Logo, company name

Description automatically generated

**Heat Indicators for Global Health: Surveillance, Early Warning Systems, and adaptation-mitigation actions to reduce heat impacts in pregnant women, infants, and health workers in the E.U. and Africa: (HIGH HORIZONS)**

**The Use of the Aga Khan Development Network Carbon Management Tool to Measure and Evaluate Carbon Emissions for Climate Mitigation Interventions in Health Facilities in Kenya, South Africa, and Zimbabwe**

**HIGH HORIZONS – D5.7**

**[GRANT NO. 101057843]**

# Investigators

This project is led by a team of investigators from several institutions in Kenya, South Africa, and Zimbabwe. In Kenya, the team is led by Sohail Muhammad Syed, the Chief Executive Officer of Aga Khan Hospital Mombasa Cluster, and Aquinius Mungatia, the Head of Grants & Security and Environment and Climate Change Focal Person at Aga Khan Hospital Mombasa. In South Africa, the team is led by Gloria Maimela, the Climate and Health Director at Wits RHI, and Matthew Chersich, a Research Professor at Wits RHI. They are joined by Feziwe Mpondo, a Senior Researcher, and Craig Parker, a Data Scientist, both from Wits RHI. In Zimbabwe, the team is led by Stanley Luchters, a Professor and Executive Director of the Centre for Sexual Health and HIV AIDS Research, with Thabani Muronzie and Jetina Tsvaki serving as Climate & Health Research Officer and Climate & Health Data Management and Science Analyst, respectively, at the same institution. Together, the team brings a wealth of experience and expertise in climate and health research, data analysis, and management to this project.

[Investigators 1](#_Toc128690039)

[List of figures and tables 4](#_Toc128690040)

[PARTNERS IN THE PROJECT 4](#_Toc128690041)

[Implementing Partners: 4](#_Toc128690042)

[Other Collaborating Partners in the HIGH Horizons Consortium: 4](#_Toc128690043)

[Deliverable Information 5](#_Toc128690044)

[History of Changes 6](#_Toc128690045)

[PROTOCOL SYNOPSIS 7](#_Toc128690046)

[Definitions 8](#_Toc128690047)

[INTRODUCTION AND BACKGROUND 9](#_Toc128690048)

[The overall HIGH Horizons project 10](#_Toc128690049)

[The focus of this protocol 11](#_Toc128690050)

[STUDY SITES: 13](#_Toc128690051)

[Kenyan sites description 13](#_Toc128690052)

[Aga Khan Hospital, Mombasa and Aga Khan Medical Centre-Kilifi 13](#_Toc128690053)

[South African sites description 13](#_Toc128690054)

[Laudium Community Health Centre 15](#_Toc128690055)

[Stanza Bopape Community Health Centre 16](#_Toc128690056)

[Mamelodi District Hospital 16](#_Toc128690057)

[Zimbabwean sites description 16](#_Toc128690058)

[Mt Darwin District Hospital 18](#_Toc128690059)

[Dotito Rural Health Care Clinic 20](#_Toc128690060)

[Chitse Rural Health Care Clinic 21](#_Toc128690061)

[PROBLEM STATEMENT/RATIONALE 24](#_Toc128690062)

[OBJECTIVES 25](#_Toc128690063)

[DESIGN 25](#_Toc128690064)

[Methodology 25](#_Toc128690065)

[Carbon Emission Measurement 28](#_Toc128690066)

[Sources emissions specific to the healthcare facility 29](#_Toc128690067)

[Supply chain contributors to carbon emissions 30](#_Toc128690068)

[Action tracker sheet and four data output sheets. 32](#_Toc128690069)

[Variables of interest 33](#_Toc128690070)

[Design and optimization modelling of mitigation intervention in health facilities: 34](#_Toc128690071)

[Optimization modelling 34](#_Toc128690072)

[Implementation of mitigation interventions in health facilities 34](#_Toc128690073)

[Effectiveness of mitigation interventions in health facilities 35](#_Toc128690074)

[Roles and Responsibilities 36](#_Toc128690075)

[PROJECT PROCEDURES 37](#_Toc128690076)

[DATA MANAGEMENT AND ANALYSIS 39](#_Toc128690077)

[Data Management 39](#_Toc128690078)

[Data Analysis 40](#_Toc128690079)

[Cost-effectiveness analysis 41](#_Toc128690080)

[Quality Assurance 43](#_Toc128690081)

[ETHICS AND DISSEMINATION 44](#_Toc128690082)

[Research ethics approval 44](#_Toc128690083)

[Dissemination 48](#_Toc128690084)

[Kenya 48](#_Toc128690085)

[South Africa 48](#_Toc128690086)

[Zimbabwe 48](#_Toc128690087)

[Scientific conferences 49](#_Toc128690088)

[Publications 49](#_Toc128690089)

[Strengths 50](#_Toc128690090)

[Limitations 51](#_Toc128690091)

[REFERENCES 53](#_Toc128690092)

[Table 1: Definitions 9](#_Toc128750565)

[Table 2: Climatic, socio-economic, and maternal and newborn health characteristics of the study sites 24](#_Toc128750566)

[Table 3: Defining Scopes of the AKDN tool 29](#_Toc128750567)

[Table 4: Sources of greenhouse gas emissions in healthcare facilities 30](#_Toc128750568)

[Table 5: Variables of interest 35](#_Toc128750569)

[Table 6: Study procedure 39](#_Toc128750570)

[Figure 1: Maps of the location of hospital and CHCs in South Africa 15](#_Toc127956466)

[Figure 2: Zimbabwe study sites 18](#_Toc127956467)

[Figure 3: Mt Darwin District Hospital 19](#_Toc127956468)

[Figure 4: Dotito Rural Health Care Clinic 21](#_Toc127956469)

[Figure 5: Chitse Rural Health Care Clinic 22](#_Toc127956470)

[Figure 6: AKDN tool cover page 27](#_Toc127956471)

[Figure 7: Supply chain input sheet 29](#_Toc127956472)

[Figure 8: Output sheet 30](#_Toc127956473)

[Figure 9: Error checking sheet 42](#_Toc127956474)

# List of figures and tables

# PARTNERS IN THE PROJECT

## Implementing Partners:

1. Aga Khan Health Sciences Kenya (AKHS) - brings expertise in modelling carbon emissions from facilities and implementing selected interventions.
2. Centre for Sexual Health and HIV/AIDS Research Zimbabwe (CeSHHAR) - specializes in maternal, neonatal, and child health research, community-based intervention research, and anthropology.
3. Wits RHI, University of Witwatersrand, South Africa - provides expertise in climate change and health, statistics, maternal health, anthropology, and intervention co-creation.

## Other Collaborating Partners in the HIGH Horizons Consortium:

1. Ghent University (UGENT) - serves as the overall project coordinator.
2. Karolinska Institutet (K.I.) - brings expertise in maternal and perinatal health epidemiology and clinical knowledge in antenatal care practices.
3. London School of Hygiene and Tropical Medicine (LSHTM) - has expertise in maternal and child health epidemiology.
4. Lunds Universitet (ULUND) and Danmarks Tekniske Universitet (DTU) - offer unique technologies for early warning systems (EWSs) and critical capacity in coding for tailoring the ClimApp to the target audience and optimizing its functionality.
5. University of Graz (UGRAZ) - provides support in societal impacts of climate change, social vulnerability, and inequality analysis.
6. World Health Organization (WHO) - provides guidance on indicators and surveillance and ensures the project findings are adequately exploited at the E.U. and global level.

|  |  |
| --- | --- |
| Deliverable Information | |
| Title | Protocol for mitigation interventions evaluation in Kenya, South Africa and Zimbabwe |
| Deliverable number | D5.7 |
| Work Package number | WP5 |
| Investigators | **Kenya**   1. Sohail Muhammad Syed, Principal Investigator   Chief Executive Officer, Aga Khan Hospital Mombasa Cluster   1. Aquinius Mungatia, Co-Investigator   Head of Grants & Security; Environment and Climate Change Focal Person, Aga Khan Hospital, Mombasa  **South Africa**   1. Gloria Maimela (MBBCH, MBA), Principal Investigator   Climate and Health Director, Wits RHI   1. Craig Parker, Data Scientist, Co-Investigator   Wits RHI   1. Matthew Chersich, Research Professor, Principal Investigator   Wits RHI   1. Feziwe Mpondo BSc (Hons), MSc, PhD, Co-Investigator   Senior Researcher, Wits RHI  **Zimbabwe**   1. Stanley Luchters MD, MSc PHDC, PhD - Principal Investigator   Professor and Executive Director of the Centre for Sexual Health and HIV AIDS Research, Zimbabwe   1. Thabani Muronzie, BSc, MSc, (Insert your role)   Climate & Health Research Officer of the Centre for Sexual Health and HIV AIDS Research, Zimbabwe   1. Jetina Tsvaki, BSc, MSc (Insert your role)   Climate & Health Data Management and Science Analyst of the Centre for Sexual Health and HIV AIDS Research, Zimbabwe |
|  | CeSHHAR |
| Type | R: Document, Report |
| Dissemination Level | PU: Public |
| Due date | Original 31 December 2022. Revised 31 January 2023 |

|  |  |
| --- | --- |
| History of Changes | |
| Version 1.0 | Final version approved by all Beneficiaries (28 02 2023) |

# PROTOCOL SYNOPSIS

**Background:** Climate change is a major threat to global health, and its impact on health in Sub-Saharan Africa is not well understood, which makes it difficult to assess health risks and formulate effective policies. The healthcare sector contributes significantly to carbon emissions, and reducing its carbon footprint is essential for mitigating climate change. To address this issue, a phased approach will be taken to use the Aga Khan Development Network's (AKDN) Carbon Management Tool to assess the carbon footprint of eight healthcare facilities in Kenya (n=2), South Africa (n=3), and Zimbabwe (n=3).

**Methods:** The project will use a three-phased approach to measure the carbon footprint of each facility every three months over xx months, using the AKDN tool, develop a resource allocation tool for mitigation strategies, and evaluate the success of mitigation strategies in reducing greenhouse gas emissions by measuring the carbon footprint of each facility every three months over xx months and the cost-effectiveness of mitigation strategies. The ultimate goal is to understand the impact of heat on healthcare facilities and provide valuable insights for future sustainability efforts.

**Study outputs:** The project's results will provide critical information on greenhouse gas emissions in health facilities and guide policy decisions around the interface between adaptation and mitigation. By using a phased approach, the study will provide a comprehensive assessment of the carbon footprint of healthcare facilities before and after mitigation interventions in three sub-Saharan African countries.

**Conclusion:** The AKDN Carbon Management Tool will enable the assessment of the carbon footprint of healthcare facilities in three sub-Saharan African countries. This information is crucial for developing effective policies and implementing interventions to reduce greenhouse gas emissions and mitigate climate change's impact on health. The project's results will guide policy decisions around adaptation and mitigation plans, and the phased approach will provide a comprehensive assessment of the carbon footprint of healthcare facilities in the region

## Definitions

| **Term** | **Definition** |
| --- | --- |
| Adaptation | Adjusting to the impacts of climate change to minimize harm and take advantage of potential opportunities |
| Anaesthetic gases | Gases used in medical procedures to induce anesthesia, which can be potent greenhouse gases |
| Carbon footprint | The total amount of greenhouse gas emissions produced by an organization or facility |
| Carbon read-outs | Measurements of carbon emissions or carbon footprints |
| Co-benefits | Benefits that occur as a result of actions taken to address one issue, in addition to the primarily intended benefit |
| CO2 equivalent | A metric measurement used to compare emissions from various greenhouse gases to an equivalent of carbon. |
| Communication strategy | A plan for disseminating information to stakeholders in an effective and targeted manner |
| Cost-benefit analysis | A method for evaluating the financial costs and benefits of a project or intervention |
| Cost-effectiveness | The degree to which an intervention or strategy achieves its goals at a reasonable cost |
| Direct emissions | Greenhouse gas emissions that result directly from an organization's activities or operations |
| Early Warning System | A system that uses indicators to identify potential hazards and provide advanced warning to those who may be affected |
| Embodied carbon | The total carbon emissions produced during the life cycle of a product or material, including production, transportation, and disposal |
| Emissions | The release of greenhouse gases into the atmosphere. Emissions can be direct, such as from burning fossil fuels, or indirect, such as from the production of electricity used to power a building or process. Emissions are typically measured in tonnes of CO2 equivalent (tCO2e). |
| Emissions scopes | The different categories of emissions that are accounted for in a carbon footprint assessment |
| Emissions hotspots | Areas or processes within an organization that produce a disproportionately high amount of greenhouse gas emissions |
| Greenhouse gas emissions | Gases that trap heat in the atmosphere and contribute to global warming, including carbon dioxide, methane, and nitrous oxide |
| Greenhouse gases (GHGs) | Any of the gases that contribute to the greenhouse effect, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), fluorinated gases, and others. |
| Indirect emissions | Greenhouse gas emissions that result from activities or operations that support an organization, such as energy consumption or waste disposal |
| Indirect impacts | Effects of climate change that occur as a result of other impacts, such as changes in infectious disease patterns due to shifting mosquito populations |
| Intervention mapping | A methodology for designing and implementing interventions that involve collaboration with stakeholders at each step |
| Longitudinal measurement design | A study design that involves measuring a variable over time to identify trends or changes |
| Mitigation interventions | Actions taken to reduce or offset the carbon emissions of a facility or organization |
| Mitigation strategies | Actions taken to reduce or prevent the negative impacts of climate change |
| Multi-faceted approach | A method that involves multiple strategies or approaches to address a problem |
| Optimization modelling | The process of using mathematical models to find the most efficient solution to a problem |
| Pre-industrial level | The global temperature level before the Industrial Revolution (approximately mid-19th century) |
| Predictive modelling | Using data and statistical methods to make predictions about future events or outcomes |
| Refrigerant gases | Gases used in refrigeration and air conditioning systems, which can contribute to emissions through leaks or improper disposal |
| Spend mapping | The process of tracking and analyzing financial spending within an organization or facility |
| Supply chain | The network of companies and suppliers involved in the production, transportation, and delivery of goods and services and the associated information flows. A sustainable supply chain consists of the consideration of environmental, social, and economic impacts throughout the supply chain, from the sourcing of raw materials to the disposal of products at the end of their life cycle |
| Temperature anomaly | The difference between the current global average temperature and the pre-industrial level |
| Vulnerability | The degree to which one is[able](https://dictionary.cambridge.org/dictionary/english/able) to be [easily](https://dictionary.cambridge.org/dictionary/english/easily) [hurt](https://dictionary.cambridge.org/dictionary/english/hurt), [influenced](https://dictionary.cambridge.org/dictionary/english/influence) or [attacked](https://dictionary.cambridge.org/dictionary/english/attack) |

Table 1: Definitions

# INTRODUCTION AND BACKGROUND

Over the past decades, the world has witnessed a rising trend in extreme weather events, such as heat waves, droughts, and hurricanes, which are linked to the accelerating pace of climate change[1]. The effects of these extreme weather events are far-reaching and impact various aspects of life, including human health[2]. Pregnant women, infants, and health workers are among the most affected by climate change in low-resource settings, as they are particularly susceptible to the negative impacts of extreme heat[3]. The health impacts of climate change are diverse and complex, including but not limited to heat exhaustion, dehydration, cardiovascular disease, respiratory distress, and mental health issues[4].

Furthermore, the effects of climate change are not limited to the direct impacts of extreme weather events. Indirect impacts, such as the spread of infectious diseases due to increased and shifting mosquito populations, air pollution, and food and water insecurity, pose additional threats to human health[5]. These health impacts are particularly concerning in low- and middle-income countries, where most of the global population resides, as these countries are often ill-equipped to address and mitigate the negative impacts of climate change[6].

## The overall HIGH Horizons project

In response to these growing concerns, the HIGH Horizons project was developed to address knowledge gaps in the surveillance and tracking of the impacts of climate change on health. The project involves five partners in the European Union, three in Africa, and one international organization. It focuses on pregnant and postpartum women, infants, and health workers as the primary groups affected by climate change. Through the implementation of a personalised Early Warning System (EWS) and integrated adaptation-mitigation actions in health facilities, the project aims to quantify and monitor direct and indirect health impacts of extreme heat and communicate findings to relevant stakeholders to inform policy decisions.

## The focus of this protocol

This protocol outlines a sub-study of the HIGH Horizons project. We describe the approach and tools for assessing and evaluating carbon emissions from health facilities, namely Kenya, South Africa, and Zimbabwe which form one component of the overall High Horizons project.. The primary objectives include: utilizing the Aga Khan Development Network's (AKDN) Carbon Management Tool[7] to assess carbon emissions generated by health facilities (Objective 1); developing a resource allocation tool for mitigation strategies, and implement mitigation strategies to decrease greenhouse gas emissions in health facilities (Objective 2); evaluating the efficacy of the mitigation strategies in terms of cost-effectiveness, and reduction in greenhouse gas emissions (Objective 3), and, communicating and disseminating the findings to relevant stakeholders through the design and implementation of an effective communication strategy (Objective 4)[8]. The ultimate goal is to develop mitigation strategies aimed at reducing carbon emissions from the healthcare sector. The project will provide valuable insights for future sustainability efforts and track progress over time through serial measurements.

The study outputs will be a crucial component to furthering our understanding of the impacts of climate change on health and informing policy and practice aimed at improving human health. This includes but is not limited to populations such as low-income communities, indigenous peoples, elderly individuals, pregnant women, children, and those with pre-existing health conditions. These populations may be at higher risk for the negative health impacts of climate change. Thus, efforts to reduce carbon emissions and mitigate these impacts are particularly important for their well-being[9].

# STUDY SITES:

## Kenyan sites description

### Aga Khan Hospital, Mombasa and Aga Khan Medical Centre-Kilifi

The study will take place in two healthcare facilities in Kenya: the Aga Khan Hospital in Mombasa, which serves as the Secondary Care Field Site, and the Aga Khan Medical Centre in Kilifi, the Primary Field Site. The regions of Mombasa and Kilifi have a tropical climate, with temperatures ranging from 21°C to 32°C and average annual rainfall ranging from 300mm to 1200mm[10]. These areas experience seasonal changes in precipitation and temperatures, which could affect the spread of infectious diseases[11]. Both sites offer Maternal, Newborn, and Child Health (MNCH) services staffed by qualified personnel, including obstetrician-gynecologists, midwives, ward and outpatient nurses, and pediatrician consultants. The patient volume at the sites for the past six months has been steady, with an average of 50 daily visits to the outpatient department and 600 admissions per month.

## South African sites description

Tshwane, located near Johannesburg in Gauteng Province, South Africa, the study will be conducted in an urban setting characterized by a subtropical climate with dry winters and hot summers[12]. The region has experienced an increased frequency and intensity of extreme weather events such as heatwaves, droughts, and heavy rainfall due to climate change[13]. The closest TAHMO weather station is TA00244 Midrand Fire Station, Cedar Road, Broadacres, with an average annual rainfall total of 657 mm[14]. The World Bank Income group (GDP per capita) for Tshwane is an upper-middle income group of $6,994[15]. Three maternity facilities in the study area offer various healthcare services, including emergency care, maternal and child health, treatment for acute and chronic diseases, and primary health services such as dental and reproductive health, mental health, and social services. Pregnant women residing in Urban Heat Islands, where concrete and steel structures absorb and retain heat, have limited means of reducing heat exposure during a heatwave, and health facilities, poorly built brick dwellings and informal housing in urban slums offer little to no protection against heat exposure[4].

Map

Description automatically generated

Figure 1: Maps of the location of the hospital and CHCs in South Africa

### Laudium Community Health Centre

The Laudium Community Health Centre (CHC) is located in Pretoria West, South Africa, and serves a population of approximately 245,387 individuals[16]. The facility offers a comprehensive array of health services, including emergency care, maternal and child health, treatment for acute, chronic, and non-communicable diseases, primary health services such as dental care, reproductive health, mental health, and social services, as well as rehabilitation services such as audiology, speech, and hearing[17].

### Stanza Bopape Community Health Centre

The Mamelodi District Hospital and Stanza Bopape Community Health Centre are in Region 4, East of Tshwane, which covers an area of 49.19 km2[18]. Stanza Bopape CHC serves a population of 261,989 and offers essential healthcare services such as peer counseling, a crisis center for gender-based violence and sexual assault victims, antiretroviral therapy adherence clubs, COVID-19 screening, and home delivery of medication[17].

### Mamelodi District Hospital

Mamelodi District Hospital is a referral center for patients needing higher-level care, including pregnant women with obstetric emergencies. The hospital has a catchment population of 334,577. It offers services such as clinical specialties in medicine, surgery, obstetrics, pediatrics, psychiatry, radiology, emergency medical services, trauma, and clinical management of NCDs, HIV/AIDS, and T.B. [17, 19].

## Zimbabwean sites description

Mount Darwin District, located in Mashonaland Central Province, Zimbabwe, the study will be conducted in a rural setting characterized by a humid subtropical climate with dry winters and hot summers[20, 21]. The average annual highest temperature is 33.3°C (91.9°F)[20], and the yearly temperature is 24.59ºC (76.26ºF)[22], 1.86% higher than Zimbabwe’s averages. Mount Darwin typically receives about 126.12 mm of precipitation annually, and the area is projected to become drier over time[22]. The World Bank Income group (GDP per capita) for Mount Darwin is a lower-middle income group of $1,737[23]. Three public health facilities in the study area provide primary care and referral services, including antenatal care, outpatient and inpatient services, and maternity care. The population in the district mainly survives with subsistence farming and artisanal gold mining, and the health facilities serve a catchment population of approximately 240,000 people[24]. The maternal mortality ratio per 100,000 live births is high, with 462 maternal deaths recorded, and the lifetime risk of maternal death is 1 in 53[25, 26]. Pregnant women have limited means of reducing heat exposure during a heatwave, and even drinking water may be scarce. Pregnant women have limited means of reducing heat exposure during a heatwave, and even drinking water may be scarce[27]. The maternal mortality ratio per 100,000 live births is high, with 462 maternal deaths recorded, and the lifetime risk of maternal death is 1 in 53 [25, 26]. Pregnant women have limited means of reducing heat exposure during a heatwave, and even drinking water may be scarce.

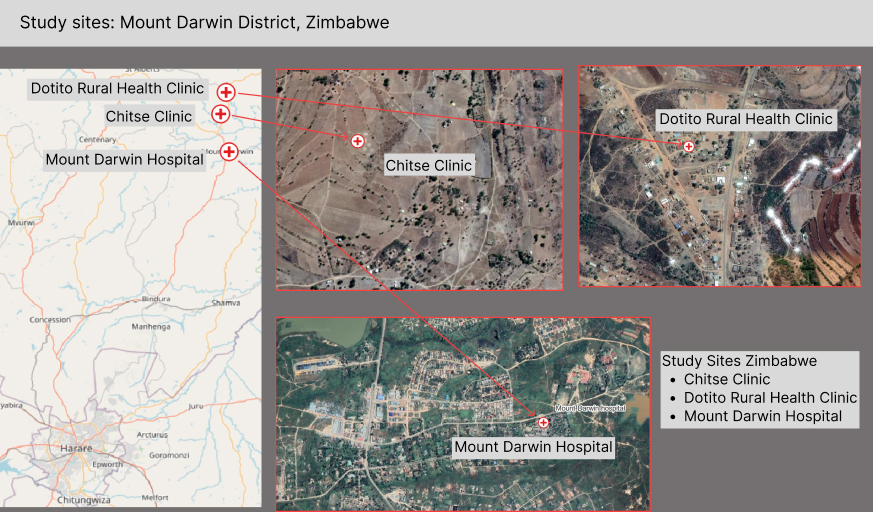


Figure 2: Zimbabwe study sites

### Mt Darwin District Hospital

Mt. Darwin District hospital is the district's primary care and referral facility. Various services are offered, including curative, preventative, maternity, postnatal, inpatient, outpatient, male and female wards, theatre, laboratory, and pharmacy[28]. The average number of women attending antenatal visits in the first month is 164180, and the average number of deliveries per year is 2295[29].



Figure 3: Mt Darwin District Hospital

### Dotito Rural Health Care Clinic

Dotito Rural Health Care Clinic is a primary care clinic situated 28 kilometres from Mt. Darwin District Hospital[30]. It offers services that include curative (chronic condition screening, monitoring and follow-up, T.B. screening, initiation, and management), maternity-related services (antenatal care, booking follow-up visit, deliver), postnatal care (Visual inspection with acetic acid and cervicography for cancer and lastly outpatient and inpatient related services. On a monthly average, the hospital services about 80 patients in the outpatient department. The maternity ward has a monthly average of 25-30 deliveries and a yearly average of 292 deliveries[29].



Figure 4: Dotito Rural Health Care Clinic

### Chitse Rural Health Care Clinic

Chitse Rural Health Care Clinic is situated 18 km from Mt. Darwin Hospital[31]. The clinic offers similar services as Dotito Rural Health Care. Services offered include curative, maternity-related services, postnatal care, outpatient and inpatient-related services. There are 18-20 monthly deliveries and about 230 deliveries yearly [29].

A picture containing outdoor, sky, ground, house

Description automatically generated

Figure 5: Chitse Rural Health Care Clinic

|  |  |  |  |
| --- | --- | --- | --- |
| **Variable** | **Tshwane, Gauteng Province, South Africa** | **Mount Darwin District, Mashonaland Central Province, Zimbabwe** | **Aga Khan Hospital in Mombasa (Secondary Care Field Site), Aga Khan Medical Centre in Kilifi (Primary Field Site), Kenya** |
| **Average daily maximum temperature (°C)** | **28.8 (January)** | **32.3 (October)** | **30.3 (February)** |
| **Average daily temperature of warmest month (°C)** | **22.8 (January)** | **25.6 (November)** | **26.8 (March)** |
| **Average annual rainfall total (mm)** | **657** | **730** | **700** |
| **Days with max apparent temp ≥32 °C [5]** | **38** | **92** | **40** |
| **Climate zone (Köppen-Geiger classification)** | **Subtropical (Cwb)** | **Humid subtropical (Cwb)** | **Tropical (Am)** |
| **Health facilities** | **Laudium Community Health Centre, Mamelodi District Hospital, Stanza Bopape Community Health Centre** | **Mt Darwin District Hospital, Chitse Rural Health Care Clinic, Dotito Rural Health Care Clinic** | **Aga Khan Medical Centre in Kilifi (primary field site), Aga Khan Hospital in Mombasa (secondary care field site)** |
| **Maternal mortality ratio per 100,000 live births (country level)** | **155.9 [8]** | **462 [9]** | **342 [18]** |
| **Lifetime risk of maternal death (country level)** | **1 in 330 [10]** | **1 in 53 [9]** | **1 in 69 [19]** |
| **Number of new women attending antenatal clinic in study area per month** | **268 [11]** | **235 [12]** | **500 [20]** |
| **Number of maternity facilities in study area** | **3** | **3** | **2** |
| **Predominant housing type** | **Informal housing with tin sheeting and low-cost government housing** | **Brick housing, or mud and sticks** | **Brick and mud houses, modern houses** |
| **Birth in a health facility** | **97.3% [13]** | **93% [14]** | **70% [21]** |
| **Preterm birth rate** | **12.6% [15]** | **17% [12]** | **12.5% [22]** |
| **Low birth weight rate** | **13% [16]** | **8.8% [9]** | **10.2% [22]** |
| **Stillbirth rate per 1000 live births** | **18 [13]** | **13 [12]** | **21.5 [23]** |
| **Caesarean section rate** | **26.0% [16]** | **4% [14]** | **9.3% [22]** |
| **Neonatal mortality rate per 1000 live births** | **12.2 [17]** | **33 [12]** | **17.8 [23]** |

Table 2: Climatic, socio-economic, and maternal and newborn health characteristics of the study sites

# PROBLEM STATEMENT/RATIONALE

Climate change poses a significant threat to human health, as rising temperatures can lead to an increased risk of heat-related illnesses and diseases . To develop effective climate policy, it's important to quantify and monitor the impacts of heat and contributors thereof, evaluate the costs and benefits of different interventions, and prioritize resources to protect those who may be most affected[2].

Healthcare facilities are significant contributors to greenhouse gas emissions due to their energy-intensive operations, which include heating, cooling, lighting, ventilation, medical equipment, and waste management[32]. While reducing these emissions has the potential for direct health benefits, the cost-effectiveness of mitigation strategies implemented in healthcare facilities is poorly understood due to limited research [33].

The project aligns with the Paris Agreement under the United Nations Framework Convention on Climate Change, which aims to limit global warming and protect against the impacts of climate change[34].

# OBJECTIVES

The primary focus of this protocol is to assess the carbon emissions generated by selected health facilities in Kenya, South Africa, and Zimbabwe. The objectives are as follows:

1. Measure the carbon footprint of health facilities using the Aga Khan Development Network's (AKDN) Carbon Management Tool.
2. Develop resource allocation tools for mitigation strategies, and implement mitigation strategies to decrease greenhouse gas emissions in health facilities.
3. Evaluate the success of the mitigation strategies in terms of reduction in greenhouse gas emissions and cost-effectiveness.
4. Disseminate the findings to relevant stakeholders through a well-planned communication strategy.

# DESIGN

## Methodology

The study will be guided by a methodological framework consisting of three phases. In the first phase, the carbon footprint of each health facility will be measured using the AKDN Carbon Management Tool. This phase aims to establish a baseline measurement of carbon emissions for each facility, which will serve as a reference point for subsequent evaluations.

In the second phase, a resource allocation tool for mitigation strategies will be developed, and mitigation strategies will be implemented to decrease greenhouse gas emissions in health facilities. The specific steps involved in this phase will be further unpacked in the subsequent sections of the study. It is important to note that this phase will be carried out by research staff from the partners within the High Horizons project rather than the health facilities themselves.

The final phase of the study will involve the evaluation of the success of the mitigation strategies in terms of reduction in greenhouse gas emissions and cost-effectiveness. Again, the specific steps involved in this phase will be further elaborated on in the subsequent sections of the study.

Overall, the study will employ a rigorous methodology that involves careful measurement, analysis, and evaluation of the impact of mitigation interventions in health facilities. Each phase of the study will be thoroughly detailed in the subsequent sections of the report, with a clear description of the activities involved, the steps taken, and the responsible parties.

Graphical user interface, text, application, Word, email

Description automatically generated

Figure 6: Phased approach to project implementation

## Carbon Emission Measurement

A serial, longitudinal measurement design will be employed to assess the carbon emissions of health facilities in Kenya, Zimbabwe, and South Africa. This will be the basis for the carbon baseline assessment in phase one of the project and carry on throughout the project. This approach involves measuring carbon emissions at three-month intervals using the AKDN Carbon Management Tool, an integrated Excel-based system designed for measuring and analyzing carbon emissions[7]. The tool covers three scopes, Scope 1, 2, and 3, which enable a comprehensive evaluation of greenhouse gas emissions, including those from supply chains(see table 3). The tool can handle specific emissions from the health sector, such as anaesthetic gases, respiratory inhalers, and emissions from energy, transport, waste, and refrigerants. The tool automatically calculates carbon footprints and assigns emissions scopes, providing instant carbon read-outs and diagnostic dashboards that can be used to identify emissions hotspots. This methodology is deemed the most appropriate for trend analysis and will provide valuable information on the effectiveness of mitigation measures over time.

To ensure that the carbon emissions of health facilities in these countries are continually monitored and evaluated, a 3-monthly measurement will be employed. This will involve measuring carbon emissions at three-month intervals using the AKDN Carbon Management Tool, which is equipped to handle specific emissions from the health sector and provides instant carbon read-outs and diagnostic dashboards. Table 3 defines the three scopes of the AKDN tool, which enables a comprehensive evaluation of greenhouse gas emissions, including those from supply chains. This approach will provide valuable information on the effectiveness of mitigation measures over time and enable health facilities to identify emissions hotspots and implement strategies to reduce their carbon footprint.

| **Emissions Scope** | **Definition** | **Example** |
| --- | --- | --- |
| **Scope 1** | **Direct emissions from the organization's activity** | **Burning fuel or waste on the premises, using anaesthetic gases, emissions from company vehicles** |
| **Scope 2** | **Indirect emissions from energy consumed by the organization** | **Buying and consuming electricity, steam, heat, or cooling from local authorities, emissions from purchased fuels, such as natural gas for heating** |
| **Scope 3** | **Indirect emissions from products or services used to support the organization's operations** | **Purchased goods and services, waste disposal, employee commuting, business travel, investments, leased assets, transportation of goods and services** |

Table 3: Defining Scopes of the AKDN tool

Graphical user interface, application

Description automatically generated

Figure 7: AKDN tool cover page

### Sources of emissions specific to healthcare facilities

Table 4 highlights the various sources of emissions that can result from energy consumption within healthcare facilities, including vehicle use, travel distances, and the use of certain medical equipment, such as anesthetic gases and respiratory inhalers. In addition, emissions resulting from refrigerant gases used in air conditioning and refrigeration systems, water usage, waste disposal, and the travel of vehicles other than those owned by healthcare facilities, such as patient or visitor vehicles also contribute to health faciltiys’ carbon footprint (Table 4). By understanding the sources and extent of emissions, healthcare facilities can identify areas where they can implement strategies to reduce their carbon footprint and improve their sustainability.

| **Sources of Emissions** | **Description** |
| --- | --- |
| **Energy** | Energy consumption within healthcare facilities can contribute to emissions from electricity, heating, and other sources such as natural gas, propane, and fuel oil. |
| **Vehicle Fuel** | Using vehicles for healthcare facilities, such as ambulances, delivery vehicles, and staff vehicles can contribute to emissions. |
| **Vehicle Distance** | The distance vehicles travel to and from healthcare facilities can also contribute to emissions. |
| **Travel Other Vehicles** | Emissions from travel by vehicles other than those owned by healthcare facilities, such as patient or visitor vehicles, may also contribute to the overall carbon footprint. |
| **Anesthetic Gases** | Anesthetic gases used in medical procedures are potent greenhouse gases, and their use in healthcare facilities can contribute to emissions. |
| **Refrigerant Gases** | Refrigerants used in air conditioning systems, refrigerators, and freezers can also contribute to emissions through leaks or improper disposal. |
| **Water** | Water usage in healthcare facilities can result in emissions through the energy used in treatment, pumping, and heating processes. |
| **Waste** | Disposing of waste from healthcare facilities can result in emissions from landfills and waste-to-energy processes. |
| **Inhalers** | Respiratory inhalers in healthcare facilities can also contribute to emissions by producing and disposing of these products. |

Table 4: Sources of greenhouse gas emissions in healthcare facilities

### Supply chain contribution to carbon emissions in health facilities

Healthcare facilities can contribute to carbon emissions through various processes, including construction and maintenance, procurement of goods and services, and waste disposal. By implementing sustainable practices, healthcare facilities can reduce their carbon footprint and improve their sustainability. This section provides an overview of the various aspects of healthcare facility management that can contribute to carbon emissions and highlights strategies to reduce emissions. These include selecting materials with low embodied carbon, implementing sustainable procurement policies, and analyzing financial spending to identify areas where emissions can be reduced. Healthcare facilities can prioritize investments in low-carbon goods and services and improve their carbon management by understanding the sources of emissions and their impact on the facility's carbon footprint. These categories are part of the categories recorded in the supply chain management sheets of the AKDN tool.

* Construction Materials: The materials used in the construction and maintenance of healthcare facilities can contribute to emissions through the production and transportation of these materials. Choosing materials with low embodied carbon, such as sustainably sourced wood or recycled materials, can help to reduce emissions[7].
* Contractor Logistics: The transportation and disposal of waste generated by contractors working in healthcare facilities can also contribute to emissions. Implementing sustainable procurement policies and practices, such as requiring contractors to reduce emissions and waste, can help to reduce emissions[7].
* Procurement\_T2: T2 procurement refers to the procurement of goods and services for the day-to-day operations of healthcare facilities. Selecting products and services with low emissions, such as energy-efficient equipment or green cleaning products, can help to reduce emissions[7].
* Procurement\_T3: T3 procurement refers to procuring goods and services for capital projects, such as construction or renovation. Choosing materials and equipment with low embodied carbon and implementing sustainable procurement practices, such as considering product lifecycle impacts, can help reduce emissions[7].
* Spend Mapping: Spend mapping tracks and analyzes financial spending within healthcare facilities. This information can be used to identify areas where emissions can be reduced and to prioritize investments in low-carbon goods and services.

### Action tracker sheet and four data output sheets.

The tool calculates the carbon footprint for all data provided and automatically assigns emissions scopes. It converts input data into instant carbon read-outs and diagnostic dashboards. Emissions outputs appear on each line, and totals appear at the top of each sheet as a sheet is completed. Four separate (Error checking, totals, supply chain totals, building totals, and benchmarking) sheets provide dashboards and charts to help consolidate and interrogate the data. These include a high-level summary and per m² facility benchmarking to help identify hotspots at a facility and at an organization level. The tool output is a set of facility-specific potential mitigation target points weighed against emissions modelling and cost-benefits[7].

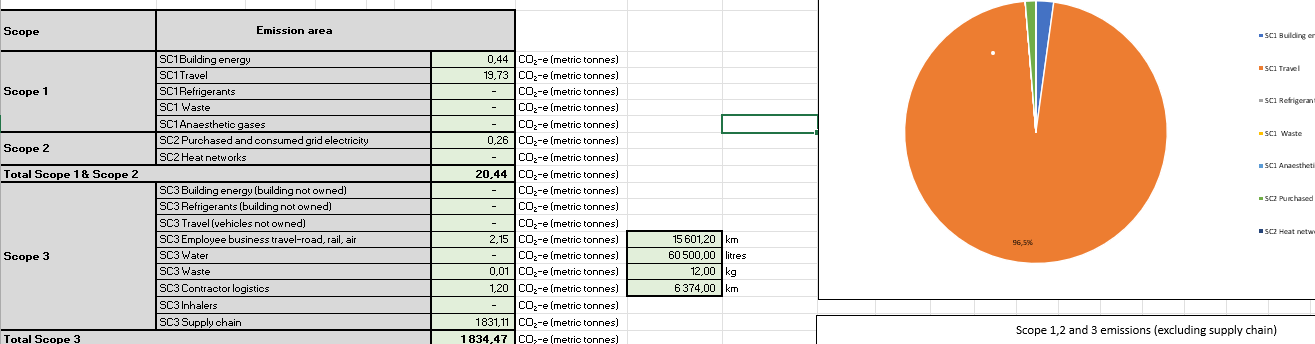


Figure 8: Output sheet

### Variables of interest

To better understand how carbon emissions are calculated in healthcare facilities, it's essential to look at the variables of interest that feed into the calculation. Table 5 provides an overview of the variables that will be collected and converted into CO2 emissions, such as building ownership, floor area, energy consumption, fuel consumption, vehicle distance, and waste generation. Additionally, details of procurement, construction materials, and logistics for contractors will be recorded, as well as progress made over time on initiatives to reduce carbon footprint. The table also includes a currency conversion rate, which will be used to convert local currency to a common currency for data analysis. By capturing these variables, healthcare facilities can better understand their carbon footprint and implement strategies to reduce emissions.

| **Sheet Name** | **Variables Collected** | **Details of Measures** |
| --- | --- | --- |
| **Buildings** | Name, Ownership2, Floor Area | Information about the building's name, ownership (whether it is owned or rented), and the floor area in square meters. |
| **Energy** | Details of energy consumption | Details of electricity, gas, and steam consumption for heating, cooling, and other purposes, in kWh or G.J. |
| **Vehicle Fuel** | Details of fuel consumption | Details of fuel consumption for vehicles, in liters or gallons. |
| **Vehicle Distance** | Details of vehicle distance | Details of the distance traveled by vehicles, in kilometers or miles. |
| **Travel Other Vehicles** | Details of other vehicle travel | Details of the distance traveled by other modes of transportation, such as trains or airplanes, in kilometers or miles. |
| **Anaesthetic Gases** | Details of anaesthetic gas usage | Details of the quantity and type of anaesthetic gases used, in liters or pounds. |
| **Refrigerant Gases** | Details of refrigerant gas usage | Details of the quantity and type of refrigerant gases used, in kilograms or pounds. |
| **Water** | Details of water usage | Details of water consumption for domestic, industrial, and medical purposes, in liters or gallons. |
| **Waste** | Details of waste generation | Details of the type and quantity of waste generated, in kilograms or pounds. |
| **Inhalers** | Details of inhaler usage | Details of the number and type of inhalers used. |
| **Construction Materials** | Details of construction materials used | Details of the quantity and type of construction materials used, in kilograms or pounds. |
| **Contractor Logistics** | Details of contractor logistics | Details of transportation and logistics activities for contractors, in kilometers or miles. |
| **Procurement\_T2** | Details of procurement | Details of procurement for equipment, appliances, and other materials, in dollars or local currency. |
| **Procurement\_T3** | Details of procurement | Details of procurement for services, in dollars or local currency. |
| **Spend Mapping** | Details of expenditures | Details of expenditures for all categories, including salaries, benefits, and other expenses, in dollars or local currency. |
| **Action Tracker** | Progress made over time on initiatives to reduce carbon footprint | Details of the initiatives taken to reduce carbon emissions, such as implementing renewable energy sources, energy efficiency measures, and waste reduction. |
| **Currency Conversion Rate** | Currency conversion rate | The exchange rate used to convert local currency to a common currency for data analysis. |

Table 5: Variables of interest

### Data Quality Scores

Data collection involves gathering information on the type and quantity of resources used. A data quality score can be assigned for each line item to ensure accuracy. The data source is selected from a drop-down list, such as 'from supplier's bills' or 'estimates,' which contributes to an overall data quality score. This score takes into account the amount of resources used and the level of quality assigned for each line item. It is displayed below the total carbon emissions figure on each sheet.

In addition, users can input the unit cost of resources, which will be helpful when prioritizing and justifying investments in carbon reduction. The carbon emissions calculated for each line item, including the carbon factor used, the emissions produced, and the GHG protocol Scope, are located on the right-hand side of each sheet. Emissions hotspots are identified through a colour ranking system, with Red indicating the highest emissions and Green the lowest.

## Design and optimization modelling of mitigation intervention in health facilities:

### Optimization modelling

The selection of the most effective mitigation interventions will be based on a thorough analysis of the cost-effectiveness ratio of each intervention[35]. To enhance the project's impact, the team intends to further develop this approach into a comprehensive tool that can be used to make informed decisions on investment in mitigation interventions. This approach, previously used for HIV, nutrition, and Maternal, Newborn, and Child Health (MNCH) interventions, will be further developed into a comprehensive tool for the HIGH Horizons project with the support of the Burnet Institute[36]. The optimization modelling technique will incorporate the latest advancements in optimization techniques, such as decision trees or Markov models, to ensure that the best possible outcomes are achieved[37]. As part of this exercise, the HIGH Horizons project will organize a stakeholder workshop to gather input and feedback from relevant stakeholders in the health care sector. The workshop will leverage the AKHS investment modelling approach, which aims to optimize the allocation of financial resources towards mitigation efforts in health care facilities in order to maximize carbon emission reductions[38].

## Implementation of mitigation interventions in health facilities

The project intends on implementing a range of facility-specific interventions to reduce carbon emissions in Maternal, Newborn, and Child Health facilities in Kenya, Zimbabwe, and South Africa.. Once areas for intervention are identified, an action plan will be developed, outlining specific activities and timelines for implementation. High Horizons partners research team, will be responsible for implementing the interventions. Progress will be monitored through serial measurements of carbon emissions, energy use, and waste management practices using the AKDN carbon management tool.

In Kenya, these interventions could include installing solar Photovoltaic(PV) systems, modifying buildings for natural ventilation and shading, and replacing air-conditioning units with more energy-efficient alternatives. In Zimbabwe, the project aims to implement environmentally-friendly waste management practices, reduce harmful refrigerants, and plant trees for shade and carbon offset. In South Africa, the interventions will be customized to meet the unique needs and circumstances of the location, focusing on reducing the use of fossil fuels, implementing waste management practices, planting trees, and replacing air-conditioning units.

## Effectiveness of mitigation interventions in health facilities

Phase three of this project will quantify the tonnes of CO2 emitted by each health facility after implementing carbon mitigation interventions. We will assess the effectiveness of these interventions on reducing carbon emissions as the main goal, while environmental impacts and cost-effectiveness will be secondary measures.

To provide a comprehensive understanding of the effectiveness of the interventions, we will present the results in a disaggregated format, including estimates of the mean costs with appropriate measures of dispersion associated with each intervention in a descriptive table. This will allow stakeholders, program leaders, subject experts, researchers, and decision-makers to establish context-specific relevance and relative importance[39].

Furthermore, we could explore the potential for replicability of the interventions in other health facilities or sectors[40]. This will help spread the interventions' positive impacts and contribute to a more sustainable future. Overall, this project's primary focus is to evaluate the effectiveness of carbon mitigation interventions in health facilities by measuring their impact on the environment and human health through the primary outcome of tonnes of CO2 emissions.

## Roles and Responsibilities

This project's success largely depends on the roles and responsibilities of the partner research teams and the district department of health. The partner research teams will play a critical role in implementing each phase of the project. They will coordinate and oversee the data collection process, develop the resource allocation tool, and implement mitigation strategies to decrease greenhouse gas emissions in health facilities. Additionally, they will evaluate the success of the mitigation strategies in terms of reduction in greenhouse gas emissions and cost-effectiveness.

In phase 1, the partner research teams will work closely with the district health department to measure each health facility's carbon footprint using the Aga Khan Development Network's (AKDN) Carbon Management Tool. They will also work together to collect baseline data on the energy and water use of the health facilities.

In phase 2, the partner research teams will develop a resource allocation tool for mitigation strategies and implement mitigation strategies to decrease greenhouse gas emissions in health facilities. This will involve working with facility staff to identify opportunities for reducing energy and water use and developing and implementing a plan for reducing waste and promoting sustainable practices.

In phase 3, the partner research teams will evaluate the effect of the mitigation strategies in terms of reduction in greenhouse gas emissions and cost-effectiveness. They will analyze the data collected in phase 1 and phase 3 to determine the interventions' effectiveness.

The district department of health will play a critical role in facilitating access to data and providing insights into the process of implementing the study. They will also serve as a valuable partner in disseminating the findings to relevant stakeholders through a well-planned communication strategy. However, it is important to note that the High Horizons research team is ultimately responsible for all phases of the project and will work closely with the partner research teams and the district department of health to ensure the successful completion of the project.

# PROJECT PROCEDURES

Project procedures refer to the steps or actions taken to successfully complete a project [41]. These procedures can include obtaining necessary approvals, collecting data, implementing interventions, evaluating outcomes, and disseminating results. The table below provides an overview of the project procedures for three countries: Zimbabwe, Kenya, and South Africa. For more detailed Gantt charts, please see annexure A.

| **Country** | **Procedure** |
| --- | --- |
| **Kenya** | 1. Utilize existing data on carbon emission monitoring. 2. Design and optimize a model comparing benefits and costs. |
| **South Africa** | 1. Obtain approvals from relevant authorities. 2. Apply for ethics approval. 3. Conduct measurements and data collection. 4. Design and optimize a model comparing benefits and costs. 5. Implement interventions in facilities. 6. Evaluate cost-effectiveness. 7. Disseminate results through conferences, publications, and policy briefs. |
| **Zimbabwe** | 1. Apply for a support letter to the Ministry of Health and Child Care. 2. Measure carbon footprints at proposed facilities. 3. Design and optimize a model comparing benefits and costs. 4. Implement interventions in facilities. 5. Evaluate cost-effectiveness. 6. Disseminate results through conferences, publications, and policy briefs. |

Table 6: Study procedure

# DATA MANAGEMENT AND ANALYSIS

## Data Management

Data management is a critical component of the High Horizons research project, and the team has taken a number of measures to ensure that the collected data are secure and protected. The implementing partners in Kenya, South Africa, and Zimbabwe will be responsible for data collection and management using the AKDN Health Carbon Management tool V1.6.1, which is a Microsoft Excel office package. The tool will be password-protected, and access to the data will be limited to authorized team members from the respective implementing partners to prevent access by unauthorized third parties. In each country, one person in the study team will be responsible for data management and protection of project activities in compliance with relevant data protection regulations and standards, including the principle of data minimization.

To ensure the security and protection of the data, the project will follow the ISO/IEC 27001:2005 standards for data storage. The data storage will be protected against risk to prevent data loss, and the partners will take necessary measures to protect all data collected during the project. These measures include access controls, regular backups, and encryption. The High Horizons project has a Data Management Plan (DMP) that outlines the data management life cycle and ensures data quality control. The DMP will be updated throughout the project to reflect the status of the project's data management activities and comply with country regulations. The Project Coordinator at Ghent University is responsible for the overall data management and the handling of the project's SharePoint folders and files and the UGent shared network drive and repositories on behalf of the project.

The AKDN Carbon Management Tool will be installed on research staff laptops for data collection during facility visits. Once the data is entered into the tool, research staff will upload it onto a secure SharePoint server as soon as they have access to an internet connection. The data will be removed from the laptops to ensure that it is not left in any unsecured location. The SharePoint server is password-protected, and access will be granted only to authorized project team members. All data will be stored securely in the cloud, and the server will be regularly backed up to prevent data loss. In addition, data will be transferred using secure methods, such as encrypted file transfers, to prevent unauthorized access.

The High Horizons research team takes data management and security very seriously and is committed to ensuring that all data collected during the project is kept confidential and secure. All partners involved in the project will work together to ensure that data is managed and transferred using the latest and most secure techniques available to prevent any potential leaks. The team will continuously monitor the data management practices and take necessary measures to address any issues arising during the project. Data training on data handling and management best practices, such as data access controls, data backup and storage, and data encryption, will be conducted for researchers handling the data to ensure that they are equipped with the necessary skills and knowledge to handle and manage data securely and responsibly.

## Data Analysis

The totals sheet is the focal point of the carbon measurement analysis, bringing together all the calculated emissions data from individual data sheets. The sheet provides an overall summary of emissions, including by source (e.g., energy, anaesthetics) and by scope (Scope 1, 2, or 3), expressed in tons of CO2 equivalent ( tCO2e). Additionally, the sheet showcases environmental indices such as water use and renewable energy generated. At the end of each data collection period(every three months)pre and post-intervention, the totals will be imported into a word document for reporting and dissemination purposes.

We will use statistical methods such as regression analysis, ANOVA, and student's t-tests to explore associations between variables. Additionally, we will use interrupted time series analysis to uncover potential relationships between interventions and reduced emissions. By varying the input parameters and evaluating their impact on the results, we can identify the input parameters with the most significant impact and uncertainty. This analysis will help us assess the significance of relationships between variables and uncover any potential associations between interventions and reduced emissions [42].

The results of the data analysis will be presented in an easy-to-understand format using graphs, tables, and charts and will be interpreted and discussed to highlight key findings and their implications for policy and practice[43]. These findings will be disseminated through academic journals, conference presentations, and policy briefs to reach a broad audience and maximize their impact.

## Cost-effectiveness analysis

The cost-effectiveness of carbon mitigation interventions in healthcare facilities will be a crucial aspect of this study. The primary unit of analysis will be the tonnes of CO2 emissions from each healthcare facility[44]. The cost-effectiveness analysis (CEA) will be conducted concurrently with the carbon measurements during and after implementing mitigation interventions to determine the economic feasibility of different interventions in reducing carbon emissions[45].

To perform the CEA, we will identify the costs associated with various carbon reduction interventions and compare them with their effectiveness in reducing CO2 emissions. We will measure the costs and outcomes of different interventions and compare the cost per unit of outcome across various interventions. The CEA will involve identifying the carbon reduction interventions used in each healthcare facility, estimating their costs, measuring their effectiveness in reducing CO2 emissions, and calculating the cost per unit of outcome for each intervention, such as the cost per ton of CO2reduced[44].

We will adhere to best practices for conducting cost-effectiveness analyses to ensure accuracy and reliability. We will use a common metric to measure outcomes, such as the cost per ton of CO2 produced, account for uncertainty through sensitivity analyses, and use country-specific discount rates to account for the time value of money(Table 7)[46].

The CEA will help identify the most economically feasible carbon reduction interventions for healthcare facilities in the participating countries. We will use a threshold for cost-effectiveness based on local context, such as the country's gross domestic product per capita or willingness to pay for health improvements[47]. By comparing the cost-effectiveness of different interventions, we will be able to determine the most efficient use of resources and generate valuable information to help inform policy decisions in the participating countries.



| **Variable** | **Description** |
| --- | --- |
| **Primary Unit of Analysis** | **Tonnes of CO2 emissions from each healthcare facility** |
| **Analysis Method** | **Cost-effectiveness analysis (CEA) conducted concurrently with carbon measurements** |
| **Purpose** | **To determine economic feasibility of different interventions in reducing carbon emissions** |
| **Steps** | **Identify costs associated with various carbon reduction interventions, compare costs with effectiveness in reducing CO2 emissions, measure costs and outcomes of interventions, calculate cost per unit of outcome for each intervention** |
| **Best Practices** | **Use common metric to measure outcomes, account for uncertainty through sensitivity analyses, use country-specific discount rates to account for the time value of money** |
| **Threshold for Cost-Effectiveness** | **Based on local context, such as the country's gross domestic product per capita** |
| **Outcome** | **Identify the most economically feasible carbon reduction interventions for healthcare facilities and generate valuable information to inform policy decisions** |

Table 7 Cost-Effectiveness Analysis of Carbon Mitigation Interventions in Healthcare Facilities

# Quality Assurance

Quality assurance is crucial in the carbon measurement project to optimize accurate and trustworthy results and reduce bias[48]. The research team will undergo thorough virtual training from the ADKN and experts from CeSHHAR and WITS RHI to master carbon footprint measurement. The virtual training will cover all aspects of the measurement process, including data collection, analysis, and reporting, and stress the significance of adhering to protocols and guidelines. The team will be equipped with the necessary skills and knowledge to deliver high-quality results.

Additionally, to further ensure the accuracy of the measurement, the ADKN Health Carbon Management tool has an error-checking sheet that detects and highlights common errors or inconsistencies in data entry, as shown in figure 9. The sheet provides instructions for fixing these errors, ensuring the integrity of the collected data, and reducing the potential for inaccurate results. Furthermore, the research team will apply data validation techniques, including range checks, format checks, and cross-referencing with external sources, to verify the accuracy and completeness of the data. A detailed record of all activities involved in the measurement process, including data collection, analysis, and reporting, will be maintained in a log book throughout the project for traceability and accountability purposes.

Table

Description automatically generated

Figure 9: Error checking sheet

# ETHICS AND DISSEMINATION

## Research ethics approval

Successfully implementing public health programs and policies requires rigorous research to guide decision-making and measure their impact[49]. Such research must be conducted with ethical considerations in mind to ensure that it is responsible, safe, and respectful of the rights and well-being of all involved[50].

Obtaining approvals and certifications in each participating country is necessary to ensure a responsible and ethical approach.

* In Kenya, the study team will adhere to nationally relevant legislation such as the Kenyan National Guidelines for Research Involving Humans as Research Participants, which sets ethical standards for research. The team will also follow the guidelines outlined in the Aga Khan University Hospital Research Ethics Policy. The team will ensure that all data is collected and stored confidentially.
* In South Africa, the study team will adhere to nationally relevant legislation such as the South African National Health Act, which sets standards for the provision of healthcare services in the country, as well as the South African Guidelines for Good Clinical Practice[51, 52]. The team will seek ethics approval from the Wits RHI Research Review Committee and the University of the Witwatersrand Human Research and Ethics Committee, performed within the faculty of Health Sciences at the University of Witwatersrand. We will also seek approval from the district to proceed with the study. Additionally, all researchers will be trained on good clinical practice and will ensure that all data is collected and stored confidentially.
* In Zimbabwe, the study team will adhere to nationally relevant legislation such as the Zimbabwe National Guidelines for Research Involving Humans as Research Participants, which sets ethical standards for research in the country[53]. The team will ensure that all data is collected and stored confidentially.
* The team comprises highly trained and experienced researchers with expertise in various relevant fields, including public health, epidemiology, environmental science, and data management. The team has extensive experience conducting research in low-resource settings. They have undergone training in research ethics and will adhere to the principles of research ethics throughout the study. We have also enlisted the services of local partners in each participating country to help us navigate the local regulatory environment and ensure that the project is carried out in a responsible and ethical manner
* All three countries have relevant national legislation and guidelines, such as the Kenyan Health Act[54], the South African National Health Act[52], and the Zimbabwe Public Health Act[55], that the team will adhere to throughout the study.
* The research project involves collecting data on carbon emissions and not human participants. However, some risks may be associated with data collection and management, including confidentiality breaches, unauthorized access, or loss of data. To minimize these risks, the team will ensure that data collection is done securely by implementing password-protected access to data and using encrypted data storage devices. The team will also ensure that any data shared between team members is done securely and kept confidential using SharePoint ,weTransfer, Box and password protects email. Additionally, the team will have protocols to handle any adverse events, such as data breaches, and will work with the appropriate authorities to minimize any potential negative impacts. By taking these measures, the team will ensure that the risks associated with the research project are minimized and conducted ethically and responsibly [56].
* in this project, the carbon measurements do not involve human participants, and the data will be collected from equipment and facilities. As a result, informed consent is not required. Nonetheless, the research team will take steps to ensure that the data is collected responsibly and ethically and that any potential risks or ethical considerations that emerge are carefully considered and addressed.
* Good Participatory Practice (GPP) plan has been developed for the overall High Horizons project, of which this specific sub-study is a part. The GPP plan outlines the project's commitment to promoting community engagement and participation, ensuring that the community is involved in all aspects of the project, from the planning phase to the dissemination of results. The GPP plan emphasizes the importance of transparency, accountability, and community ownership and provides guidance on achieving these goals.
* The potential benefits of this research project are significant and extend beyond the participating communities to society as a whole[58]. The project's outcomes will be useful in informing policy development, identifying environmental and health risks, and developing strategies to mitigate those risks. The project's potential to reduce carbon emissions is also significant, as carbon emissions contribute to climate change and negatively impact the environment[59]. Therefore, the benefits of the project, which include better health policy, improved environmental health, and reduced carbon emissions, far outweigh the potential risks involved.
* country-specific, including the Kenyan Data Protection Act[60], the South African Protection of Personal Information Act[61], and the Zimbabwe Data Protection Act[62]. Our research strategy aligns with these data privacy laws, as we will prioritize data confidentiality, security, and protection. We will obtain the necessary approvals and certifications to maintain data privacy throughout the project.

## Dissemination

We aim to share our findings with local, regional, and global governments mentioned hereafter and local stakeholders who can influence policy. We intended to share the findings with country-specific groups discussed subsequently.

## Kenya

In Kenya, we plan to disseminate our findings to local stakeholders who may benefit from our work. The objective is to increase understanding of the implications of our work and national policies and identify potential remaining knowledge gaps and actions for future work. We plan to present our results at stakeholder meetings, including representatives from the Ministry of Health, Ministry of Environment and Forestry, individuals involved in developing the National Climate Adaptation plans, professional health worker associations, facility managers, and community leaders. Additionally, we will present our findings to community advisory boards to engage with the local community and gather their perspectives.

## South Africa

In South Africa, we will disseminate our results to local stakeholders who may benefit from our findings. The objective is to increase understanding of our work's implications and national policies and identify any remaining knowledge gaps and actions for future work. We plan to present our results at stakeholder meetings, including representatives from the Department of Health, Department of Forestry, Fisheries and the Environment, individuals involved in developing the National Climate Adaptation plans, professional health worker associations, facility managers, and community leaders. Additionally, we will present our findings at Community Advisory Boards to engage with the local community and gather their perspectives.

## Zimbabwe

In Zimbabwe, we plan to disseminate our results to people who may directly benefit from our findings. The objective is better to understand the implications of the work and national policies and identify potential remaining knowledge gaps and actions for future work. We plan to present our findings at stakeholder meetings. Attendees at these meetings may include the Ministry of Health and Child Care, Ministry of Environment, Climate, Tourism and Hospitality, individuals involved in developing the National Climate Adaptation plans, professional health workers associations, facility managers, and church leaders. Additionally, we also plan to present our findings to community advisory boards.

## Scientific conferences

Presenting findings at scientific conferences is an important aspect of our project. This provides a platform to share our results with a broader audience of experts, researchers, and decision-makers in climate change, health, and sustainability. We aim to engage with a diverse group of individuals and institutions who may be able to use our findings to inform their work, policies, and decision-making[63].

We plan to attend local and international conferences, providing opportunities to share our findings with a broader audience and receive feedback from experts from different regions and perspectives. The presentations will be structured to effectively communicate our results, including the methods used, main findings, and their implications for policy and practice. This will help promote evidence-based practices and contribute to advancing knowledge in the field.

Participating in scientific conferences will allow us to contribute to the scientific community, establish new collaborations and partnerships, and provide opportunities to learn from others working in the field.

## Publications

Publishing the findings of our project in open-access journals is a vital aspect of disseminating the results to a broader audience. Open-access journals provide a platform for the results to be widely available and easily accessible to diverse individuals, including policymakers, practitioners, researchers, and the general public. This will help promote evidence-based practices and contribute to advancing knowledge in the field.

The manuscripts we plan to publish will provide a comprehensive overview of the study's methods, results and implications. We aim to publish in high-impact, peer-reviewed journals that are widely read and recognized in the relevant fields. This will ensure high-quality results and receive the necessary recognition and visibility[64].

In addition to publishing the results, we plan to publish the study's methodologies and protocols. This will help others to understand the methods used and to replicate the study if needed. Overall, publishing the results of our project in open-access journals will help promote transparency and accountability and contribute to advancing knowledge and evidence-based practices in the field[65].

Limitations.

## Strengths

The project has several strengths that increase the validity and generalizability of its findings:

1. **Multi-country approach:** The project covers healthcare facilities in three different sub-Saharan African countries, increasing the diversity of its findings and allowing for cross-country comparisons.
2. **Use of AKDN Carbon Management Tool**: The project will use the AKDN Carbon Management Tool, which has been widely validated and used in previous studies, ensuring the reliability of the data collected.
3. **Longitudinal study design:** The project will use a serial measurements approach, which will enable the tracking of progress over time, providing valuable insights for future sustainability efforts.
4. **Partnership with local health departments:** The project is working closely with local health departments in each country, which will facilitate access to data and ensure the feasibility of implementing mitigation strategies.
5. **Clear communication strategy:** The project has a well-planned communication strategy for disseminating its findings to relevant stakeholders, including policymakers, researchers, and healthcare professionals, ensuring that the results are widely shared and can inform future efforts.

These strengths will increase the project's impact and contribute to its overall success in improving our understanding of the healthcare sector's contribution to greenhouse gas emissions in sub-Saharan Africa and identifying effective mitigation strategies.

## Limitations

Despite the strengths of this project, there are several limitations that must be acknowledged:

1. **Limited sample size:** The study is limited to eight healthcare facilities in three sub-Saharan African countries, which may not be representative of all healthcare facilities in the region. Therefore, the findings may not be generalizable to other healthcare facilities in the region or other parts of the world.
2. **Incomplete data:** Some facilities may not have accurate or complete data on energy consumption and waste management practices, which could impact the accuracy of the carbon footprint measurements.
3. **Limited timeline:** The study is limited to a three-year timeline, which may not be sufficient to capture all changes in greenhouse gas emissions resulting from mitigation strategies. Longer-term studies would be necessary to fully evaluate the impact of interventions on reducing emissions and achieving sustainability goals.
4. **Resource limitations**: The project's success depends on the availability of resources and the cooperation of the healthcare facilities. Some facilities may not have the resources or capacity to implement mitigation strategies, which could impact the effectiveness of the interventions.
5. **External factors:** The study may be limited by external factors that could impact healthcare facilities' emissions, such as changes in energy prices or natural disasters. These factors are beyond the control of the research team and could impact the accuracy and generalizability of the findings.

Overall, while this project has the potential to provide valuable insights into the carbon footprint of healthcare facilities in sub-Saharan Africa and the effectiveness of mitigation strategies, it is important to acknowledge these limitations and interpret the findings in the context of these limitations.

# REFERENCES

1. Seneviratne, S., et al., *Changes in climate extremes and their impacts on the natural physical environment.* 2012.

2. Ebi, K.L., et al., *Extreme Weather and Climate Change: Population Health and Health System Implications.* Annu Rev Public Health, 2021. **42**: p. 293-315.

3. Roos, N., et al., *Maternal and newborn health risks of climate change: A call for awareness and global action.* Acta obstetricia et gynecologica Scandinavica, 2021. **100**(4): p. 566-570.

4. Kuehn, L. and S. McCormick, *Heat Exposure and Maternal Health in the Face of Climate Change.* Int J Environ Res Public Health, 2017. **14**(8).

5. Myers, S.S. and A. Bernstein, *The coming health crisis: indirect health effects of global climate change.* F1000 Biol Rep, 2011. **3**: p. 3.

6. Borg, F.H., et al., *Climate change and health in urban informal settlements in low- and middle-income countries - a scoping review of health impacts and adaptation strategies.* Glob Health Action, 2021. **14**(1): p. 1908064.

7. *Aga Khan Development Network. Guide to the Aga Khan Development Network's carbon management tool. 2018.* [*https://d1zah1nkiby91r.cloudfront.net/s3fs-public/guide\_to\_the\_aga\_khan\_development\_networks\_carbon\_management\_tool\_.pdf*](https://d1zah1nkiby91r.cloudfront.net/s3fs-public/guide_to_the_aga_khan_development_networks_carbon_management_tool_.pdf)*.*

8. Baddley, J. *Guide to the Aga Khan Development Network's Carbon Management Tool* 2022.

9. King, P.T., et al., *Co-design for indigenous and other children and young people from priority social groups: A systematic review.* SSM-Population Health, 2022: p. 101077.

10. *Weatherspark. (n.d.). Average Weather in Mombasa, Kenya Year Round. Retrieved from* [*https://weatherspark.com/y/101135/Average-Weather-in-Mombasa-Kenya-Year-Round*](https://weatherspark.com/y/101135/Average-Weather-in-Mombasa-Kenya-Year-Round)*.*

11. Fares, A., *Factors influencing the seasonal patterns of infectious diseases.* Int J Prev Med, 2013. **4**(2): p. 128-32.

12. Garland, R., et al., *CITY OF TSHWANE CLIMATE RISK & VULNERABILITY ASSESSMENT*. 2015.

13. Li, X., L.C. Stringer, and M. Dallimer, *The Impacts of Urbanisation and Climate Change on the Urban Thermal Environment in Africa.* Climate, 2022. **10**(11): p. 164.

14. *The Trans‐African Hydro‐Meteorological Observatory (TAHMO). TAHMO weather data.*

15. *The World Bank. World Development Indicators: Data for Upper middle income, South Africa 2021.*

16. Mabuza, L.H., et al., *Awareness of health care practitioners about the national health insurance in tshwane district, south africa.* The Open Public Health Journal, 2018. **11**(1).

17. *Statistics South Africa. (2021). Mid-year population estimates 2021. Retrieved from* [*https://www.statssa.gov.za/publications/P0302/P03022021.pdf*](https://www.statssa.gov.za/publications/P0302/P03022021.pdf)*.*

18. *City of Tshwane Metropolitan Municipality. (n.d.). City of Tshwane Official Website. Retrieved from* [*https://www.tshwane.gov.za/?page\_id=10032*](https://www.tshwane.gov.za/?page_id=10032)*.*

19. Ilunga, B.B., et al., *Interpreting Mamelodi Community-Oriented Primary Care data on tuberculosis loss to follow-up through the lens of intersectionality.* Afr J Prim Health Care Fam Med, 2020. **12**(1): p. e1-e6.

20. Ncube, A. and M. Tawodzera, *Communities' perceptions of health hazards induced by climate change in Mount Darwin district, Zimbabwe.* Jàmbá Journal of Disaster Risk Studies, 2019. **11**.

21. *tcktcktck. (n.d.). Mount Darwin, Mashonaland Central, Zimbabwe. Retrieved from* [*https://tcktcktck.org/zimbabwe/mashonaland-central/mount-darwin*](https://tcktcktck.org/zimbabwe/mashonaland-central/mount-darwin)*.*

22. *Climate-Data.org. (n.d.). Climate: Mount Darwin - Climate graph, Temperature graph, Climate table. Retrieved from* [*https://en.climate-data.org/africa/zimbabwe/mashonaland-central-1610/*](https://en.climate-data.org/africa/zimbabwe/mashonaland-central-1610/)*.*

23. *The World Bank. World Development Indicators: Data for Lower middle income, Zimbabwe 2021.*

24. Choga, J., *Impact of microfinance on rural smallholder farmers in MT. Darwin District of Mashonaland Central Povince in Zimbabwe*. 2013.

25. *Zimbabwe National Statistics Agency and Unicef. Zimbabwe Multiple Indicator Cluster Survey 2019, Survey Findings Report. In: ZIMSTAT and UNICEF Harare, Zimbabwe; 2019.*

26. *The Committee on Morbidity and Mortality in Children Under 5 Years (CoMMiC). 4th Triennial Report of The Committee on Morbidity and Mortality In Children Under 5 Years (CoMMiC): 2017 - 2020; 2020.*

27. *Centers for Disease Control and Prevention. (n.d.). Heat Stress: Protecting Workers from the Effects of Heat. Retrieved from* [*https://www.cdc.gov/niosh/topics/repro/heat.html#:~:text=Take%20steps%20to%20prevent%20heat,not%20provide%20adequate%20cooling%20breaks*](https://www.cdc.gov/niosh/topics/repro/heat.html#:~:text=Take%20steps%20to%20prevent%20heat,not%20provide%20adequate%20cooling%20breaks)*.*

28. *Samaritan's Purse. (n.d.). Karanda Mission Hospital, Mt. Darwin, Zimbabwe. Retrieved from* [*https://www.samaritanspurse.org/medical/karanda-mission-hospital-mt-darwin-zimbabwe/*](https://www.samaritanspurse.org/medical/karanda-mission-hospital-mt-darwin-zimbabwe/)*.*

29. *Ministry of Health and Child Care (MoHCC). (n.d.). Zimbabwe Health Information System (HIS).*

30. *Doctor4Africa. (n.d.). Dotito Rural Health Clinic. Retrieved from* [*https://doctor4africa.com/listing/zimbabwe/hospital,rural-health-clinic/dotito-rural-health-clinic/*](https://doctor4africa.com/listing/zimbabwe/hospital,rural-health-clinic/dotito-rural-health-clinic/)*.*

31. *Samaritan's Purse. (n.d.). Karanda Mission Hospital, Mt. Darwin, Zimbabwe. Retrieved from* [*https://www.samaritanspurse.org/medical/karanda-mission-hospital-mt-darwin-zimbabwe/*](https://www.samaritanspurse.org/medical/karanda-mission-hospital-mt-darwin-zimbabwe/)*.*

32. Brown, L.H., P.G. Buettner, and D.V. Canyon, *The energy burden and environmental impact of health services.* Am J Public Health, 2012. **102**(12): p. e76-82.

33. Reddy, K.P., et al., *Cost-effectiveness of public health strategies for COVID-19 epidemic control in South Africa: a microsimulation modelling study.* Lancet Glob Health, 2021. **9**(2): p. e120-e129.

34. Greene, L.A., *EHPnet: United Nations Framework Convention on Climate Change*. 2000.

35. Gray, A.M., et al., *Applied methods of cost-effectiveness analysis in healthcare*. Vol. 3. 2010: OUP Oxford.

36. *Optima. (n.d.). Optima: Modelling to improve health. Retrieved from* [*http://optimamodel.com/*](http://optimamodel.com/)*.*

37. Marshall, D.A., et al., *Addressing challenges of economic evaluation in precision medicine using dynamic simulation modeling.* Value in health, 2020. **23**(5): p. 566-573.

38. *World Health Organization. (2023). Health financing. WHO Health Topics. Retrieved from* [*https://www.who.int/health-topics/health-financing#tab=tab\_1*](https://www.who.int/health-topics/health-financing#tab=tab_1)*.*

39. Horton, T.J., J.H. Illingworth, and W.H. Warburton, *Overcoming challenges in codifying and replicating complex health care interventions.* Health Affairs, 2018. **37**(2): p. 191-197.

40. Kilbourne, A.M., et al., *Implementing evidence-based interventions in health care: application of the replicating effective programs framework.* Implementation Science, 2007. **2**(1): p. 42.

41. *ProjectManager.com. (n.d.). Quick guide to resource management. Retrieved from* [*https://www.projectmanager.com/blog/quick-guide-resource-management*](https://www.projectmanager.com/blog/quick-guide-resource-management)*.*

42. Lock, R.H., et al., *Statistics: Unlocking the power of data*. 2020: John Wiley & Sons.

43. Midway, S.R., *Principles of effective data visualization.* Patterns, 2020. **1**(9): p. 100141.

44. Tennison, I., et al., *Health care's response to climate change: a carbon footprint assessment of the NHS in England.* The Lancet Planetary Health, 2021. **5**(2): p. e84-e92.

45. Russell, L.B., et al., *The role of cost-effectiveness analysis in health and medicine.* Jama, 1996. **276**(14): p. 1172-1177.

46. Williams, M.L., et al., *The Lancet Countdown on health benefits from the UK Climate Change Act: a modelling study for Great Britain.* The Lancet Planetary Health, 2018. **2**(5): p. e202-e213.

47. MacNeill, A.J., F. McGain, and J.D. Sherman, *Planetary health care: a framework for sustainable health systems.* The Lancet Planetary Health, 2021. **5**(2): p. e66-e68.

48. Montgomery, D.C., *Introduction to statistical quality control*. 2020: John Wiley & Sons.

49. Brown, A.F., et al., *Structural interventions to reduce and eliminate health disparities.* American journal of public health, 2019. **109**(S1): p. S72-S78.

50. Kruger, M., P. Ndebele, and L. Horn, *Research ethics in Africa: A resource for research ethics committees*. 2014: African Sun Media.

51. *South African Health Products Regulatory Authority (SAHPRA). (2020). South African Good Clinical Practice Guidelines. Retrieved from* [*https://www.sahpra.org.za/wp-content/uploads/2021/06/SA-GCP-2020\_Final.pdf*](https://www.sahpra.org.za/wp-content/uploads/2021/06/SA-GCP-2020_Final.pdf)*.*

52. *University of Pretoria. (2013). National Health Act, No. 61 of 2003. Retrieved from* [*https://www.up.ac.za/media/shared/12/ZP\_Files/health-act.zp122778.pdf*](https://www.up.ac.za/media/shared/12/ZP_Files/health-act.zp122778.pdf)*.*

53. *Medical Research Council of Zimbabwe (MRCZ). (2011). Ethics Guidelines for Health Research Involving Human Participants in Zimbabwe 2011. Retrieved from* [*http://www.mrcz.org.zw/wp-content/uploads/2021/04/Ethics-Guidelines-for-Health-Research-Involving-Human-Participants-in-Zimbabwe-2011.pdf*](http://www.mrcz.org.zw/wp-content/uploads/2021/04/Ethics-Guidelines-for-Health-Research-Involving-Human-Participants-in-Zimbabwe-2011.pdf)*.*

54. *Government of Kenya. (2012). Public Health Act, Cap 242. Retrieved from* [*http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/PublicHealthActCap242.pdf*](http://kenyalaw.org/kl/fileadmin/pdfdownloads/Acts/PublicHealthActCap242.pdf)*.*

55. *Government of Zimbabwe. (2018). Public Health Act [Chapter 15:09]. Retrieved from* [*https://faolex.fao.org/docs/pdf/zim190656.pdf*](https://faolex.fao.org/docs/pdf/zim190656.pdf)*.*

56. Goldsteen, A., et al., *Data minimization for GDPR compliance in machine learning models.* AI and Ethics, 2021: p. 1-15.

57. Kadam, R.A., *Informed consent process: a step further towards making it meaningful!* Perspectives in clinical research, 2017. **8**(3): p. 107.

58. *National Institute of Environmental Health Sciences (NIEHS). (n.d.). What is Bioethics? Retrieved from* [*https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm*](https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm)*.*

59. *Centers for Disease Control and Prevention. (n.d.). Climate Effects on Health. Retrieved from* [*https://www.cdc.gov/climateandhealth/effects/default.htm#:~:text=The%20health%20effects%20of%20these,and%20threats%20to%20mental%20health*](https://www.cdc.gov/climateandhealth/effects/default.htm#:~:text=The%20health%20effects%20of%20these,and%20threats%20to%20mental%20health)*.*

60. *Office of the Data Protection Commissioner (ODPC). (2019). Data Protection Act. Retrieved from* [*https://www.odpc.go.ke/dpa-act/*](https://www.odpc.go.ke/dpa-act/)*.*

61. *South African Government. (2013). Protection of Personal Information Act, 2013. Retrieved from* [*https://www.gov.za/documents/protection-personal-information-act*](https://www.gov.za/documents/protection-personal-information-act)*.*

62. *Government of Zimbabwe. (2019). Data Protection Act [Chapter 24:27]. Retrieved from* [*https://www.veritaszim.net/sites/veritas\_d/files/DataProtectionAct\_1.pdf*](https://www.veritaszim.net/sites/veritas_d/files/DataProtectionAct_1.pdf)*.*

63. *National Institutes of Health. (2021). Data Management and Sharing Policy. Retrieved from* [*https://sharing.nih.gov/data-management-and-sharing-policy*](https://sharing.nih.gov/data-management-and-sharing-policy)*.*

64. Triaridis, S. and A. Kyrgidis, *Peer review and journal impact factor: the two pillars of contemporary medical publishing.* Hippokratia, 2010. **14**(Suppl 1): p. 5-12.

65. *Springer Nature. (n.d.). Open Research - Benefits. Retrieved from* [*https://www.springernature.com/gp/open-research/about/benefits*](https://www.springernature.com/gp/open-research/about/benefits)*.*