRICITY PRODUCTION AND SUPPLY

The country's goal for the national energy mix for electricity production and supply is a 50% increase of the renewable energy share in the energy mix by 2030 relative to the 2010 baseline year. The 2030 renewable electricity generation capacity targets from hydro, solar PV, and biomass sources

are 80MW, 55.85MW, and 95MW respectively. In the baseline year, renewable electricity generation capacity was 60.0MW from hydro and 61MW from biomass sources. The increased renewable energy electricity generation capacity in 2030 translates to 221Gg CO₂e GHG emissions avoided.

In 2020, the renewable electricity generation capacity will be comprised of 57.3MW from hydro, 0.10MW from solar PV, and 100.5MW from biomass sources. This translates to 157.9Gg CO₂e GHG emissions avoided, as shown in Table 4-16. The GHG emissions in the 'with policy' scenario are zero between 2013 to 2030, as it is assumed that electricity generation from non-renewable sources does not occur. Thus, the ex-post 'without policy scenario' represents the GHG emissions avoided had non-renewable electricity generation sources been used instead.

The country's first intention to pursue renewables was communicated through the adoption of the Swaziland Utilisation of Renewable Energy Action Plan in 1997. Increasing power generation from renewable energy in the total energy mix is required to meet the energy needs of the country in a sustainable manner so that the sector can contribute to economic growth and wellbeing of the population. Commitments to securing increasing renewable energy sources in the national energy mix by 2030 are described in detail in the National Energy Policy 2018, and aligned with the National Development Strategy. In 2013, Eswatini joined the SEforALL initiative and Eswatini committed to a 50% renewable energy target by 2030. The renewable sector has slowly grown support by a succession of regulations in the form of the Electricity Act, Energy Regulatory Act, the Electricity Company Act published in 2007, and the introduction of the Electricity licensing by-laws under the Electricity Act and Independent Power Producer Policy in 2016. The Short-Term Generation Plan for Eswatini was adopted to guide the relevant authorities on the amount of the various possible types of generation capacity including renewables that will need to be procured, and the envisaged timeframes which are required. The development of an integrated resource plan aligned to the current energy masterplan that was also published is on-going to guide medium to long term energy supply planning. The total annual emission reductions from biomass, solar, and biomass renewable energy sources increase from 2010 to 2020 due to the increasing electricity generation capacity from biomass as shown in Table 4-16.

Table 4-16: Annual GHG emission reductions from the ex-post assessment of renewable electricity generation compared to the GHG emissions in the 'with policy scenario.'

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Hydro GHG emissions avoided (Gg CO ₂ e)	57.74	57.27	57.27	57.27	57.27	57.27	57.27	57.27	57.27	57.27	57.27
Solar PV GHG emissions avoided (Gg CO ₂ e)	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.12	0.13	0.11	0.10
Biomass GHG emissions avoided (Gg CO ₂ e)	57.83	116.62	116.62	116.62	100.50	100.50	100.50	100.50	100.50	100.50	100.50

Total	115.57	173.88	173.88	173.88	157.76	157.76	157.86	157.88	157.89	157.87	157.86
-------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

4.2.2.1.4 ENERGY FOR INDUSTRIAL PROCESSES, COMMERCIAL, AGRICULTURE AND RESIDENTIAL ACTIVITIES

Electricity energy efficiency and conservation measures are implemented, which target electricity demand and consumption, lowers energy use, and can therefore reduce GHG emissions. Implementation of energy efficiency measures are ongoing. It is a focal area for action in the Energy Policy 2018, and a key strategic fuel and energy objective of the NDS. The implementation strategy of the energy policy is aligned to the short to long term plans outlined in the National Energy Efficiency and Conservation Policy 2019 through the National Energy Efficiency Strategy and Action Plan. The Eswatini Energy Regulatory Authority (ESERA) employs an electricity tariff setting methodology for bulk energy consumers, which encourages efficient electricity usage. The targets for electricity energy efficiency in the NDC includes a 5% reduction in electricity energy intensity for industry, and a 3% reduction in electrical energy intensity for commercial, public services, and agriculture by 2030 relative to the 2010 baseline year.

4.2.2.1.5 ENERGY FOR RESIDENTIAL USAGE

Access to electricity has grown rapidly in the past decade. In 2007, only 40.9 per cent of the population had access to electricity and by 2017 this had risen to 73.5 per cent. Estimates show that this has risen to 80% by 2020 (UNCDF, 2020). The population relies on multiple fuel sources to meet its domestic and productive energy needs. In rural areas, biomass is used for cooking and heating; and candles, paraffin, and electricity for lighting. Approximately 90 per cent of the total rural energy is provided by fuelwood. In urban areas, households rely less on biomass and more on electricity for lighting, heating, and cooking. Despite relatively good access to the electricity grid (estimated at 80 per cent for 2020), there is still large-scale use of biomass energy, which reflects the level of poverty and affordability of other energy sources. Since 2011, ESERA implemented a tariff setting methodology which included amongst the criteria for consumer pricing least cost options to improve the affordability of electricity to households. Additionally, ESERA implemented a migration plan in 2020 for a subsidy framework which aims to reduce the costs of electricity for vulnerable households, thereby encouraging a shift from biomass consumption to electricity for energy usage.

4.2.2.1.6 GHG EMISSION REDUCTIONS RELATED TO ENERGY EFFICIENCY

The total GHG emission reductions related to energy efficiency in manufacturing industries and construction, agriculture, commercial, and residential are shown cumulatively due to the aggregated reporting of GHG emissions from residential, agricultural, and commercial fuel combustion activities in the Other sectors category of the 2018 GHG inventory and the aggregated electricity tariff information for industrial and commercial consumers sourced from the Eswatini Electricity Company annual reports. The GHG emission reductions from energy efficiency are shown in Table 4-17 The decline in emission savings is due to increasing GHG emissions from fuel combustion. Implementation of energy efficiency measures in all sectors would need to be intensified for this to offset GHG emissions from fuel combustion activities.

Table 4-17: Annual GHG emission reductions from the ex-post assessment of energy efficiency compared to the GHG emissions in the 'with policy scenario'

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2018	2019	
Ex-post GHG emission reductions (Gg CO ₂ e)	129.53	103.96	53.03	37.73	10.21	46.45	61.51	67.50	69.62	69.62	76.11	0.00

4.2.2.1.7 METHODOLOGY APPLIED TO QUANTIFY GHG EMISSION REDUCTIONS

To estimate GHG emission reductions from renewable energy generation, the activity data collected included electricity generation capacity statistics and grid emission factors. Annual renewable electricity generation capacity statistics were sourced from IRENASTAT. The CO₂e Southern African Power Pool combined margin emission factor was applied to quantify GHG emissions avoided.

To quantify the GHG emissions from energy efficiency, the activity data collected included electricity sales, tariff statistics, and grid emission factors. Electricity sales data and tariff information were sourced from Eswatini Electricity Company annual reports published online. The CO₂e Southern African Power Pool combined margin emission factor was applied to quantify GHG emissions avoided. The energy intensity of electricity consumption electrical energy intensity was estimated in terms of electricity demand and revenue generated for small and bulk electricity users.

4.2.2.2 IPPU

Although the IPPU sector contributes to only 1% of Eswatini's emissions, the country still intends to set a relative GHG target to achieve net emissions reductions of 5.96 Gg CO₂e by implementing the Kigali Amendment to the Montreal Protocol to reduce HFC usage. Refrigeration and air-conditioning product use contribute to the highest emissions in the sector and, hence, mitigation actions are focused towards improving their usage. The emissions from HFCs are expected to increase until they reach a peak in 2028, then gradually reduce.

The country is part of the group of A5 (developing countries) Group 1 which have the flexibility to prioritize HFCs, define sectors, select technologies and alternatives, and design and implement their own strategies for HFC phase-down to freeze HFC growth in 2024 relative to baseline levels and to begin reducing product use from 2029 with a 10% reduction and an 80% reduction in 2045. The baseline is calculated from the average product use in 2020, 2021, and 2022 plus 65% of this average.

Steps taken and planned as part of building capacity to initiate enabling activities for the HFC phase-down are as follows:

1. The Kigali Amendment was ratified in 2020.
2. The current data reporting and inventory system for HFCs was reviewed as part of the Climate Action Enhancement Program (CAEP) of the NDC Partnership in 2021.
3. The review of licensing and quota systems indicate that these are operational with 2022, the date the HFC licensing system was last reported.
4. Institutional arrangements were reviewed, and the Ozone Depleting Substance Regulations, 2003, were amended in 2014 to cover the HCFC baseline freeze of 2013. However further revisions are planned to cover the commitments under the Kigali amendment.

Project coordination and monitoring is ongoing. As part of development progress for the management of ODS, achievements to date include:

1. Training of Customs and other border enforcement agencies: Capacity building for 150 customs officers undertaken; ODS issues incorporated into customs curriculum.
2. Strengthening of technical colleges and Refrigeration Association: The Swaziland National Refrigeration Association was formed at a training workshop for refrigeration technicians held from the 22nd to 26th August 2011 at MITC, Manzini. The role of the association is envisaged to organize the profession of refrigeration; assist the National Ozone Unit in data collection in the refrigeration sector; raise awareness of their members on the harmful effects of refrigeration ODS on human health and the environment; strengthen the capacity of the refrigeration sector to reduce emissions and consumption of ODS; and participate in the implementation of policies, strategies, programs and projects for the implementation of the Montreal Protocol.
3. Three vocational training institutions: Gwamile Vocational and Commercial Training Institute, Manzini Industrial Training Centre, and Eswatini College of Technology were identified to serve as referral centres for training of technicians and management of some set of equipment for the technicians in the country. They are also used to collect data on ODS consumption. UNEP and UNDP have been strengthening these institutions through the provision of equipment.
4. Training of refrigeration technicians: SEA has trained 200 service technicians in good refrigeration practices in the country and continues to do so each year to build capacity. These technicians are from the formal and informal servicing sectors throughout the country. With the high number of refrigeration technicians, continuous training to sustain the ODS phase out and the expanding of the refrigeration industry is being

done.

5. Conversion of HCFC141b Palfridge Ltd completed: Palfridge is a manufacturer of domestic and commercial refrigerators. Palfridge Limited has phased out the use of HCFC 141b in its PU insulation foam production for domestic and commercial refrigerators. The company completed the conversion project of refrigerants HCFC22 and HFC 134a to isobutene and propane refrigerants at Palfridge.

4.2.2.3 WASTE

Eswatini has set a relative GHG target of reducing emissions by 16% in 2030 compared to baseline scenario through improvements in waste treatment and landfilling across urban and rural areas. The mitigation actions identified for the waste sector have emerged from the 'Draft Waste Strategy' which has identified improvement in the collection process as an essential strategy to curb emissions from open burning of waste.

The following mitigation actions have been identified as implemented actions in the waste sector which are directly linked to the NDC mitigation measure to reduce GHG emissions in the waste sector through improvements in waste treatment:

- Avoiding, minimizing, and recycling solid waste;
- Improving wastewater treatment and control through expanding sanitation coverage.

Several progressive measures are being considered by the government to introduce sustainable waste management practices through enhanced policies such as the National Solid Waste Management Strategy (NSWMS), the Waste Regulations Act of 2000, revision of the Environmental Management Act (EMA) of 2002, national level initiatives such as 'Clean Eswatini Campaign', amongst others. The Climate Change Policy of 2016 mentioned the following actions in waste management for low carbon development:

- Increase rates of waste minimization, recycling, and combustion of waste-to-energy through incineration;
- Implement affordable, effective, sustainable, and integrated waste management strategies;
- Enhance home composting at household level to turn generated waste into useful rich compost for vegetable gardens and agriculture;
- Promote fuel or energy generation from waste;
- Improve the management of existing waste disposal facilities to control GHG emissions.

The key tool for implementing waste management in Eswatini is the NSWMS. The strategy attempts

to give effect to the Environmental Management Act of 2002 and the Waste Regulations Act of 2000. It details the goals and action points for all relevant government agencies for adopting and implementing a holistic approach in waste management. Most importantly, EMA 2002, Waste Regulations 2000, and the NSWMS together mandate all municipalities and regions to develop an 'Integrated Waste Management Plan (IWMP)' for efficient on-ground waste management.

The Waste Regulations Act 2000 provides the regulatory framework for managing waste in the country. The Act introduces regulatory instruments, such as waste management licensing and controls, waste management services, remediation of contaminated land, national waste information system, and compliance and enforcement mechanisms to enforce effective waste management.

The Waste Regulations Act 2000 outlines the duties and responsibilities of relevant stakeholders such as Eswatini Environment Authority (EEA), local authorities, and waste generators, and waste service providers (recyclers, sorters). The responsibility for waste management is divided among different line ministries which are responsible for regulating waste management within their legal jurisdictions. This includes Ministry of Health (MoH) for monitoring and control of biomedical waste generated from hospitals, health centres, clinics, and medical retailers. The Ministry of Housing and Urban Development (MHUD) is the principal national agent for supervising household and commercial waste under the auspices of urban local government bodies such as city councils, town councils, and town boards.

4.2.2.3.1 AVOIDING, MINIMISING AND RECYCLING SOLID WASTE

By 2030, Eswatini aims to reduce waste generation through prevention, reduction, recycling, and re-use which is currently achieved through food waste composting and paper and wood recycling. GHG emission reductions from food waste composting and paper recycling and wood-waste reclamation are observed to pick up from 2018 onwards. Food waste composting emission reductions increase from 0.08Gg CO₂e in 2018 to 0.43Gg CO₂e in 2020. Paper recycling and wood-waste reclamation emission reductions increase from 0.10Gg CO₂e in 2018 to 0.61Gg CO₂e in 2020 (Table 4-18). Data from reports published online for recycling activities in urban areas indicate that these activities started in Mbabane from 2012, Manzini from 2020, and Matsapha from 2017.

The waste information system is not in place. Most cities started collecting waste activity data about 3 years ago. The historical record for solid waste management data is, therefore, very limited. Documented composting is not widely practised. Looking at the domestic and commercial composting activities, only the Municipal Council of Mbabane is known to practise food waste composting through the European Union funded program called the Mbabane Municipal Council European Union Project on Waste Minimization and Management Initiatives that started in 2018. Intensified implementation of existing waste legislation is required for there to be increased uptake of waste minimization, reuse, and avoidance measures by local government authorities. In the meantime, the informal activities for recycling have the most impact on GHG emission reductions in solid waste.

Table 4-18: . Annual GHG emission reductions from the ex-post assessment of food waste composting, paper recycling and wood-waste reclamation compared to the GHG emissions in the 'with policy scenario'

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Food waste composting GHG emission reductions (Gg CO₂e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.22	0.43
Recycling paper, reclaiming wood-waste GHG emission reductions (Gg CO₂e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.31	0.61
Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.53	1.04

4.2.2.3.2 IMPROVING WASTEWATER TREATMENT AND CONTROL THROUGH EXPANDING SANITATION COVERAGE

Eswatini aims to expand access to improved sanitation facilities to 100% of the population including latrines, septic tanks, sewerage, and wastewater treatment technologies. However, for sanitation projects to have mitigation impact, there needs to be greater household access to treated wastewater systems in urban areas. Therefore, mitigation is a co-benefit for improved sanitation coverage as an adaptation action, and it is more likely for emission reductions to be lower since there is greater government prioritization of increasing rural sanitation access and broader improved sanitation indicates that annual emission reductions from sanitation improvement decline from 2010 to 2020, as household access to flush toilets with treated sewerage drops over this period overall relative to septic tanks and latrines for which effluent does not enter wastewater treatment. The rising GHG emissions from wastewater treatment in the 'with policy' scenario is attributed to the assumption that the bulk of eSwatini's population is rural-based with dependence on mainly the latrine wastewater discharge pathway (which has a higher methane correction factor). There is a decline in urban high-income populations that depend on mainly the shallow lagoon wastewater treatment pathway (which has a lower methane correction factor). There is also growth of the urban low-income populations that depend mainly on the latrine wastewater treatment pathway.

Table 4-19: Annual GHG emission reductions from the ex-post assessment of improving sanitation coverage in wastewater handling compared to the GHG emissions in the 'with policy scenario'

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GHG emission reductions (Gg CO₂e)	12.31	11.21	10.27	9.30	8.33	7.16	6.02	4.78	3.62	2.31	2.25

An 'improved sanitation facility' is defined as one designed to hygienically separate human excreta from human contact. Improved sanitation facilities include wet sanitation technologies such as flush or pour flush toilets connected to sewer systems, septic tanks, or pit latrines; and dry sanitation technologies such as dry pit latrines with slabs (constructed from materials that are durable and easy to clean), ventilated improved pit (VIP) latrines, pit latrines with a slab, composting toilets, and container-based sanitation.

Most of the urban areas are partially covered by a sewer network. There are 24 sewerage systems including wastewater treatment plants in the country. These systems collect grey water, black water, and industrial wastewater, but do not collect rainwater. The total population connected to a sewer line is about 12 000 units (or about 60 000 equivalent-persons) including households, commercial buildings, public buildings, and industries. Treatment technologies used in Eswatini are waste stabilization ponds, vertical constructed wetlands (or reed beds), activated sludge, trickling filter, chlorination, etc. In urban areas, most of inhabitants rely on flush toilets either to a piped sewer system or a septic tank with a soak pit. In peri-urban, rural areas, and informal settlements, the population mainly uses septic tanks, VIP, and pit latrines

The relevant existing legal and regulatory instruments that frame the development of the sector are listed below:

- Eswatini Water Act, 2003;
- Public Health Act, 1969. This act is currently being refined and updated;
- Environment Management Act, 2002;
- Water Services Corporation Act, 1992;
- Waste-water Regulations, 2000;
- Water Pollution Control Regulations, 2010;
- Eswatini National Sanitation and Hygiene Policy, 2019.

4.2.2.3.3 METHODOLOGY USED TO QUANTIFY GHG EMISSION REDUCTIONS

The methodology used to estimate GHG emissions from solid waste was the 2006 IPCC waste model. The GWP value for CH₄ applied was from the SAR. Historical population and projections for baseline and policy scenario were the same as those used in the 2018 GHG inventory. The total solid waste generated was extrapolated based on 2016 and 1996 data to calculate waste generation per capita (Swaziland Government, 2000; Dlamini et al. 2017). The following assumptions were included to quantify the GHG emissions ex-post:

- No methane recovery factor is applicable to any of the landfills in Eswatini;
- It is assumed that for waste management activities after 2016 in the baseline scenario the fractions of waste disposed, recycled, and burnt remain the same as

2016 as these are the latest reported values for Eswatini;

- Total solid waste generated in 2016: 238341 tonnes (Dlamini et al. 2017);
- Total waste generated in 1996: 86323 tonnes (Swaziland Government, 2000);
- Fraction of waste generated that is disposed into landfill in 2016: 0.26 (Dlamini et al. 2017);
- Fraction of waste generated that is recycled in 2016: 0.29 (Dlamini et al. 2017);
- Fraction of waste generated that is burnt in 2016: 0.45 (Dlamini et al. 2017);
- It is assumed that the waste disposal and burnt fractions are capped at 0.71 and 0.29 respectively, as there are no earlier reported values for Eswatini;
- Fraction of waste generated that is disposed into landfill in 1991: 0.71 (Ohnesorgen, 1991);
- Fraction of waste generated that is burnt in 1991: 0.29 (Ohnesorgen, 1991).

To estimate the GHG emissions from wastewater treatment, the existing wastewater handling worksheet for the 2018 GHG inventory was adapted. The historical population estimates used were the same as the values in the 2018 inventory. The methane correction factors applied were the same as the factors applied in the 2018 GHG inventory. The GWP value for CH₄ applied was from the SAR.

Fractional urban rural population by income was extrapolated for the period 1990 to 2021 based on:

- Swaziland Demographic and Health Survey 2006-07;
- Swaziland Multiple Cluster Indicator Survey (MICS) 2014;
- Eswatini Household Income and Expenditure Survey 2016/17.

The extrapolated fractional urban rural population by income degree of utilisation of treatment/discharge pathway system for the period 1990 to 2020 was based on the Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene estimates for 2000 to 2020.

4.2.2.4 AFOLU

There is far more potential to reduce emissions in forestry and sustainable land management activities, compared to the livestock sector, that was the initial focus for mitigation assessment. In the case of the AFOLU sector, the government's plan to increase productivity of livestock is leading to an increase in emissions by 15% in 2030 as compared to the baseline scenario. The reason for this increase is due to the improvement in the fertility rates, animal weights, and mortality parameters because of the projected increase in the quantity of livestock available within the country in 2030.

As such, forestry and sustainable land management activities are more effective mitigation actions which can support the broader national environmental and climate change adaptation agenda which benefit communities as well as contribute towards the national environmental management

goals to combat loss of biodiversity, adapt to climate change, and provide safe water and energy to communities.

In general, the EEA is the national directing body for development of environmental laws, policies, and strategies, for setting up environmental regulations, and for ensuring implementation. The Swaziland Environment Authority Act was passed by Parliament, putting in place an authority responsible for environmental matters in 1992. The UNFCCC convention as well as the United Nations Convention to Combat Desertification (UNCCD) was ratified in 1996. The following year, several major milestones were achieved regarding signing soft laws. The Flora Protection Act was gazetted in 1997, and the Swaziland Environment Action Plan was also developed that year. In 2000, the National Environment Policy was approved, and a National Greenhouse Gas inventory was completed in 2000. In 2001, the National Action Program of the Convention to Combat Desertification was approved. In 2002, the National Forest Policy, the Swaziland Biodiversity Strategy, and Action Plan were approved, and the Environment Management Act was gazetted and in the same year, in 2002, the National Forestry Program was implemented.

The following are additional policies in the AFOLU sector:

- Private forests Act 1951;
- Grass burning Act 1955;
- Dairy Act 1968;
- Veterinary Public Health Act 2013;
- Comprehensive Agriculture Sector Policy;
- The Food Security Policy;
- Livestock Development Policy;
- Irrigation Policy;
- Rural Resettlement Policy;
- Fisheries Policy;
- National Agricultural Research Policy.

4.2.2.4.1 CLIMATE SMART AGRICULTURE

Climate smart agriculture is articulated in several national policy documents – including the National Strategic Development Plan (2018/19-2022/23), the Comprehensive Agricultural Sector Plan (CASP) (2005), National Drought Plan (2020), and the National Agricultural Investment Plan (2015). As indicated in the Ministry of Agriculture's Strategic Plan (2020), at the centre of the program is the organization of systems for transformative change in Eswatini's smallholder agriculture and allied sectors through catalytic private investment in agricultural and food sectors, and in associated services industries—along agricultural value chains. This includes supporting small-scale food producers to adopt inclusive climate resilient value chain approaches in agriculture and allied

sectors.

Agroforestry is a suite of agricultural land practices that integrate the cultivation of crops or livestock with trees and shrubs on the same piece of land, with the NFP the primary policy driver. The actions are prioritized in the NFP for the sustainable utilization, development, and management of forest resources that help to improve livelihoods and tenure while conserving biodiversity and achieving a balance between forestry and other uses of the land and water resources.

Although the current monitoring and evaluation of climate smart agriculture programs is limited, there has been progress achieved towards improving agrarian livelihoods. Eswatini Water and Agriculture Development Enterprise (EWADE) has built farmers' capacity on climate-smart agriculture practices, which have enhanced the adoption of sustainable agriculture. The organization has further promoted land rehabilitation, ecosystem restoration, and the sustainable use of water through various interventions that engage communities. Several other projects have been initiated, including the Lower Usuthu Sustainable Land Management Project (whose objective is to decrease biodiversity loss), Komati Basin Water Authority, Komati Downstream Development Project, and Lower Usuthu Smallholder Irrigation Project.

Through EWADE, the Kingdom of Eswatini has facilitated the development of over 10 000 hectares with irrigation infrastructure to enhance farmers' resilience to climate change. A new phase is underway in the Lower Usuthu where over 5 000 hectares are being developed with irrigation infrastructure, and is expected to be in full production by 2023. The country and the host communities for these projects have experienced significant transformation of their economies through direct earnings from the agriculture enterprises, and they also realized significant benefits from indirect positive externalities such as employment opportunities.

Eswatini's National Agriculture Marketing Board (NAMBoard) has implemented the Climate-Smart Market-Oriented Agriculture Project that supports farmers with climate-smart agriculture techniques. The Climate-Smart Market-Oriented Agriculture Project is supporting farmers' irrigation schemes, such as Mavulandlela under Ntfontjeni Inkhundla in the Hhohho region and Intamakuphila under Ngwempisi Inkhundla in the Manzini region, to create jobs for several EmaSwati, with an emphasis on opportunities for women and the youth. These schemes, for example, are focused on producing baby vegetables for the export market, but also encourage the growth of conventional vegetables during the off-season period. However, a lack of capacity has meant a slow adoption of climate-smart agriculture practices by farmers, and not all are reaping the rewards of climate-smart agriculture and enjoying increased profits from their enterprises.

4.2.2.4.2 FOREST AND GRASSLAND RESTORATION

The country aims to reduce GHG emissions in the AFOLU sector by combating land degradation of forestland and grasslands. Reforestation and afforestation are activities that convert land to forest, where reforestation is the planting or restoration of forest on land that historically contained forests but was converted to a different land use, while afforestation is the planting of a forest on land not previously forested. Urban forestry is a form of urban greening activity for tree planting in urban communities along road reserves and in public open spaces (Australian Bureau of Agricultural and

Resource Economics and Sciences – ABARES, 2020).

The NDS, 2014, recognizes the essential role of the National Biodiversity Strategy and Action Plan (NBSAP) in reversing or halting the alarming loss of biodiversity and the associated impacts. Eswatini prepared its first NBSAP in 2001; however, implementation has been limited and challenged by several factors including mainstreaming of the NBSAP into the National Development and Economic Planning Processes.

The second National Biodiversity and Action Plan (NBSAP 2) has been prepared in a highly participatory and consultative manner involving multiple national stakeholders. Several consultative meetings were held throughout the various stages of the development of the strategy. Stakeholders made inputs and validated several reports throughout the various stages. A national think-tank of local experts involved in biodiversity issues also met on several occasions to deliberate on specific technical biodiversity issues. Special stakeholder groups, for example, chiefs, were consulted at special regional workshops. Consultations were held with experts in South Africa to ensure adequate coverage of both local and regional biodiversity issues. Building from the lessons learnt from the implementation of the first NBSAP and from the national prioritization exercise, the NBSAP 2 was formulated to capitalize on the following issues:

- Improving the status of the country's biodiversity by monitoring, reduction of threats and pressures, safeguarding ecosystems and encouraging sustainable utilization.
- Generation of reliable information data for continued monitoring of the status of biodiversity.
- Mainstreaming and integration of biodiversity into national plans and strategies, and contribute to the National Development objective.
- Building and strengthening human capacity in all aspects pertaining to conservation and management of biodiversity.
- Strengthening the existing legislative and policy framework to improve the management and sustainable use of biodiversity and ecosystem.
- Exploitation of synergies with other Multilateral Environmental Authorities (MEAs).
- Increasing awareness on biodiversity to the citizenry of Eswatini.

4.2.2.4.3 GHG EMISSIONS REDUCTIONS RELATED TO MITIGATION MEASURES IN AFOLU

As shown in Table 4-20 **Error! Reference source not found.**, mitigation activities in forestland and grassland land categories contribute the most to GHG emission reductions in AFOLU, particularly from afforestation and grassland conversion from other land uses. Deforestation activity is the main driver of carbon stock loss through reduced forestland area and conversions to other land uses. The total annual emissions reductions from forest and grassland restoration actions increase from

584Gg CO₂e in 2010 to 1367Gg CO₂e in 2020.

Table 4-20: Annual GHG emission reductions from the ex-post assessment of AFOLU mitigation measures compared to the GHG emissions in the 'with policy scenario'.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Reduced tillage and agroforestry GHG emission reductions (Gg CO ₂ e)	1.23	1.25	1.27	1.29	1.31	1.46	1.48	1.50	1.53	1.55	1.57
Afforestation; reforestation and grassland (restoration and conversion) GHG emission reductions (Gg CO ₂ e)	584.20	590.28	598.29	594.11	591.57	595.99	605.25	636.82	713.66	1456.12	1367.02
Total	585.43	591.53	599.57	595.41	592.89	597.46	606.74	638.32	715.18	1457.67	1368.58

4.2.2.4 METHODOLOGY USED TO QUANTIFY GHG EMISSION REDUCTIONS

Annual emission reductions due to land cover change were informed by land cover change analysis using HYBMAP data (Zhu et al. 2022); mitigation potential emission intensities (DEA, 2015); land area under reduced tillage (Kassam et al. 2019); and the land area under agro-forestry (FAO Global Forest Resources Assessment Eswatini, 2020).

4.2.3 IMPLEMENTATION CONSIDERATIONS AND IMPROVEMENTS

Vulnerable communities are not homogenous and face risks from climate change and due to being excluded from the social and economic systems (Ojha, 2021). EmaSwati who are socially and economically disadvantaged (women, children, people living with disabilities and poor communities) have been found to be the most sensitive to climate change. Investment to empower and promote these most vulnerable groups as champions will help to build community and social resilience that could build acceptance of projects, and build independent and resilient communities. Vulnerability Assessments can be used to promote dialogue, learning, and collaborative actions by involving a variety of stakeholders, e.g., government officials across departments, public health practitioners, local communities, scientists, and policy makers. implementation

Adaptation actions should not only change local practice but should, apart from variations in socio-economic status, also consider differences in knowledge, worldviews and interests, developing projects that incorporate social learning. This will encourage adoption in communities when scaling up projects. Social learning also provides opportunities for people to share local ecological/traditional/expert knowledge which enhances people's awareness about climate change, and may improve adaptive capacity.

A strong, science-driven, stakeholder-informed Climate Change Bill should be developed and implemented to provide a platform for mainstreaming climate action (Armstrong, 2021). This process should ensure that the process and results are transparent, informed by the latest IPCC findings, and link directly with all NDC goals and priority areas to create an enabling environment.

Armstrong (2021) also recommends the development of a Green Recovery that could dovetail with, or even replace, the current Post-COVID Economic Recovery Plan to ensure a more sustainable strategy for national development that is in line with the NDCs and ultimately results in the climate-proofing of the economy, infrastructure, jobs, and livelihoods of the private sector and Eswatini as a whole (Armstrong, 2021).

5 OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVE OF THE CONVENTION

5.1 TRANSFER OF TECHNOLOGIES

In Eswatini, last technology needs assessment (TNA) was done between 2015 2018 and focused both on mitigation and adaptation. Under adaptation, sectors of water, agriculture and forestry & biodiversity were prioritised. Under mitigation, energy, waste and Land Use, Land Use Change and Forestry (LULUCF) were prioritised.

The technologies prioritised under adaptation were as follows:

Table 5-1: Priority Climate Adaptation Technologies by Sector

Num	Sector	Technologies prioritised
1	Water	Wetlands restoration and protection
2		Rainwater harvesting
3	Agriculture	Conservation agriculture
4		Micro and drip irrigation
5	Forestry and biodiversity	Agroforestry
6		Conservation of genetic resources

The technologies prioritised under mitigation were as follows:

Table 5-2: Priority Climate Mitigation Technologies by Sector

Num	Sector	Technologies prioritised
1	Energy	Energy efficiency building insulation
2		Power generation –

		combined heat and power
3		Solar Photovoltaic (PV)
4	Waste	Waste sorting
5		Composting
6	LULUCF	Agroforestry
7		Urban forestry

Technology action plans (TAP) were developed for each of the above technologies, informed by extensive stakeholder engagement and a barrier and enabling framework analysis. The final outputs were published in 2018 and is available on the UNEP Denmark Technical University (DTU) websites for download.

5.1.1 IMPLEMENTATION

Progress has been made in adopting and implementing prioritised technologies under both adaptation and mitigation through the TNA process. In this section, some of the prioritised technologies are included with examples of projects which supported the implementation. Wetlands restoration and protection has been undertaken by a number of projects including by Matsapha Town Council, where “silent parks” are being created around wetlands for birdwatching and exercise (jogging/walking). Supported by the Environment Fund (housed within Eswatini Environment Authority), community led wetlands rehabilitation and tree planting for reducing soil erosion have been ongoing. Eswatini Environment Fund approved projects for 2022/23 include Sankolweni wetland, Bhidlilili wetland, Lusitini donga (eroded gully), Yonge Nawe Manyeveni donga and Nkambeni Donga rehabilitation projects. Such initiatives help preserve Eswatini’s wetlands. Additionally, NGOs are also supporting wetlands rehabilitation through their various donor funded projects. Also notable are the wetlands restoration work done through Eswatini Water & Agricultural Development Enterprise (EWADE).

Rainwater harvesting is also supported through the Environment Fund and is being implemented as part of several projects including the India Brazil and South Africa (IBSA) funded project implemented through National Disaster Management Agency (NDMA) and partners Wateraid and Africa Cooperative Action Trust. Additionally, NGOs and schools are also implementing this through donor funded projects.

The Ministry of Agriculture has been promoting conservation agriculture in the country through capacity building in collaboration with development partners such as FAO, COMESA and UNDP and through the Resilient Food Systems (RFS) programme implemented by EWADE. Through the RFS, a training programme in the Manzini, Lubombo and Shiselweni regions were conducted in 2019.

Within each constituency, 10 farmers were trained and supported as lead farmers within their communities, with a particular emphasis on developing the capacity of women and elderly farmers. Led by the Chieftdom Development Unit, these farmers went through vigorous theoretical and practical training. Held at demonstration plots in each chieftdom, the practical training sessions centred around a learning-by-doing approach and encouraged experimentation. Farmers were able to apply the conservation agriculture approaches and techniques learned in the classroom, such as minimal soil disturbance and intercropping, in a field setting and see tangible results.

Additionally, the Environment Fund is also supporting adaptation interventions including climate smart agriculture. Several NGOs such as World Vision are supporting climate smart agriculture interventions. The IBSA funded project trained 600 farmers on climate smart agriculture in 2022 in the Hhohho region.

However, some constraints remain in this technology's adoption. According to Dlamini et al. (2023), from a study conducted in Manzini region on adoption of conservation agriculture technologies by farmers, it was found that "the major constraints to the adoption of agricultural conservation technologies were low yield, lack of technical know-how, shortage of land for farming, insufficient finance for farm operations, lack of capital, lack of motivation by extension agents, high cost of capital and low level of income. Also, household size, farm size, farm experience, shared experience among the farmers, financial access and training of new technologies significantly influence Agriculture Conservation Technologies (ACTs)". They concluded that farmers with larger households have a higher chance of adoption when there is adequate training, an increase in the number of extension agents and a review of land reforms.

Micro and drip irrigation has been used in the country. The Climate Smart Market Led Agriculture (CSMA) Project at Mavulandlela Irrigation Scheme in the Hhohho Region and Intamakuphila Irrigation Scheme in the Manzini Region was a three-year project, which was funded through a partnership between the European Union and COMESA, coordinated by UNDP, and implemented by the Ministry of Agriculture through NAMBoard. saw the improvement of livelihoods for over 500 households in the communities. In 2021, a 16-hectare water-saving drip irrigation system was commissioned and build on a previously implemented scheme funded by the European Union known as Water Harvesting and Development Project. Private sector in agriculture sector has been investing in such technologies. The Royal Eswatini Sugar has invested in water saving technologies including drip irrigation and water scheduling. Furthermore, through the IBSA project drip irrigation was provided to 600 farmers in Hhohho region. Most of the agriculture related projects also incorporate composting and agroforestry as technologies in climate smart agriculture.

Based on the recommendations from Eswatini's TAPs, technologies of wetland protection, conservation agriculture, agroforestry and livestock selective breeding were integrated into the Eco-Lubombo Biosphere project under the auspices of UNESCO. As part of the Lubombo Biosphere project, Eswatini is implementing a National Wetland Policy, an agroforestry program to supply households with fruit and indigenous trees and free-range chickens as part of a Lubombo Eco-trails program (UNEP-DTU and UNFCCC Secretariat, 2019).

Eswatini is currently preparing to package the different components of the Eco-Lubombo project under a Green Climate Fund proposal for further implementation of these actions. Eswatini also included its TNA results in its Green Climate Fund 'country readiness report', which contributed to the country being given a grant under the Green Climate readiness Fund. The country also built on its TNA in a successful application to the Africa Climate Change Fund (ACCF) for a project with a value of USD 1.35 million (ibid).

The TNA also provided input into the development of the country's revised Nationally Determined Contributions (NDC) in 2021, which included all the technologies prioritized by the TNA. Further to agroforestry and tree planting being prioritised in the TNA, the NDC put a target of 10 million trees to be planted between 2021 to 2030. To implement this, the Dept. of Forestry in the Ministry of Tourism and Environmental Affairs (MTEA), conducted several tree planting campaigns and established mini forests in cities in collaboration with municipalities, embassies, private sector and schools. This was featured as a success story in the UNEP-DTU and CTCN publication titled, "Scaling up investment in climate technologies; Pathways to realising technology development and transfer in support of the Paris Agreement". The article explains how this simple, low-tech and inexpensive adaptation technology of tree planting was prioritised through a mix of top-down political will, volunteerism and bottom-up community action. Within a short period, many indigenous, fruit and selected non-invasive trees were planted in the country, in "Hlanyela Sihlahla, Wonge Imvelo" translated as "Plant a Tree and Save the Environment" in Eswatini campaign. The trees were planted in accordance with the Department of Forestry's tree planting manual. The initiative saw the mushrooming of "mini forests" in urban areas for the first time in Eswatini, driven by the voluntary efforts of diverse stakeholders. Until April 2023, over 4.6million trees have been planted, which gives an optimistic outlook to achieving the NDC target of 10 million planted by 2030 (Pullanikkatil and Nxumalo, 2021). Noteworthy is the Great Green Wall initiative, which Eswatini has joined in 2022 with a target of rehabilitating 200,000 hectares of land through planting trees. The initiative is spearheaded by Ministry of Agriculture with support from FAO.

Regarding solar PV installation, in Eswatini, 12 MW has been installed and 40MW are in the pipeline. Energy efficiency in buildings need to be emphasised and is not yet widely practiced. The Building Act was recently revised in the country; however, it fails to adequately incorporate energy efficiency and renewable energy, hence more work is required for uptake of these technologies.

Waste sorting is partially being done by municipalities. Some success has been noted by Matsapha and Mbabane cities where sorting of household waste and composting has been done. These initiatives need to be scaled up. Additionally, the Eswatini Environment Authority in collaboration with UNDP undertook a campaign to reduce single use plastics in the country. This campaign was successful and most of the supermarkets in the country promote reusable bags and do not provide single use plastics.

5.1.2 RECOMMENDATIONS

As it has been close to five years since the last TNA, Eswatini would need to undertake another TNA exercise to prioritise technologies as per current needs. The TAPs which will be developed from the new prioritised technologies need to be developed into bankable proposals. Mobilizing resources

is key to implementing technologies. Undertaking the TNAs alongside the NDCs will help support NDC implementation.

5.2 RESEARCH AND SYSTEMATIC OBSERVATION

Climate research and systematic observation are important components of Eswatini's efforts to understand and address the impacts of climate change. Research and systematic observations are vital processes for understanding climate change causes, effects, magnitude, and timing based on the best available scientific knowledge to adopt effective and progressive measures in response to climate threats. Eswatini has prioritised research and systematic observation in the national climate change policy and national climate change strategy and action plan.

Climate observations encompass a broad range of environmental observations, including a) routine weather observations which when collected over a long period of time, can be used to help describe a region's climatology; b) observations collected as part of research investigations to explain processes that contribute to the maintenance of climate patterns or to their variability; c) continuous observations of climate variables collected for the purpose of documenting long-term change; and d) observations of climate proxies, collected to extend the instrumental climate record in remote areas and back in time to provide information on climate change for longer time periods/scales. Climate systematic observation is critical for understanding the Earth's climate system and detecting changes over time. It helps to identify trends in temperature, precipitation, and other climate variables, as well as extreme weather events such as droughts, floods, and hurricanes. This information is critical to develop climate models, improve weather forecasting, and inform climate change policy decisions.

5.2.1 SURFACE BASED OBSERVATIONS

Eswatini, as part of the global community, contributes to the development and operation of global observing systems that combine data inputs from operational observing platforms to provide a comprehensive measure of climate system variability and climate change. Eswatini also collaborates with other regional and international partners to enhance observations and improve data quality and availability. By virtue of being a Member State of the Southern African Development Community (SADC) and of the World Meteorological Organization (WMO), Eswatini therefore constitutes an integral part of the regional and global system or network of the WMO programmes and structures.

The Eswatini Meteorological Service (EMS) is the national agency responsible for providing weather and climate information and services to the public, government agencies, and other stakeholders in Eswatini. The EMS is part of the Ministry of Tourism and Environmental Affairs.

5.2.1.1 STATION NETWORK

The country has a vast number of stations (56) well distributed across the country of which 45 are rainfall stations and 11 are climate stations. Among these stations only 15 consist of data covering the climatological period of 30 or more years. These stations include; Mbabane, Piggs peak, Nhlangano, Malkerns Research, Matsapha, Mphisi, Mananga, Mhlume, Siteki, Tikhuba,

Sithobelweni, Siphofaneni, Nsoko and Bigbend.

Furthermore, the country has a total number of 33 automatic weather stations across the country. 20 were recently installed in 2021 and 18 are currently operational. In 2010 the department installed 13 stations, however, only 9 are currently operating.

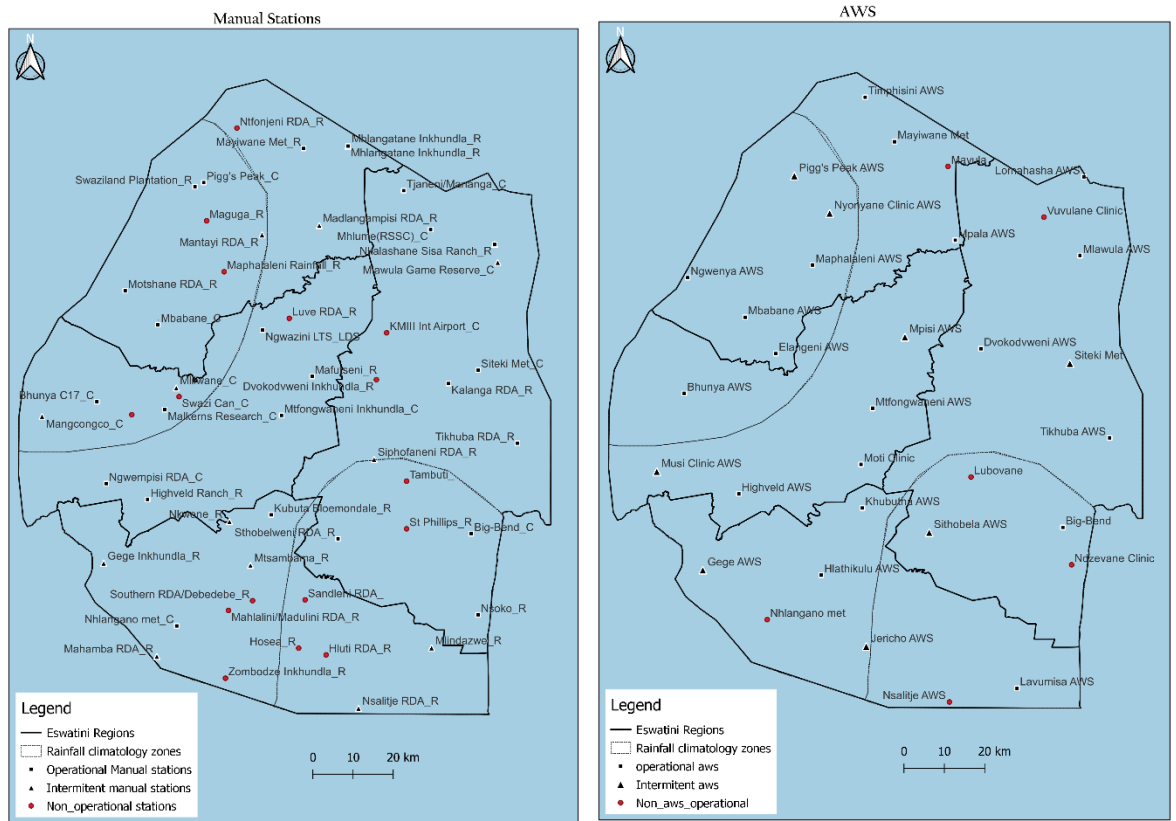


Figure 5-1: Manual Stations and AWS

5.2.1.2 OBSERVED DATA

- Average Temperatures
- Cumulative Precipitation
- Soil Temperatures at different depth
- Relative Humidity
- Atmospheric Pressure
- Solar Radiation
- Sunshine duration
- Wind direction, speed & totalizer
- Clouds
- Weather type

5.2.1.3 CHALLENGES AND GAPS

Table 5-3: Challenges Facing Manual and Automatic Weather Stations (AWS) in Eswatini

Manual	AWS
<ul style="list-style-type: none"> • Most stations are down • Shortage staff and payments • Trainings • Mercury Thermometers are still in use 	<ul style="list-style-type: none"> • Maintenance • Data Gaps • Resources • Institutional and technical capacity

5.2.2 DATA MANAGEMENT

The Climate Data Management Services (CDMS) has the mandate of managing climate data from all meteorological observation systems owned by Eswatini Meteorological Service and other partners in weather observations. Climate data is received through paper registers/forms, email, telephone and from Automatic Weather Stations (AWSs). Currently the department is using **Climsoft** and **Met cap** data base.

5.2.2.1 CHALLENGES

The Eswatini Meteorological Service (EMS) faces several challenges and constraints that can make it difficult to provide accurate weather and climate information and services to the public and other stakeholders. Some of these challenges include:

1. **Limited Resources:** Like many other meteorological services in Africa, the EMS faces limited financial and human resources to invest in weather and climate monitoring and forecasting activities. This can make it difficult to maintain and operate weather stations and other data collection systems, as well as to hire and retain qualified staff.
2. **Infrastructure Challenges:** The EMS may also face infrastructure challenges, including unreliable power supply, poor road networks, and limited telecommunication facilities. This can make it difficult to operate and maintain weather stations and other data collection systems.
3. **Data Quality:** Ensuring the quality of meteorological data is critical for accurate weather forecasting and climate monitoring. However, the EMS lacks the capacity to maintain and calibrate weather stations and other data collection systems, leading to potential errors and inconsistencies in the data.
4. **Inadequate technical capacity:** Building and maintaining the capacity of the EMS is crucial for ensuring that it can provide accurate and reliable weather and climate information and services. However, the EMS faces challenges in attracting and retaining qualified staff, as well as in providing training and capacity building programs. There is still a need for a

comprehensive training for the Meteorological Personnel who are doing the climate observation. This could be in the form of the World Meteorological Organization Certification (W.M.O Class 111). Most of the Observers have only in-house training, and the advanced training would help them produce quality and consistent meteorological observation/data.

5. Meteorologists and Climatologists in the climate section also need to be capacitated in downscaling outputs from regional and global climate centers. Training in merging of satellite data with satellite data would also improve the quality of the services provided by Eswatini Meteorological Services.

Overall, addressing these challenges will require sustained investment in the EMS, including infrastructure, human resources, and capacity building programs. Improved collaboration and partnerships with other meteorological services and organizations can also help to address data and information access challenges.

5.3 EDUCATION, TRAINING AND PUBLIC AWARENESS

5.3.1 EDUCATION

The role of education in addressing the challenges of climate change is recognised in Eswatini. As articulated in the national climate change policy, climate change education provides children and young people with the knowledge and skills to make informed decisions about how to adapt individual lives and ecological, social, or economic systems to a changing environment. The National Climate Change Strategy and Action Plan also sets out some strategic actions for climate change education which include integration of climate change knowledge into curricula at all levels and conducting training for practitioners with regard to mitigation and vulnerability and risk assessments.

Additionally, the Climate Change Unit under MTEA organizes workshops and dialogues for various stakeholders, including government officials, civil society organizations, private sector representatives, community leaders, and youth groups. These engagements facilitate knowledge sharing, exchange of best practices, and collaborative approaches to climate change adaptation and mitigation.

At the community level, the Climate Change Unit supports school clubs, farmer groups, women associations, and youth networks to promote participatory learning and grassroots action on climate change issues.

5.3.2 PRIMARY SCHOOL CURRICULUM AUDIT

The Ministry of Tourism and Environmental Affairs (MTEA), in collaboration with the Ministry of Education and the National Curriculum Centre, is working to incorporate climate change education into the national curriculum for primary schools, as well as teacher training programmes. With support from the ongoing National Adaptation Plan (NAP) project, Eswatini initiated the

development of a National Primary School Climate Change Integration Guide. Through extensive training and stakeholder consultations, the country identified gaps and opportunities to integrate climate change topics into Grades 1 to 5.

A Climate Change Integration Guide was developed specifically for Grades 1 to 5. Additionally, a draft manual was created for Grades 6 and 7, and the country is actively seeking funding opportunities to finalize and implement climate change integration in these grades. This initiative aims to enhance the knowledge and skills of both learners and educators on the causes, impacts, and solutions related to climate change, promoting awareness and fostering action-oriented education.

5.3.3 UNIVERSITY MASTER'S PROGRAMME

The University of Eswatini has launched two Master's programmes on Climate Change. These programmes aim to build advanced expertise in climate change science, policy, and adaptation strategies, contributing to national and regional efforts to address climate-related challenges through research, innovation, and capacity building.

These are some of the examples of what is being done in Eswatini on climate change education. However, there are still gaps and challenges that need to be addressed, such as limited resources, data availability, coordination mechanisms, and monitoring and evaluation systems. To support the existing initiative there is a need for the government to strengthen institutional capacity for climate change education and training, by developing policies, strategies, guidelines, and tools to support the design, delivery, and evaluation of climate change education programmes.

5.3.4 CHALLENGES

Education is a critical factor in leveraging climate change ambition. Considering the cross-cutting nature of climate change and sustainability, it is necessary to develop climate change related skills, capacities and knowledge in the curriculum of courses related to environmental issues, and also to courses that are not directly linked to such issues. This will help to inform a wide range of sectors on the crosscutting nature of climate change issues. Currently educational programs within the Universities and colleagues in Eswatini still delineate the concepts of sustainability and climate change only to specialized courses and environmental degrees.

There is still much to do in leveraging partnerships between the private sector and research centres. Regulations and incentives would clearly foster cooperation and engagement among governments, private sector actors and academia, positively contributing to the advancement of the goals established in the Paris Agreement. There is also a need to strengthen capacities with regards to digitalization, innovative agricultural techniques, water management and energy reconversion. Accordingly, a set of related actions could include increased financial support for innovation projects, development of cross-cutting climate change approaches in professional degrees, and high-level dissemination of climate change-related impacts across economic sectors.

5.3.5 AWARENESS RAISING

Climate change awareness programs are important because they help to educate individuals and communities about the impact of climate change on the environment and human societies. By raising awareness of the issue, these programs can motivate individuals and communities to take action to reduce their carbon footprint and advocate for policies and programs that promote sustainable development. The national climate change policy calls for increased awareness and understanding of climate change impacts across all sectors and at all levels. The national climate change strategy has prioritised the four areas for public awareness.

6. Environmental education in schools: This can involve integrating climate change education into school curricula, organizing school-based activities that promote environmental awareness, and encouraging students to participate in environmental initiatives.
7. Public education campaigns: These can involve developing and distributing informational materials about climate change, such as brochures, fact sheets, and videos.
8. Community outreach initiatives: This can involve organizing public forums and workshops, collaborating with local community organizations, and engaging with community leaders to raise awareness about climate change.
9. Social media campaigns: Social media platforms such as Facebook, Twitter, and Instagram can be used to reach a wider audience with targeted messages about climate change and promote climate action.

The Ministry of Tourism and Environmental Affairs through the climate change unit has been conducting climate change awareness campaigns through various media platforms, such as radio, television, newspapers, and social media, to reach out to different segments of the population and inform them about the challenges and opportunities of climate change. The Ministry also partners with other stakeholders in celebrating all relevant environment and climate change days, such the World Environment Day, Earth Hour, World Forest Day, World Water Day, world meteorological day and many more.

Overall, climate change awareness programs are an important tool in addressing climate change. By raising awareness and understanding of the issue, these programs can help to mobilize individuals and communities to act, advocate for policies and programs that promote sustainable development, and ultimately build a more resilient and sustainable future. To achieve the national aspiration for awareness raising the country needs to increasing access to information, conducting campaigns in local languages, working with traditional leaders to integrate climate change messages into their practices, providing funding and resources for awareness campaigns, and developing education and training programs for individuals and communities.

5.4 CAPACITY BUILDING

The Government of Eswatini is committed to enhance the knowledge, skills, and resources of

individuals, institutions, and communities across the country to address climate change challenges and opportunities. In the past few years, several capacity building initiatives have been implemented with support from various partners. The table below summarizes these initiatives.

Table 5-4: Climate-Related Training and Capacity-Building Initiatives by Development Partners

	DONOR	FOCUS	ACTIVITY /OBJECTIVE
1	FANRPAN COMESA	Policy and NDC	Training workshop on NDC project development and investment mobilisation held under the theme: Transforming Paris Agreement Aspirations into Action through the implementation of the Nationally Determined Contributions in COMESA Member States
2	GIZ	Mitigation: Waste Sector	The training was aimed at improving Eswatini's climate data management system in the Waste Sector to ensure enhanced data gathering and to improve the quality of reporting in the waste sector for Eswatini's National Greenhouse Gas Inventory. It targeted stakeholders in data collection, data management and compilation of waste information. The stakeholders included various municipalities and town boards, the private sector, national authorities, government ministries tertiary and research institutions as well as waste management companies.
3	UNFCCC - GHG MANAGEMENT INSTITUTE	Mitigation	Trainings of National Stakeholders on the BUR, National Communications and overall UNFCCC processes for inclusion in the roster of experts. Certification of experts on the GHG inventory
4	UNFCCC and UNEP-GSP	Mitigation: MRV	The first Southern Africa Regional MRV Network Training and Peer Review workshop as part of the provisions Southern Africa MRV Network, in partnership with UN Environment Global Support Programme (GSP), in collaboration with the United Nations Framework Convention on Climate Change (UNFCCC) . The Southern Africa MRV Network, comprised of 13 countries, including Eswatini, Mozambique, Zambia, South Africa, Lesotho, Mauritius, Seychelles, Comoros, Zimbabwe, Malawi, Botswana, Angola and Madagascar. The Main objectives of this workshop included; Provide specific training on use of 2006 IPCC GHG Guidelines software Conduct peer review for national draft reports for selected countries Share challenges and good lessons on experiences on national MRV institutional arrangements. Identify priority

	DONOR	FOCUS	ACTIVITY /OBJECTIVE
			<p>areas for capacity building in the North and Central Africa region and develop a plan addressing the identified gaps in the region</p> <p>Identify specific capacity needs and develop a schedule of in-country or bilateral training</p>
5	NDC Partnership Climate Action Enhancement Package	Mitigation	<p>Training on the “Low Emissions Analysis Platform” (LEAP) model. The training primarily focused on how LEAP can be used to model energy systems, and estimate emissions of greenhouse gases (GHGs), short-lived climate pollutants (SLCPs) and air pollutants. Participants learnt how LEAP can model energy supply and demand, and greenhouse gas emissions associated with them. One session (15th Oct) focused on how LEAP can be used to model non-energy sector emission sources. This was attended by participants including Government officials and national consultants engaged by UNEP as well as participants from relevant sectors and the training was virtual.</p>

	DONOR	FOCUS	ACTIVITY /OBJECTIVE
6	NDC Partnership Climate Action Enhancement Package	Mitigation	<p>Greenhouse Gas Mitigation Assessment Capacity Building virtual trainings on the Energy, Waste and Livestock Sector for National GHG Inventory Expects. An economy-wide GHG mitigation assessment has been conducted, quantifying GHG emissions and evaluating mitigation options in the energy, industrial processes (IPPU), agriculture, forestry and land-use (AFOLU), and waste sectors.</p> <p>The GHG mitigation assessment has updated the estimate of historical GHG emissions, providing the most up-to-date basis for projecting emissions into the future.</p> <p>The baseline, or reference projection of GHG emissions in Eswatini to 2030 has been revised, based on key national documents, and accounts for the impact of COVID-19 on Eswatini's economic outlook.</p> <p>An extensive assessment of policies and measures has been undertaken. The GHG mitigation assessment evaluates the GHG emission reduction potential of key plans and policies that have been put in place since 2015 to assess how these plans could contribute to reducing GHG emissions in Eswatini.</p> <p>The GHG mitigation assessment also evaluates emission reductions of short-lived climate pollutants (SLCPs), such as black carbon, and health-damaging air pollutants that are emitted alongside GHGs. The inclusion of these additional pollutants allows for an evaluation of the local benefits that can be achieved in Eswatini from taking action to reduce GHGs to be evaluated, highlighting important local co-benefits from climate change mitigation. The Mitigation Assessment identified 13 mitigation measures which were included in the NDC. The mitigation assessment work included data collection, stakeholder workshops, data analysis and capacity building through webinars.</p>
7	Commonwealth Secretariat	Mitigation, Adaptation	<p>Embedded Climate Finance Advisor at MTEA. Commonwealth Secretariat provided a Climate Finance Advisor, since July 2020 and he will be undertaking the Climate Public Expenditure and Institutional Review (CPEIR) and assisting the country to develop proposals to access</p>

	DONOR	FOCUS	ACTIVITY /OBJECTIVE
			climate finance.
8	NDC Partnership (CAEP)	Mitigation, Adaptation	Gender assessment of Eswatini's climate policy and planning instruments.
9	UNEP-GSP	Mitigation	Trainings were undertaken for national experts to build their capacity on the use of the 2006 IPCC guidelines and methodology, data sharing protocols and QA/QC procedures. 2006 GHG Inventory IPCC Software training.
10	UNEP-GSP	Mitigation	Trainings were undertaken for national experts to build their capacity Mitigation Assessment in the Energy and Waste workshop)
11	UNEP-GSP	Mitigation	V&A assessment training workshop for national Stakeholders on the Health, Agriculture and Tourism Sectors
12	ACCF	Climate Finance	This was a training of trainers on climate finance. Its overall objective was to build capacity and equip participants with the necessary knowledge, practical skills and tools to access sources of climate finance and eventually submit a funding proposal to the Green Climate Fund (GCF).
13	NDC Partnership Climate Action Enhancement Package – UNEP DTU	Climate Finance	Training on development of GCF concept note. The main objective of this training was to equip stakeholders with the necessary skills and knowledge on how to design and develop a GCF project. Participants were trained on the GCF investment criteria and on the requirements for GCF concept note.

5.5 INFORMATION AND NETWORKING

Public participation and access to information are crucial for effective climate action. By engaging individuals and communities, promoting informed decision-making, fostering innovation, promoting accountability and transparency, and encouraging behavioural change, we can create a more sustainable future and mitigate the impacts of climate change. Those affected by the decision have a right to be involved in the decision-making process. By engaging a wide range of stakeholders and ensuring transparency and accountability, climate policies and strategies can be better informed, more effective, and more widely supported.

As a result, public participation in the policy-making process is the key commitment that has been carried out in various climate policy development, such as stakeholders' consultation and engagement during the preparation of this national communication, national adaptation plan and the nationally determined contribution. Stakeholder consultation and engagement by Eswatini's National Climate Change Committee provides a platform for public participation in climate action. The committee brings together stakeholders from government, civil society, and the private sector

to discuss and coordinate climate change actions, and to ensure that the public's perspectives are taken into account in decision-making.

6 CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

Eswatini faces several challenges in understanding, mitigating, and adapting to predicted climate change. These challenges arise from gaps in knowledge and understanding, and our ability to address them is constrained by a lack of capacity and research infrastructure, and an inability to communicate understanding and to facilitate the implementation of solutions and action. In particular, there is a need to develop human capital, generate new and relevant knowledge, facilitate the establishment of research infrastructure, and bridge the divide between research results and socio-economic outcomes

With the numerous opportunities there are still challenges retrogressing the climate action initiatives. The gaps revolve around institutional arrangements, finance, capacity building and knowledge sharing, technology and infrastructure and integrated planning and data management. Specifically: lack of sustainable funding especially from the national governments; capacity limitations in terms of lack of proper institutional arrangements to tackle climate change; weak inter-sectoral collaborations from the public sector, private sector to local communities; poor involvement of the local communities who are more vulnerable to climate change; and gender inequality in the context of climate change mitigation and adaptation and capacity building are some of the setbacks.

At the national level there is generally inadequate information on the potential cost of planned adaptation responses to climate change, especially in relation to uncertainty about a potentially wide range of needs for infrastructure upgrade or new infrastructure development. A comprehensive assessment of these needs and their potential costs and technical and capacity implications could draw usefully from information on the impacts and vulnerability information provided in this communication. An estimate of the average annual cost of climate-related events (storms, floods, droughts, and fires) in Eswatini cannot be made with any level of accuracy, due to a lack of reliable and comprehensive data.

Eswatini's capacity to meet its reporting obligations to the United Nations Framework Convention on Climate Change has gradually improved since its first national communication in 2002. Currently, the compilation process is led by national experts who work with sector working groups that are drawn from various Ministries, Departments, and Agencies (MDAs). However, a number of constraints and gaps remain. These are outlined in this section.

6.1 Barriers, measures, and support needed toward climate change adaptation in Eswatini

Table 6-1: Barriers, measures, and support needed toward climate change adaptation in Eswatini.

Priority areas for adaptation	Barriers, constraints, and challenges	Measures needed to overcome barriers	Support needed	Target audience
Institutional, technical, and human resource capacity	<ul style="list-style-type: none"> → Low institutional, technical, and human capacity to implement climate change adaptation → Limited understanding and awareness of climate change impacts and adaptation approaches 	<ul style="list-style-type: none"> → Build capacity of national stakeholders on climate change adaptation → Strengthen institutional capacity (human resources, skills development, and data management), technical capacity (skills transfer, modelling for future water risks, baseline assessments, Post-Disaster Needs Assessments), capacity building (e.g., for climate-smart agriculture/conservation farming) → Build awareness and understanding of climate change among various stakeholders through education, training, and public awareness 	<ul style="list-style-type: none"> → Capacity building on climate change adaptation → Skills development on climate modelling and baseline assessment → Information materials on climate change (infographics, policy briefs, newsletters) 	Line ministries, NGOs, private sector
Legal, policy, and institutional frameworks	<ul style="list-style-type: none"> → Lack of an overarching legal framework for climate change → Fragmented policy development → Poor integration of climate change adaptation measures into the various sectoral policies and national development planning and budgeting 	<ul style="list-style-type: none"> → Integration of climate change adaptation measures into the various sectoral policies and national development planning and budgeting → Strengthening legal and institutional framework for effective coordination and implementation of climate change adaptation and mitigation actions, programs, and initiatives → Review and update policy frameworks 	<ul style="list-style-type: none"> → Programs to strengthen legal and institutional frameworks for climate change 	Line ministries

Priority areas for adaptation	Barriers, constraints, and challenges	Measures needed to overcome barriers	Support needed	Target audience
Monitoring, reporting, and verification for climate change adaptation	<ul style="list-style-type: none"> → Inadequate data collection and data management systems → Lack of software, modelling skills, and telemetry systems for measurement, which impacts the predictions of models and early-warning systems → Monitoring and reporting systems for climate change reporting are fragmented 	<ul style="list-style-type: none"> → Improvement of data collection and data management systems → Monitoring systems → Capacity building → Climate modelling 	<ul style="list-style-type: none"> → Database management training → Software development → Climate modelling 	Line ministries and research institutions
Climate finance	<ul style="list-style-type: none"> → Limited capacity to access climate finance → Financial needs in Eswatini are not well documented → Low technical capacity to develop climate change adaptation proposals → Climate change has not been directly mainstreamed into the national budget; hence, funding is not sufficient to implement climate change-related projects such as investments in large water-storage infrastructure 	<ul style="list-style-type: none"> → Provision of mechanisms for mobilizing and accessing support for technology development and transfer, capacity building, and financial resources from the international community and other sources → Integration of budgeting for climate change adaptation measures into the various sectoral policies and national development planning 	<ul style="list-style-type: none"> → Training to develop climate change proposals → Studies to assess the country's climate change adaptation financial needs 	Line ministries, research institutions, NGOs
Indigenous and traditional knowledge systems	<ul style="list-style-type: none"> → Poor integration of traditional knowledge into climate change adaptation → Limited capacity on the integration 	<ul style="list-style-type: none"> → Development of traditional knowledge systems and conventional science in adaptation research and development 	<ul style="list-style-type: none"> → Programs to assess traditional knowledge systems and how to target them for climate change adaptation 	Research institutions, line ministries, NGOs, traditional custodians
Private sector engagement	<ul style="list-style-type: none"> → Limited private sector engagement 	<ul style="list-style-type: none"> → Promote private sector engagement and enhance private sector capacities in developing strategies 	<ul style="list-style-type: none"> → Technical assistance to develop a policy and strategy for private 	Line ministries, private sector, NGOs

Priority areas for adaptation	Barriers, constraints, and challenges	Measures needed to overcome barriers and action plans for climate action	Support needed	Target audience
Early-warning systems	<ul style="list-style-type: none"> → Lack of technical capacity to develop early-warning systems → Early-warning systems are not integrated (i.e., operating in silos) → The country's response capacity to early-warning systems is low 	<ul style="list-style-type: none"> → Enhance preparedness and emergency response to climate change, hazards, impacts, and disasters through a multi-hazard early-warning system → Early-warning systems and preparedness policies → Integrate climate change information into early-warning systems 	<ul style="list-style-type: none"> → Development of integrated multi-hazard early-warning systems → Development of early-warning systems and preparedness policies. → Modernization of the Meteorological service 	Line ministries and departments
Systemic risk assessment	<ul style="list-style-type: none"> → Inadequate technical capacity to assessment climate risk 	<ul style="list-style-type: none"> → capacity-building on screening for climate risks and implementing adaptation. 	<ul style="list-style-type: none"> → Training on systemic risk assessment → Training climate modelling → Modernization of the meteorology service 	Sector ministries Department of Meteorology
Assessment of adaptation costs and benefits	<ul style="list-style-type: none"> → Inadequate capacity to assess cost and benefits of adaptation 	<ul style="list-style-type: none"> → Adequate Capacity on cost benefit assessment 	<ul style="list-style-type: none"> → Training on costing of adaptation action 	Economist and sectoral planners in the different ministries

It has been identified that there are gaps and constraints in policies, laws and regulations for effective implementation to address climate change. In this respect, followings are important to be carried out;

1. Updating existing National Policies and strategies with the aim of integrating climate change across sectors.
2. Updating the national climate change strategy and action plan
3. Enacting a law on climate change for Eswatini. It is important to note that Climate Change management bill is being drafted at present. It will be crucial for the Act to have a clear mandate and powers vested in it empower effective ground level climate actions.
4. Establishing a coordination mechanism under the proposed Act for

the implementation of laws and policies that are related to climate change with robust actions against those violating the provisions of the Act

Addressing these gaps and barriers can enable Eswatini to build capacity and resilience, increase the effectiveness of her adaptation measures, and protect vulnerable communities from the impacts of climate change.

6.2 Technical or capacity support needs

Eswatini's transition towards low carbon, climate resilient development pathways will need a host of capacities and the country faces many institutional, capacity, and technology constraints in addressing challenges related to climate action. The country has conducted assessments to identify its capacity needs and barriers. Under the Technology Needs Assessments (TNA) process, Eswatini's needs assessments have focused on feasible technology options and barriers for mitigation and adaptation. Similarly, the National Capacity Needs Self-Assessment and the Third National Communication to UNFCCC report (2016) highlighted many of the capacity challenges of the country. Eswatini's Adaptation communication to the UNFCCC highlighted the need to understand the barriers and gaps in the implementation of climate change adaptation to enable the proper identification of support needed for adaptation action. The technical report for the revised NDC outlines recommendations from these assessments which include setting up a comprehensive cost capacity building programme for various stakeholders, developing resource mobilization plan for key institutions dealing with climate change, and building technical skills in numerical weather prediction and modelling (GoE-MTEA, 2021b).

Based on the findings and recommendations of these assessments, current challenges and capacity gaps in climate action can be summarized in the following categories:

- Technical Knowledge and skills;
- Data management and Management Information Systems (MIS);
- Technology transfer and diffusion
- Institutional capacity, technical, and human resource capacity;
- Effective Measurement, Reporting and Verification (MRV) System;
- Finance;
- Legal, policy, and institutional frameworks;
- Private sector engagement;
- Early warning systems.

The Technology Needs Assessment for Eswatini to identify technology priorities for adaptation and

mitigation sectors included delineating capacity building requirements (Pullanikkatil, 2018). Based on this assessment, the following specific needs related to technology and capacity building for adaptation and mitigation were identified (Note: the needs listed in this chapter reflect needs of prioritised sectors only highlighted in the TNA and not needs across all sectors in the country). The technical and capacity building needs for Eswatini are summarised for adaptation and mitigation in Table 6-2 and Table 6-3, respectively.

Table 6-2. Technical and capacity building needs for adaptation

ADAPTATION
Technology needs
Wetlands Restoration and Protection (WRP) – Undertake WRP for five chosen medium size wetlands thereby improving the country's preparedness for flood control, biodiversity management and enhancing micro-climatic conditions
Rainwater harvesting (RWH) – Providing subsidized RWH systems for 20,000 households and demonstration of systems in 100 institutions with the aim of improving access to water and creating awareness about the benefits of such practices
Conservation Agriculture (CA) – Providing access to mechanised planters that can be hired by farmers and creating demonstration CA sites to showcase improved / sustainable farming practices and thereby transform the sector to become climate resilient in the long run
Micro and Drip Irrigation – Provide access to subsidized irrigation technology to improve farm yield and water use efficiency
Agroforestry techniques to increase crop production, improving soil quality and thereby enhancing the economic gain for farmers and preparing the sector from flood and other disasters
Conservation of genetic resources – Building a National Botanical Garden and Field Gene Bank to preserve genetic plants of Eswatini and train officials in conservation techniques
Capacity building needs
Training of staff in plant genetic resources management, plant ecology, plant taxonomy and ethnobotany
Training of National Water Authority on water use efficiency and resource management
Training of staff and field officers for scaling up implementation of micro and drip irrigation technology across the country and designing of awareness programmes for farmers
Building capacity of government staff implementing policies and measures such as the National Water Act and Integrated River Basin Management
Build capacity of education system to include RWH in the curriculum and impart practical training for students on the technology implementation
Build capacity of officials to identify financing instruments for implementing NDC strategies, targets, and actions

Table 6-3. Technical and capacity building needs for mitigation

MITIGATION
Technology needs
Access to state-of-the-art building insulation materials to improve energy efficiency across buildings
Access to state-of-the-art renewable energy generation technologies such as solar PV, wind, and biomass
Access to affordable clean transport technologies such as electric 2-wheelers and 4-wheelers
Access to waste sorting and composting technology for handling increasing solid waste load from the country
Capacity building needs
Build capacity of officers to develop energy efficiency standards, regulations, and policies
Build capacity of construction sector professional in improving energy efficiency performance of buildings through insulation and other technologies
Build skill of artisans and engineers of power production from combined heat and power using biomass, solar, wind and other emerging technologies

Build skill of energy sector officers on energy planning using globally practised energy models
Build capacity of officers to access renewable energy and climate change funds such as the GCF for implementation of projects
Develop capacity building programmes for training, testing and accreditation of solar PV installation officials
Build capacity of waste sector stakeholders on diversifying waste streams and conversion to useful products and creating a circular economy value chain

Eswatini has undertaken several comprehensive assessments and technical studies to identify climate risks, adaptation needs, and gaps that inform decision-making which included the Technology Needs Assessment (2016-2018). Eswatini's TNA, completed in 2018, emphasized the importance of adaptation and mitigation and identified key sectors in adaptation (agriculture, water, and forestry & biodiversity) and mitigation (energy, waste, and Land Use, Land-Use Change and Forestry (LULUCF)). The technology assessment process included the identification of barriers hindering the acquisition, deployment, and diffusion of prioritized technologies (Barrier Analysis and Enabling Framework (BAEF) reports) and included accompanying Technology Action Plans (TAPs) for both adaptation and mitigation².

The TNA for adaptation prioritised the following technologies:

- Water sector integrated river basin management, rooftop rainwater harvesting, and wetland restoration;
- Agriculture sector livestock and poultry selective breeding, conservation agriculture, and micro and drip irrigation;
- Forestry and biodiversity sector agroforestry, conservation of genetic resources, and alien invasive species management.

The TNA for mitigation prioritised the following technologies:

- Energy (Power generation subsector) – Hydro power, biomass combined heat, and power, solar PV, and energy efficient buildings;
- Waste – Separate/reuse/recycle, composting, and semi-aerobic landfill;
- LULUCF – agroforestry, urban forestry, and grazing land management.

The high impact of Eswatini's TNA on subsequent climate-related activities was highlighted in Gregersen, L. et al. (2019) and includes the following examples:

- Based on the recommendations of Eswatini's Technology Action Plans (TAPs) for mitigation and

adaptation, technologies integrated into the Eco-Lubombo

- Biosphere project under the auspices of UNESCO includes technologies related to wetland protection, conservation agriculture, agroforestry, and livestock selective breeding.
- As part of implementation of the TNA results, it has resulted in the development of the National Wetland Policy.
- Developing a Green Climate Fund Proposal for further implementation of actions which form part of different components of the Eco-Lubombo Biosphere project.
- The TNA results were included in a Green Climate Fund 'country readiness report' which contributed to the country being given a grant under the Green Climate Readiness Fund.
- Eswatini built on its TNA in a successful application to the Africa Climate Fund for a project with a value of USD 1.35 million.
- Inclusion of TNA as an input to the country's Nationally Determined Contributions and all technologies prioritised were included in the NDC.

7 References

Acha-Anyi, P.N. and Dlamini, N.N., (2019). Festival tourism as an instrument of sustainable livelihood in Eswatini. *Geo Journal of Tourism and Geosites*, 26(3), pp.849-860.

African Development Bank. (2020). Country strategy paper 2020 2024.

Alvaro and Sasanne (2008). <https://www.tandfonline.com/doi/full/10.1080/09669580802651681>

Armstrong, DM. 2021. Green Growth and Policy Instruments in Eswatini. Draft Report. FAO, NDC Partnership

Barnes, E. A., and Polvani, L. (2013). Response of the midlatitude jets, and of their variability, to increased greenhouse gases in the CMIP5 models. *Journal of Climate*, 26(18). <https://doi.org/10.1175/JCLI-D-12-00536.1>

Calderwood, L.U. and Soshkin, M. (2019, September). The travel and tourism competitiveness report 2019. World Economic Forum.

Castro and Byenkya, (2019). Draft Eswatini country strategic plan (2020–2024). World Food Programme. <https://docplayer.net/163385741-Draft-eswatini-country-strategic-plan.html>

CDC, nd. Assessing Health Vulnerability to Climate Change. A Guide for Health Departments. <https://www.cdc.gov/climateandhealth/pubs/assessinghealthvulnerabilitytoclimatechange.pdf>

Central Statistics Office (CSO), 2017. The 2017 Housing and Population Census, Vol 2-6.

Chaitoo, R., and McGinn, A. (2022). Development of a strategy for sustainable tourism in Eswatini (ESW-006). REPORT AND RECOMMENDATIONS.

Chemura, A., Nangombe, S. S., Gleixner, S., Chinyoka, S., and Gornott, C. (2022). Changes in Climate Extremes and Their Effect on Maize (*Zea mays* L.) Suitability Over Southern Africa. *Frontiers in Climate*, 4. <https://doi.org/10.3389/fclim.2022.890210>

Chiluwe, M. (2021). Final report on an assessment of cost benefit and macro-economic impacts of climate change in Eswatini. Comesa support to Eswatini's NDC revision

COMESA. (2021). Final Report on an assessment of cost benefit and macro-economic impacts of climate change in eSwatini. Common Market for Eastern and Southern Africa, Lusaka, Zambia.

COP, (2021). Eswatini Country Operational Plan (COP) 2021 Strategic Direction Summary. May 03,

2021

Cross-border Road Transport Agency. (2019). SWAZILAND HANDBOOK.

DEA (2015) National Terrestrial Carbon Sink Assessment Department of Environmental Affairs, Pretoria, South Africa.

Del Barrio, M.J., Devesa, M. and Herrero, L.C. (2012). Evaluating intangible cultural heritage: The case of cultural festivals. *City, Culture and Society*, 3(4), pp.235-244.

Dlamini W.M.D. (2017). Geomorphological heterogeneity and biodiversity in Swaziland. Conference proceedings of the South African Association of Geomorphologists. Manzini, Swaziland.

Dlamini, S.I.; Huang, W.-C. (2019). A Double Hurdle Estimation of Sales Decisions by Smallholder Beef Cattle Farmers in Eswatini. *Sustainability*, 11, 5185. <https://doi.org/10.3390/su11195185>

Dlamini, W.B., Migiro, S. and Tefera, O. (2020). Balanced scorecard usage for hotel and tourism small and medium enterprises growth in ESwatini (Former Swaziland): A Proposed conceptual framework. *African Journal of Hospitality, Tourism and Leisure*, 9(1), pp.1-13.

Dlamini, W.M.D. (2012). Action plan for implementing the convention on biological diversity's programme of work on protected areas. Swaziland Environment Authority. <https://www.cbd.int/doc/world/sz/sz-nbsap-powpa-en.pdf>

Dlamini, W.M.D. (2021). Climate risk mapping. Final report, August, 2021. FAO, NDC Partnership.

Donat, M. G., Alexander, L. V, Yang, H., Durre, I., Vose, R., Dunn, R. J. H., Willett, K. M., Aguilar, E., Brunet, M., Caesar, J., Hewitson, B., Jack, C., Tank, A. M. G. K., Kruger, A. C., Marengo, J., Peterson, T. C., Renom, M., Rojas, C. O., Rusticucci, M., Kitching, S. (2013). Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset. *Journal of Geophysical Research Atmospheres*, 118(5). <https://doi.org/10.1002/jgrd.50150>

Dosio, A.; Jones, R.G. et al. (2019). What can we know about future precipitation in Africa? Robustness, significance and added value of projections from a large ensemble of regional climate models, *Climate Dynamics* 53: pages5833-5858 <https://link.springer.com/article/10.1007/s00382-019-04900-3>

Duan, Y., Ma, Z., and Yang, Q. (2017). Characteristics of consecutive dry days variations in China. *Theoretical and Applied Climatology*, 130(1-2). <https://doi.org/10.1007/s00704016-1984-6>

Du-Pont, T. and Sacolo, T. (2019). An Insight into Community-Based Ecotourism in Eswatini: Theory versus Practice. <https://www.separc.co.sz/wp-content/uploads/2020/06/An-Insight-into-Community-Based-Ecotourism-in-Eswatini.pdf>

Engelbrecht, F., Adegoke, J., Bopape, M. J., Naidoo, M., Garland, R., Thatcher, M., McGregor, J., Katzfey, J., Werner, M., Ichoku, C., and Gatebe, C. (2015). Projections of rapidly rising surface temperatures over Africa under low mitigation. *Environmental Research Letters*. <https://doi.org/10.1088/1748-9326/10/8/085004>

ENTC (2022). Conserving Eswatini's Natural and Cultural Heritage. Available at: <http://eswatininaturereserves.com/>

ESEPARC (2021) Eswatini National Circumstances on Climate Change. Final draft report - February 2021. Eswatini Economic Policy Analysis and Research Centre.

Eswatini Ministry for Natural Resources and Energy. (2018). National water policy report 2018.

Eswatini Tourism Authority. Eswatini Tourism Research: Annual Report (2015-2019).

Eswatini Water Services Corporation (EWSC). (2021). Eswatini Water Services Corporation Annual Report 2021.

ETA (2015-2021). Eswatini Tourism Authority. Eswatini Tourism Research: Annual Report (2015-2021). <https://www.thekingdomofeswatini.com/eta-resources/research/>

EU-CIRCLE. (2019). Impacts of Climate Change and Extreme Weather Events on Critical Infrastructure State of the Art Review and Taxonomy of Existing Knowledge. <http://www.eu-circle.eu/for>

FAO. (2005). Country profile-Swaziland. www.fao.org/

FAO. (2020). Global Forest Resources Assessment. Key Findings 2020. Available online: www.fao.org/forest-resources-assessment

Fick, S. E., and Hijmans, R. J. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology*, 37(12). <https://doi.org/10.1002/joc.5086>

Forestry Commission. (2015). Tracking tool for biodiversity projects in GEF-3, GEF-4, and GEF-5: Management effectiveness tracking tool (METT): Sikumi and Ngamo forests. Harare: Forestry Commission.

Government of Eswatini (2021). GoE-MTEA. Eswatini Nationally Determined Contributions (NDC) Technical Report.

Government of Eswatini. (2020). State of the Environment Report, 2020.

Government of Swaziland. (2016). Swaziland's Second National Biodiversity Strategy and Action Plan.

Government of Swaziland. (2016a). Eswatini National Communication to the UNFCCC. April 2016. <https://unfccc.int/documents/81631>

Government of the Kingdom of Eswatini. (2019). National Tourism Policy, May 2019.

Grace C. Wu, Ranjit Deshmukh, Kudakwashe Ndhlukula, Tijana Radojicic, Jessica Reilly. (2015). 'Renewable Energy Zones for the Africa Clean Energy Corridor,' International Renewable Energy Agency and Lawrence Berkeley National Laboratory, LBNL

Green, D., Billy, J. and Tapim, A. (2010). Indigenous Australians' knowledge of weather and climate. *Climatic change*, 100(2), pp.337-354.

Grundling, A., Beckedahl, H., le Roux, J., le Roux, J., Engelbrecht, C., Sumner, P., Ndlela, T., Kunene, W., Bosman, B., Gangathele, A. and Nemakhavhani, L. (2022). Determining Climate Change Aspects on the Ecosystem Resilience of Headwater Wetlands in two Catchments in Eswatini (Swaziland) and in South Africa Respectively.

Hamilton, J. (2003). Climate and the Destination Choice of German Tourists. *Nature* <https://EconPapers.repec.org/RePEc:fem:femwpa:2004.21>

Hermann, U.P., Tshipala, N.N., Dlamini, N.N., Hermann, U.P., Tshipala, N. and Dlamini, N.N.N. (2020). An Exploratory Analysis of Visitor Spending at a Cultural Event in Eswatini. *African Journal of Hospitality, Tourism and Leisure*, 9(5), pp.1193-1204.

Human Resources for Health. (2020) 18:66, <https://doi.org/10.1186/s12960-020-00504-9>

Huntley, J.; Aubert, M.; et al. (2021). The effects of climate change on the Pleistocene rock art of Sulawesi *Nature Scientific Reports*, Article 9833 <https://www.nature.com/articles/s41598-021-87923-3>

Imani Development International Ltd. (2021). Agricultural Finance Scoping Report. An Agriculture Finance Scoping Exercise in Eswatini. www.finmark.org.za

IPCC. (2022). Impacts of 1.5°C Global Warming on Natural and Human Systems. In *Global Warming of 1.5°C: IPCC Special Report on Impacts of Global Warming of 1.5°C above Pre-industrial Levels in Context of Strengthening Response to Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (pp. 175–312). Cambridge University Press. <https://doi.org/10.1017/9781009157940.005>

IRENA. (2014). SWAZILAND RENEWABLES READINESS ASSESSMENT. www.irena.org/rra

- J.I. (eds.): Socioeconomic Development and the Environment in Swaziland: p. 30-38: Manzini.
- Kassam, A., Friedrich, T., and Derpsch, R. (2019). Global spread of conservation agriculture. *International Journal of Environmental Studies*, 76(1), 29-51.
- Kruger, A. C., and Sekele, S. S. (2013). Trends in extreme temperature indices in South Africa: 1962-2009. *International Journal of Climatology*. <https://doi.org/10.1002/joc.3455>
- Krüger, O. (2005). The role of ecotourism in conservation: panacea or Pandora's box?. *Biodiversity and Conservation*, 14(3), pp.579-600.
- Kurniawati, M. A. (2020). The role of ICT infrastructure, innovation and globalization on economic growth in OECD countries, 1996-2017. *Journal of Science and Technology Policy Management*, 11(2), 203-225. <https://doi.org/10.1108/JSTPM-06-2019-0065/FULL/XML>
- MA (2017). Kingdom of Swaziland National Land Degradation Neutrality Targets. Ministry of Agriculture, Mbabane, Swaziland.
- Mabaso, S. and Tfwala, S. (2022). Scoping and Gap Analysis Report for Activity 3 – Agriculture Sector (online). https://climateactiontransparency.org/wp-content/uploads/2022/09/Activity-3_Del-J-Agriculture-Sector-Gap-Analysis_Final.pdf
- Maddison, D. (2001). In Search of Warmer Climates? The Impact of Climate Change on Flows of British Tourists. *Climatic Change* 49, pages193–20 <https://link.springer.com/article/10.1023/A:1010742511380>
- Majodina, M., Botai, J. O., and Rautenbach, H. (2018). The vulnerability of the South African electricity transmission network infrastructure to weather and climate: A review. *Journal of Energy in Southern Africa*, 29(3), 51–59. <https://doi.org/10.17159/24133051/2018/V29I4A4748>.
- Masarirambi, M.T., Manyatsi, A.M. and Mhazo, N. (2010). Distribution and utilisation of wetlands in Swaziland. *Research Journal of Environmental and Earth Sciences*, 2(3), pp.146-152.
- Masarirambi, M.T., Zwane, P.E., Surana, N., Kunene, E.N., Moyo, S., Mabuza, L.L. and Makhanya, B.P. (2019). Indigenous dye plants of the Kingdom of Eswatini, traditional uses and new prospects. *Adv. Med. Plant Res*, 7, pp.8-14.
- Matondo JI, Graciana P and Msibi KM. (2004). Evaluation of the impact of climate change on hydrology and water resources in Swaziland: Part I. *Physics and Chemistry of the Earth* 29 (15): 11811191.
- Matsenjwa, G.N. and Musiiwa, E. (2016). The globalization of the rural Swazi weaver: Lavumisa women in the commercial handicraft industry, 1981-2013. *Journal of International Women's Studies*,

17(1), pp.102-116.

McGregor, J. L. (2005). C-CAM: Geometric aspects and dynamical formulation.

McGregor, J. L., and Dix, M. R. (2001). The CSIRO conformal-cubic atmospheric GCM. *Fluid Mechanics and Its Applications*. https://doi.org/10.1007/978-94-010-0792-4_25

Mhlanga-Ndlovu, B. F. N., and Nhamo, G. (2017). An assessment of Swaziland sugarcane farmer associations' vulnerability to climate change, 14(1), 38-56. <https://doi.org/10.1080/1943815X.2017.1335329>

Ministry of Economic Planning and Development (MEPD). (2019). Kingdom of Eswatini. National Development Plan, 2019/20-2021/22. Towards Economic Recovery.

Ministry of Tourism and Environmental Affairs (MTEA) (2013). National Climate Change Strategy and Action Plan. Ministry of Tourism and Environmental Affairs, Mbabane, The Kingdom of Swaziland.

Ministry of Tourism and Environmental Affairs (MTEA) (2015). Swaziland Intended Nationally Determined Contributions. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Swaziland.

Ministry of Tourism and Environmental Affairs (MTEA) (2016). Swaziland's Third National Communication to the United Nations Framework Convention on Climate. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Swaziland. <https://unfccc.int/documents/81631>

Ministry of Tourism and Environmental Affairs (MTEA) (2018a). Technology Needs Assessment for Climate Change: Technology Action Plan for Adaptation; Report III of Technology Needs Assessment for Swaziland. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of eSwatini.

Ministry of Tourism and Environmental Affairs (MTEA) (2021b). Update of the Nationally Determined Contributions: Second Report on Eswatini's National GHG Inventory and Quantification of SLCP and Air Pollutant Emissions for the Waste and IPPU sectors. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Eswatini.

Ministry of Tourism and Environmental Affairs (MTEA). (2002). Swaziland's First National Communication to the United Nations Framework Convention on Climate. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Swaziland. <https://unfccc.int/resource/docs/natc/swanc1.pdf>

Ministry of Tourism and Environmental Affairs (MTEA). (2012). Swaziland's Second National Communication to the United Nations Framework Convention on Climate. The Ministry of Tourism

and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Swaziland. <https://unfccc.int/sites/default/files/resource/swznc2.pdf>

Ministry of Tourism and Environmental Affairs (MTEA). (2021). Review and update of the State of Environment Report. Restoring the environment for climate resilient economic recovery. The Kingdom of Eswatini. <https://www.undp.org/eswatini/publications/third-state-environment-report-kingdom-eswatini>

Mkhonta, S.; Mathunjwa, M and Msane, G (2022a). Scoping and gap analysis report for the energy sector in Eswatini (on-line). https://climateactiontransparency.org/wp-content/uploads/2022/09/Activity-2_Del-F_Energy-sector-scoping-and-gap-analysis_Final.pdf

MNRE (2016a). Kingdom of eSwatini: Sustainable Energy for Investment Prospectus. The Ministry of Natural Resources and Energy, Mbabane, The Kingdom of Swaziland.

MNRE (2016b). Kingdom of eSwatini: Sustainable Energy for All Action Agenda. The Ministry of Natural Resources and Energy, Mbabane, The Kingdom of Swaziland.

MNRE (2018c). Kingdom of eSwatini: Energy Masterplan 2034. The Ministry of Natural Resources and Energy, Mbabane, The Kingdom of eSwatini.

MoA (2002). National Forest Policy. Ministry of Agriculture, Mbabane.

Moagi, L.L.; Bourne, A.R.; Cunningham, S.J.; Jansen, R.; Ngcamphalala, C.A.; Ganswindt, A.; McKechnie, A.E. Hot days are associated with short-term adrenocortical responses in a southern African arid-zone passerine bird. *J. Exp. Biol.* 2021, 224, jeb242535.

Morishima, W., and Akasaka, I. (2010). Seasonal Trends of Rainfall and Surface Temperature Over Southern Africa. *African Study Monographs*, 40(March).

Mpandeli, S., Naidoo, D., Mabhaudhi, T., Nhemachena, C., Nhamo, L., Liphadzi, S., Hlahla, S., and Modi, A. T. (2018). Climate change adaptation through the water-energy-food nexus in Southern Africa. *International Journal of Environmental Research and Public Health*, 15(10). <https://doi.org/10.3390/IJERPH15102306>

MTEA (2018b). Technology Needs Assessment for Climate Change TNA Mitigation Technology Action Plans Report for Swaziland. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of eSwatini.

MTEA (2020). Draft National Inventory Report. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Swaziland.

MTEA (2020). Eswatini National Greenhouse Gas Inventory: Agriculture, Forestry and Land Use

Sector Report. Ministry of Tourism and Environmental Affairs. Kingdom of Swaziland.

MTEA (2020). Eswatini National Greenhouse Gas Inventory: Energy Sector Report. Ministry of Tourism and Environmental Affairs. Kingdom of Swaziland.

MTEA (2020). Eswatini National Greenhouse Gas Inventory: Waste and IPPU Sector Report. Ministry of Tourism and Environmental Affairs. Kingdom of Swaziland.

MTEA (2021a). Kingdom of Eswatini: Update of the Nationally Determined Contributions submitted to the United Nations Framework Convention on Climate Change. The Ministry of Tourism and Environmental Affairs: Department of Meteorology, Mbabane, The Kingdom of Eswatini.

Navarro-Racines, C., Tarapues, J., Thornton, P., Jarvis, A., and Ramirez-Villegas, J. (2020). High-resolution and bias-corrected CMIP5 projections for climate change impact assessments. *Scientific Data*, 7(1). <https://doi.org/10.1038/s41597-019-0343-8>

Ndlovu, T., Sibandze, G.F., Vilakati, D.G., and Mafu, L.D. (2022). Initiative for Climate Action Transparency – ICAT Gap analysis and action plans for water and health sectors. Centre for Sustainable Energy Research (CSER).

Nhlengethwa, S., Matchaya, G., Greffiths, I., and Fakudze, B. (2021). Analysis of the determinants of public capital investments on agricultural water infrastructure in Eswatini. *Business Strategy and Development*, 4(1), 49–58. <https://doi.org/10.1002/BSD2.156>

NHSSP. (2019). Kingdom of Eswatini National Health Sector Strategic Plan: 2019 – 2023.

OECD (2018). Climate-resilient infrastructure. Policy perspectives. OECD Environment Policy Paper no 14. ISSN 2309-7841. <https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>

Ojha H. (2021). Adaptation funding can exacerbate vulnerability if not managed carefully. Institute for Study and Development Worldwide (IFSD), Adaptation Funding can Exacerbate Vulnerability if Not Managed Carefully – IFSD – Institute for Study and Development Worldwide

Pradyumna, A., and Sankam, J. (2022). Tools and methods for assessing health vulnerability and adaptation to climate change: A scoping review. *The Journal of Climate Change and Health*, 8, 100153. <https://doi.org/10.1016/j.joclim.2022.100153>

Pullanikkatil, D. (2016). Swaziland Technology Needs Assessment Report I – Climate Change Adaptation, Global Environmental Facility, UNEP, available at: <https://tech-action.unepdtd.org/wp-content/uploads/sites/2/2019/03/swaziland-adaptationtna-report.pdf>

Pullanikkatil, D. (2018). Technology Needs Assessment for Adaptation: Report III of Technology

Needs Assessment. UNEP DTU Partnership. <https://tech-action.unepccc.org/wp-content/uploads/sites/2/2019/08/tap-adaptation-swaziland.pdf>

Pullanikkatil, D., Thondhlana, G. and Shackleton, C. (2021). The cultural significance of plant-fiber crafts in Southern Africa: a comparative study of Eswatini, Malawi, and Zimbabwe. *Forests, Trees and Livelihoods*, 30(4), pp.287-303.

Ratsiu, M. L., Nkopane, M., and Simelane, M. (2022). An Assessment of Hand Hygiene Markets in Lesotho and Eswatini.

Rommelzwaal, A. (1993). Physiographic map of Swaziland, scale 1:250,000. FAO/UNDP/ GOS. Land use planning for rational utilization of land and water resources project SWA/89/001, field doc, 41 Mbabane.

Schlüter, T. (2010). Highlights of the Geology of Swaziland. In: Tevera, D. and Matondo,

Schlüter, T., and Schumann, A. (2018). Geosites as a potential for the development of tourism – overview of relevant sites in Eswatini (formerly Swaziland). *GeoJournal of Tourism and Geosites*. 22(2), 535-547. <https://doi.org/10.30892/gtg.22222-309>

Sibitane, Z.E., Dube, K. and Lekaota, L. (2022). Global Warming and Its Implications on Nature Tourism at Phinda Private Game Reserve, South Africa. *International Journal of Environmental Research and Public Health*, 19(9) <https://www.mdpi.com/1660-4601/19/9/5487>, [10.3390/ijerph19095487](https://doi.org/10.3390/ijerph19095487)

Simpson, M.C., Gössling, S., Scott, D., Hall, C.M. and Gladin, E. (2008). Climate change adaptation and mitigation in the tourism sector: frameworks, tools and practices. *Climate change adaptation and mitigation in the tourism sector: frameworks, tools and practices*.

Singh, R. (2021). *Solid Waste Management in Eswatini: Challenges and Opportunities*, Centre for Science and Environment, New Delhi

Singleton, A. T., and Reason, C. J. C. (2007). Variability in the characteristics of cut-off low pressure systems over subtropical southern Africa. *International Journal of Climatology*, 27(3). <https://doi.org/10.1002/joc.1399>

Singwane, S.S. and Beckedahl, H. (2020). *The Governance of Community Forests in Eswatini: The Case of Ezikhotheni and Ngcayini Chiefdoms*.

South Africa Department of Environmental Affairs. (2018). *Mitigation Monitoring and Evaluation Guideline Series of the National Climate Change Response Monitoring and Evaluation System Volume 1 Policies, Strategies and Laws*. Department of Environmental Affairs, Pretoria, South Africa.

Stronza, A.L., Hunt, C.A. and Fitzgerald, L.A. (2019). Ecotourism for conservation? *Annual Review of Environment and Resources*, 44, pp.229-253.

The Kingdom of Eswatini. Masterplan towards the elimination of Neglected Tropical Diseases - 2015- 2020

Thondhlana, G., Pullanikkatil, D. and Shackleton, C.M. (2020). Plant Fibre Crafts Production, Trade and Income in Eswatini, Malawi and Zimbabwe. *Forests*, 11(8), p.832.

UN Eswatini Country Team. (2020). 2021-2025 United Nations Sustainable Development Cooperation Framework for Eswatini, Mbabane, Eswatini.

UNDP (2018). Mid-term Evaluation Report for the UNDP Eswatini Country Program Document 2016-2020. Independent Evaluation Office, United Nations Development Programme, New York.

UNDP (2020). Independent Country Programme Evaluation Eswatini. Independent Evaluation Office, United Nations Development Programme, New York.

UNDP (2023). United Development Plan. Human Development Index. <https://hdr.undp.org/data-center/human-development-index#/indicies/HDI>

UNEP (2016). Further Amendment of the Montreal Protocol: Submitted by the Contact group on HFCs. Twenty-Eighth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, United Nations Environment Programme (UNEP), UNEP/OzL.Pro.28/CRP/10, Kigali, 10- 14 October 2016.

UNEP-WCMC and IUCN (2022). Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], October 2022, Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.

United Nations Eswatini, (2022). Sustainable Development Goals. Accessed from: <https://eswatini.un.org/en/sdgs>.

Uniting for Combat. (2017). Neglected tropical disease treatment report, 2017.

VAC (2022). Kingdom of Eswatini Annual Vulnerability Assessment and Analysis Report, July 2022.

Vasco, F. (2010). Basic chemical mechanisms outdoors. Chapter 7. In *Basic Environmental Mechanism Affecting Cultural Heritage: Understanding Deterioration Mechanism for Conservation Purposes* (eds Camuffo, D. et al.) 75-105 (Nardini Editore, 2010).

Waliser, D. E., and Gautier, C. (1993). A satellite-derived climatology of the ITCZ. *Journal of Climate*, 6(11). [https://doi.org/10.1175/1520-0442\(1993\)006<2162:ASDCOT>2.0.CO;2](https://doi.org/10.1175/1520-0442(1993)006<2162:ASDCOT>2.0.CO;2)

Walker, C.; Burtcher, D.; Myeni, J.; Kerschberger, B.; et al. (2020). 'They have been neglected for a long time': a qualitative study on the role and recognition of rural health motivators in the Shiselweni region, Eswatini. *Human Resources for health*, 18:66. <https://doi.org/10.1186/s12960-020-00504-9>.

WFP (2021). World Food Programme Annual country report 2021. Eswatini. Progress towards gender equality. https://www.wfp.org/operations/annual-country-report?operation_id=SZ02&year=2021#/23236/23237

WHO (2018). Eswatini Health Situation. <http://apps.who.int/gho/data/node.cco>

WHO (2018b). WHO country cooperation strategy at a glance: Swaziland. World Health Organization. <https://apps.who.int/iris/handle/10665/136886>. License: CC BY-NC-SA 3.0 IGO.

WHO (2021). Climate Change and Health. <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>

WHO-SARA (2017). Eswatini Service Availability and Readiness Assessment (SARA), [https://www.hst.org.za/publications/NonHST%20Publications/Eswatini%20SARA%20March%20\(05%2004%202019\).pdf](https://www.hst.org.za/publications/NonHST%20Publications/Eswatini%20SARA%20March%20(05%2004%202019).pdf)

WHO-SARA (2019). Eswatini Service Availability and Readiness Assessment (SARA).

Wietze, L., and Tol, R. (2002). Impact of Climate on Tourist Demand. *Climatic Change* 55, pages429-449, <https://link.springer.com/article/10.1023/A:1020728021446>

WMO (2021). State of the Global Climate 2020 (WMO-No. 1264), https://library.wmo.int/doc_num.php?explnum_id=10618

Wootten, A., Terando, A., Reich, B. J., Boyles, R. P., and Semazzi, F. (2017). Characterizing sources of uncertainty from global climate models and downscaling techniques. *Journal of Applied Meteorology and Climatology*, 56(12). <https://doi.org/10.1175/JAMC-D-17-0087.1>

World Bank, (2021). Eswatini Climate Risk Profile: (2021) https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15929-WB_Eswatini%20Country%20Profile-WEB.pdf

World Bank. (2021). Eswatini Education Sector Analysis. www.worldbank.org

W TTC. (2020). Travel and Tourism: Global Economic Impact and Trends 2020. World Travel and Tourism Council, pp.1-20.

W TTC. (2022). Economic Impacts Report. Accessed at: <https://wtcc.org/research/economic-impact>

Wulff K, Donato D, and Lurie N. (2015). What Is Health Resilience and How Can We Build It? Annual Reviews in Public Health 2015. 36:361–74

Zhu, Z., Luo, Y, Zhao, W., Li, M, Chen, J and Zhao, P. (2022). HYBMAP: Global hybrid land-cover maps from 2000 to 2020 with a resolution of approximately 1 km (data online). DOI 10.5281/zenodo.7095045.

Zwane, P.E., Masarirambi, M.T., Seyoum, T. and Nkosi, B.S. (2011). Natural fibre plant resources of economic value found in wetlands of Swaziland: A review. African Journal of Agricultural Research, 6(4), pp.773-779.

WFP (2021). World Food Programme Annual country report 2021. Eswatini. Progress towards gender equality. https://www.wfp.org/operations/annual-country-report?operation_id=SZ02&year=2021#/23236/23237

WHO (2022). <https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>

WHO (2018). Eswatini Health Situation. <http://apps.who.int/gho/data/node.cco>

WHO (2018b). WHO country cooperation strategy at a glance: Swaziland. World Health Organization. <https://apps.who.int/iris/handle/10665/136886>. License: CC BY-NC-SA 3.0 IGO.

8 Appendices

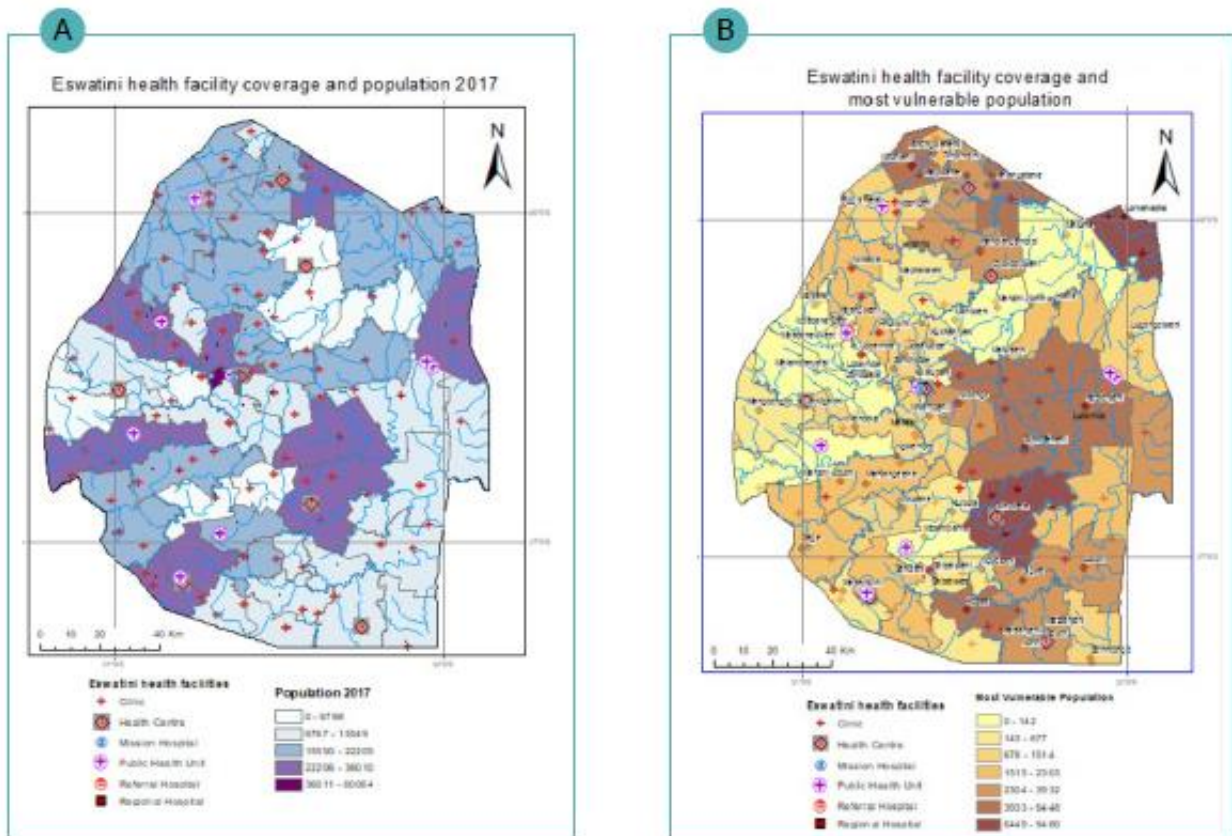


Figure 8-1. Health facilities by a) areas with the most people and b) areas with the most vulnerable population (source: VAC, 2022).

Tinkhundla	Highest population density	Annual growth rate	Overall dependency ratio/100	Child dependency ratio/100	Aged dependency ratio/100	Males/100 females	Unimproved Sanitation	1 h to water source (%)	Unsafe drinking water (lowest % safe dw)	Lowest functional tel (%)	Double orphans (%)	Female headed hh	Child-headed hh	Unemployment rate 15-19y	Unemployment rate 20-24 y	Unemployment rate 25-29 y	Unemployment rate 30-34y	Unemployment rate 35 y	Youth unemployment rate	Unemployment 15 y and above	
Dvokodvweni																					
Gege																					
Hhukwini																					
Hlane																					
Hosea																					
Kubuta																					
Kwaluseni																					
Lobamba																					
Lomahasha																					
Lubuli																					
Ludzeludze																					
Lugongolweni																					
Madlangempisi																					
Mafutseni																					
Mangcongco																					
Manzini North																					
Manzini South																					
Matsanjeni North																					
Matsanjeni South																					
Mayiwane																					
Mbabane East																					
Mbabane West																					
Mhlangatane																					
Mhlume																					
Mkhiweni																					
Mpolonjeni																					
Mtfongwaneni																					

Tinkhundla	Highest population density	Annual growth rate	Overall dependency ratio/100	Child dependency ratio/100	Aged dependency ratio/100	Males/100 females	Unimproved Sanitation	1 h to water source (%)	Unsafe drinking water (lowest % safe dw)	Lowest functional tel (%)	Double orphans (%)	Female headed hh	Child-headed hh	Unemployment rate 15-19y	Unemployment rate 20-24 y	Unemployment rate 25-29 y	Unemployment rate 30-34y	Unemployment rate 35 y	Youth unemployment rate	Unemployment 15 y and above	
Mtsambama																					
Ndzingeni																					
Ngudzeni																					
Ngwempisi																					
Nhlambeni																					
Nkhaba																					
Nkilongo																					
Ntfonjeni																					
Sandleni																					
Shiselweni																					
Sigwe																					
Siphofaneni																					
Sithobela																					
Somntongo																					
Timphisini																					
Zombodze																					
Emuva																					

Figure 8-2: Distribution of social vulnerability among Tinkhundla

Table 8-1: The highest ranges found for vulnerability indicators

Indicator	Highest indicator range
Highest population density	923-2379
Annual growth rate	2.3-5.4
Overall dependency ratio/100 persons	119.6-146.8
Child dependency ratio/100 persons	112.6-131.1
Aged dependency ratio/100 persons	14.4-18.7
Males/100 females	108-143
Unimproved Sanitation	9.8-17.1
1 h to water source (%)	0.16-0.29
Unsafe drinking water (lowest % safe dw)	39.8-49.6
Lowest functional tel (%)	10.5-20.7
Double orphans (%)	2.6-3.5%
Female-headed hh	42.2-52.9%
Child-headed hh	0.44-0.58%
Unemployment rate (15-19y)	71.4-88.6%
Unemployment rate 20-24 y	73.2-83.2%
Unemployment rate 25-29 y	57.4-75.9%
Unemployment 30-34y	52-66.1%
Unemployment rate 35 y	49.4-58.9%
Youth Unemployment rate	54.2-70.6%
Unemployment 15 y and above	51.2-61.6%