Climate Resilient Health and Well-Being for Rural Communities in southern Malawi (CHWBRC)

Annex 3a: Economic and Financial Analysis

Accredited Entity: Save the Children Australia

Version: Final B.40 - 20 September 2024

Contents

1 Overview of the Economic and Financial Analysis

1. This annex is the narrative presentation of the Economic and Financial Analysis conducted for the project "Climate-resilient health and well-being for rural communities in southern Malawi". This Economic and Financial Analysis was conducted in the form of an integrated Cost Benefit Analysis (CBA). The CBA incorporates financial assessments, including the assessment of the investments, operational and maintenance costs, revenue generation, and more importantly includes economic consideration of non-marketable benefits that are directly linked to the investment and the interventions of the project.

2. The assessment utilises key financial metrics for the selected project interventions, i.e. the financial Internal Rate of Return (IRR) and Net-Present Value (NPV). As the analysis incorporates non-marketable societal benefits the relevant economic measures are presented as Economic Internal Rate of Return (EIRR) and Economic Net-Present Value (ENPV) to signify their consideration of societal factors.

3. The evaluation covers the following interventions supported by activities of the project:

    Measure 1. Operational health Early Warning and Response System (EWARS) supported through Activities 1.1.1, 1.1.2, 1.1.3, 3.1.1, 3.1.2 and 4.1.2.

    Measure 2. Improved climate resilience of healthcare facilities (solar energy supply and improved WASH infrastructure) supported by Activity 2.1.2.

    Measure 3. Improved climate resilience of schools (rainwater harvesting systems) supported by Activity 2.1.5.

    Measure 4. Reduced climate health risk and improved response through the provision of medical supplies and technologies (malaria prophylaxis, cholera/diarrhoea and malnutrition treatment) supported by Activity 3.1.3.

    Measure 5. Reduced malnutrition through production of climate-resilient foods and quality complementary feeding for children under 2 Activity 4.1.4.

4. Each one of the above interventions has been evaluated for a different lifetime of investment based on their specific characteristics. An overall economic assessment of the project was also conducted taking into consideration the non-investment costs and for a 25-year horizon.

5. The analysis rigorously examines the five investment interventions. Nevertheless, it should be emphasized that the analysis is an indicative assessment of the expected financial and economic impacts of the project design and that actual outcomes may differ from the estimates presented in the report.

6. Based on the analysis and for a discount rate of 9% the investments of approximately USD 12.3 million have an ENPV equal to USD 3.4 million and an EIRR of 11%.

7. The results of the economic and financial analysis show that the project generates robust economic benefits from a societal perspective, brings about significant benefits in terms of public health, contributes to the long-term sustainability of the healthcare system in Malawi, and the GCF's goal of low-carbon and climate resilient development.

2 Introduction

8. As described in the funding proposal, the project will achieve climate-resilient health and wellbeing through a multi-pronged approach. Institutionally, the project will establish a climate-informed health surveillance system and health early warning system that functions at national level and is able to

track and provide appropriate early warning for the occurrence of climate-sensitive diseases and conditions. The healthcare system physical infrastructure will be adapted to withstand climate risk through the development of standards and guidelines for climate-resilient facilities and strengthened resilience of hospitals and health centres. Enabled by information from the climate-informed health surveillance system and health early warning system and improved medical structures and technologies for responding to climate risk to health, healthcare staff will be trained to collect the data necessary to inform the early warning, to better manage the impacts of climate-induced health risk, and to cascade this awareness and capacity to anticipate and reduce risk reduction to communities. Malawian citizens will therefore also be better equipped to manage the risk of climate to their own health, which will be supplemented by tangible nutrition interventions targeting the most physiologically vulnerable groups, i.e. pregnant women and mothers of children under two, to ensure that their health outcomes are not impacted by climate change.

9. The project's goal statement is that IF the health system in southern Malawi is strengthened in terms of governance, health and climate information systems, service delivery and community engagement, THEN the negative impacts of climate change on the health of women, children and men will be reduced, BECAUSE healthcare staff, facilities and communities will have stronger capacity to anticipate, plan and respond to climate-health risks.

10. The project is targeting 79 health facilities and 500 villages across 6 vulnerable districts in the south of Malawi and is estimated to have 1,798,650 direct beneficiaries and 2,359,162 indirect beneficiaries.

11. Malawi is a land-locked country in south-eastern Africa, bordered by Tanzania to the north, Mozambique to the east, south and southwest, and Zambia to the west. It is also bordered by Lake Malawi to the east, which it shares with Tanzania and Malawi. The country comprises highlands and lowlands divided into four agro-ecological zones reflecting different soil, topographical and climate conditions: the Lower Shire valley, the lakeshore plains and Upper Shire valley, the mid-altitude plateau, and the highlands. Malawi gained independence from Britain in 1966 and, since then, has transitioned from a one-party totalitarian state to a multi-party democracy. Over recent years population growth rates have been high, with the most recent census reporting a population of 19.1 million[1]. The population is largely rural, with smaller proportions living in the main cities of Lilongwe, Blantyre and Mzuzu. Urbanisation is proceeding slowly, with city-based labour markets struggling to absorb labour due to population growth. Low levels of education impede opportunities in productive economic activities. Although primary school completion rates are fairly high at 80%, this drops to around 20% completing secondary education[2]. The economy is heavily reliant on agriculture, which contributes significantly to GDP, including through exports of tobacco. This sector is also the main livelihood activity for the majority of the population, although its contribution has declined over time such that, by 2019, just under a third of the population received their only income from agriculture[3] . This reflects greater diversification, including in ganyu (informal short-term labour) and the informal labour market. However, food insecurity remains a major issue.

12. Against a backdrop of interannual climate variability, Malawi is experiencing increasing impacts from climate change as a result of high exposure and high vulnerability. Malawi is highly at risk from the impacts of extreme weather events given its location along the great African Rift Valley, rapid population growth, unsustainable urbanization, climate variability and change, and environmental degradation[4]. The most common historical weather-related shocks affecting Malawi (of interest to this project) include floods, drought and stormy rains. In the 30-year period from 1979 to 2008 Malawi experienced more than 40 weather-related disasters. Climate-related national disasters were declared in 5 of the last 8 years, with costs to GDP ranging from 0.13-5.6%. On average, Malawi loses approximately 1.7% of GDP every year due to the combined effects of droughts and

[1] National Statistical Office (2019) 2018 Malawi population and housing census. Main report. National Statistical Office, Zomba, Malawi. Available at: https://malawi.unfpa.org/sites/default/files/resource-pdf/2018%20Malawi%20Population%20and%20Housing%20Census%20Main%20Report%20%281%29.pdf.
[2] Caruso, G. & Sosa, L.C. (2022) Malawi poverty assessment: poverty persistence in Malawi - climate shocks, low agricultural productivity, and slow structural transformation. World Bank Group, Washington, D.C. Available at: http://documents.worldbank.org/curated/en/099920006302215250/P174948072f3880690afb70c20973fe214d.
[3] *Ibid*.
[4] Malawi Government (2019) Malawi 2019 Flood Post Disaster Needs Assessment Report. Government of Malawi, Lilongwe, Malawi. Available at: https://www.unicef.org/malawi/media/1756/file/Malawi%202019%20Floods%20Post%20Disaster%20Needs%20Assessment%20Report.pdf.

floods – which is more than 5 times higher than the average for Least Developed Countries of 0.3%[5].

13. In terms of climate projections, the project's Feasibility Study (Annex 2) states the following:
14. Southern Malawi has become both hotter and drier in recent decades, and trends in climate-related extremes all exhibit an increase: risk of flooding has increased as a result of a combination of climatic factors (as indicated by increases in observed streamflow) and land-use change factors; the impact of tropical cyclones has increased in recent years due to a combination of the frequency and intensity of such events as well as high vulnerability of communities to such events; and drought events have also increased, consistent with observed changes in temperature.
15. Climate change poses risks to human health through several pathways. In terms of water and sanitation, declines in the water table, resulting from a combination of environmental degradation, **decreasing rainfall**, and increasing demands placed on water resources, have cost implications for the provision of safe water, sanitation, and health (WASH) in the Southern Region, due to increased demand for water pumping systems (Annex 2). In addition, **extreme rainfall events and floods** will exacerbate the damage to WASH infrastructure that has already been observed in recent extreme events, such as the destruction of boreholes, water taps, gravity-fed schemes, and latrines by tropical storm Ana in 2022[6].
16. The rain-fed nature of agriculture in Malawi means that its productivity levels are highly dependent on the nature and change of rainfall. Thus, **drying trends** will negatively impact what is already a short growing season; further, **increases in temperature** negatively affect crops (Annex 2). Thus, climate change is anticipated to negatively impact agricultural production affecting food security by reducing the quantity, quality, and diversity of foods available[7]. These factors will have a severe impact on malnutrition, exacerbating an already challenging situation where 39% of under-five children in rural areas are stunted, 3% are wasted, and 12% are underweight[8]. Poor food quality and diversity weakens immune systems, increasing susceptibility to diseases.
17. **Changing temperature and rainfall patterns** will influence the seasonality, intensity, and geographical prevalence of climate-sensitive infectious and vector-borne diseases. For one example, there is a strong relationship between increased temperatures and diarrhoeal diseases like cholera, which is the 5th biggest cause of mortality in Malawi[9], with the country experiencing regular cholera outbreaks. **Floods** have also typically increased exposure to water-borne diseases as a result of contamination.
18. Non-infectious climate-sensitive diseases and conditions are also highly likely to increase in the future, with **heat and heatwaves** impacting many diseases and conditions. **Increased temperatures and heat-related extremes** in Malawi will also affect people's health and well-being more broadly (see Annex 2). These hazards are associated with increased mental health issues, multiple adverse pregnancy and birth outcomes, occupational health issues, and increased healthcare costs. Repeated extreme events, particularly **floods,** cause physical damage to healthcare infrastructure and to transport infrastructure, which impedes the availability of and access to health care.
19. The project will address these climate change impacts and respond to the vulnerabilities and needs described in Annex 2 by implementing a suite of interventions to achieve the following outcomes:

    - **Outcome 1: Reduced risk from climate-sensitive diseases and conditions**

[5] Pauw, K. *et al*. (2011) The economic costs of extreme weather events: a hydro-meteorological analysis for Malawi. Environment and Development Economics 16: 177-98. Available at: doi:10.1017/S1355770X10000471.
[6] Department of Disaster Management Affairs (2022) Emergency Response Plan: Tropical Cyclone Ana.
[7] Owino *et al*. (2022) The impact of climate change on food systems, diet quality, nutrition, and health outcomes: a narrative review. Frontiers in Climate 4. Available at: https://www.frontiersin.org/articles/10.3389/fclim.2022.941842.
[8] Doctor, H. & Nkhana-Salimu, S. (2017) Trends and determinants of child growth indicators in Malawi and implications for the Sustainable Development Goals. AIMS Public Health 4: 590-614. Available at: Doi: 10.3934/publichealth.2017.6.590.
[9] Institute for Health Metrics and Evaluation (IHME) (2023) Malawi. Institute for Health Metrics and Evaluation, Seattle, USA. Available at: https://www.healthdata.org/malawi.

- **Outcome 2: Healthcare infrastructure is able to deliver service and care in the context of changing climate risk**
- **Outcome 3: Healthcare staff are able to deliver service and care in the context of changing climate risk**
- **Outcome 4: Community level health is more resilient in the context of changing climate risk**

20. **Outcome 1: Reduced risk from climate-sensitive diseases and conditions**
21. Within the sphere of strengthening institutional capacity for reducing the risks from climate-sensitive diseases and conditions, under this Outcome the project will establish a health surveillance system and health early warning system at the national level that incorporates climate information (Output 1.1); and will strengthen climate-resilient health policy and planning policy at the district level. This outcome will be realised by strengthening the health surveillance system and the health Early Warning and Response System to incorporate climate information (Output 1.1) as well as by enhancing adaptation planning for health in districts (Output 1.2). The health surveillance system and early warning system prioritises selected climate-sensitive diseases and conditions: malaria, diarrhoeal diseases, malnutrition, and diseases/conditions linked to heat exposure. The project will develop targeted knowledge on climate parameters for the risk of these diseases/conditions, and this targeted knowledge will be used to inform a climate-informed health surveillance system and early warning system (Activity 1.1.1), with the institutional architecture for managing its ongoing operation strengthened through Activity 1.1.2, and sentinel sites established at selected healthcare facilities to provide improved climate and health data for the system (Activity 1.1.3). At a more local level, the project strengthens district-level institutional capacity for addressing climate risks in the health sector by supporting the development of district Health Adaptation Plans in the project target districts (Activity 1.2.1), thus complementing and localising the draft Health National Adaptation Plan; whilst advocacy for stronger integration of climate-resilient health within adaptation planning at district and sub-district level (Activity 1.2.2) seeks to strengthen governance structures for the management of climate change risks and effects on health within the district.
22. **Outcome 2: Healthcare infrastructure is able to deliver service and care in the context of changing climate risk**
23. Climate hazards pose threats to the capacity of the health care system. Health infrastructure in Malawi is not well equipped to withstand climate extremes and provide climate-resilient healthcare. Under this Outcome, the project therefore seeks to facilitate the adaptation of the healthcare system physical infrastructure to climate risk through the development and application of standards and guidelines for climate-resilient health facilities and strengthened resilience of health facilities. The project will develop a national standard for climate-resilient healthcare facilities (Activity 2.1.1), and then apply that standard to select health care facilities in the project districts (Activity 2.1.2) to address the current challenge that health care facilities are not withstanding climate extremes; and it will build capacity more broadly on the use of the standard elsewhere in the country, including in non-project districts (Activity 2.1.3). Climate-resilient WASH facilities are particularly important to address the health impacts associated with floods, drought and high temperatures, because they reduce the likelihood of water-borne disease transmission (diarrheal diseases) during floods, and because they address the provision of water of sufficient quality and quantity to ensure good health. Therefore, the project will also develop a guideline on climate-resilient WASH for use in public facilities, i.e., schools and public buildings beyond health facilities (Activity 2.1.4). Building on this guideline, the project will then implement climate-resilient WASH solutions at select public schools in the project districts (Activity 2.1.5), recognising that school facilities are more numerous and used by more people more frequently than healthcare facilities. This outcome will be achieved by climate resilience upgrades to health facilities under Output 2.1, which will also include improving school water supply for children's health (Activity 2.1.5), development and implementation of national standards for climate resilient health facilities (Activities 2.1.1. and 2.1.3), as well as creating guidelines for climate resilient WASH facilities at public buildings (Activity 2.1.4).
24. **Outcome 3: Healthcare staff are able to deliver service and care in the context of changing climate risk**
25. Also within the broad sphere of strengthening institutional capacity for addressing climate risks in the health sector at the local level, healthcare staff are not well-capacitated to anticipate, prepare

for and respond to the health impacts of a changing climate, a gap that the project will address through this Outcome. The project will thus build data entry capacity for the climate-informed health surveillance and early warning systems by training staff at district level in effective and efficient data collection regarding diseases, as well as building capacity for the district staff to use technology to more effectively link facility-level health data to the national dashboard (Activity 3.1.1). It will build knowledge among district and community healthcare staff to be able to understand and effectively communicate the early warning alerts arising from the health early warning system to the community level (Activity 3.1.2), as well as train them more widely on the range of expected climate change impacts on health. Whilst increased knowledge and understanding can reduce risk, the increasing negative health impacts from climate change create additional needs for medical supplies and technologies to reduce the incidence of climate-sensitive diseases and conditions, which will be provided as part of this Outcome to equip healthcare staff to manage the health impacts of a changing climate. Therefore, Activity 3.1.3 focuses on providing medical supplies and technologies for climate health risk reduction and response, with a focus on malaria, cholera and malnutrition, as priority diseases in the health surveillance and early warning system that can also be relatively easily supported within the scope of this project, given greater knowledge of their prevention/treatment baseline (there are still large weaknesses in Africa regarding response systems for heat exposure). Of the wide range of expected climate change impacts on health, there are two specific sets of health impacts of a changing climate that are increasingly recognised as important and at the same time are highly under-prioritised in the African context. These consist of the mental health impacts and the gendered impacts of a changing climate. The state of current science and practice does not yet allow for the inclusion of such impacts within a health surveillance and early warning system. But the growing recognition in the climate change health field of the importance of these impacts necessitates laying the groundwork for capacitating the health sector to address them, and such effort also represents an important area of innovation for the project. Therefore, the project will equip healthcare staff with Mental Health and Psychosocial Support (MHPSS) capacity to address the mental health impacts of a changing climate (Activity 3.1.4); and with capacity to address the gendered impacts of a changing climate (Activity 3.1.5). This outcome will be achieved by strengthening the capacity of healthcare staff to reduce climate health risk through improved disease monitoring, health messaging, and disease treatment and prevention (Output 3.1). This will require enhancing data collection for health surveillance (Activity 3.1.1.), boosting the capacity of healthcare staff to disseminate early warnings to communities (Activity 3.1.2), providing strategic medical supplies and technologies (Activity 3.1.3), and addressing climate impacts on health in terms of gender (Activity 3.1.5) and mental health dimensions (Activity 3.1.5).

26. **Outcome 4: Community level health is more resilient in the context of changing climate risk**

27. Mirroring the fact that healthcare staff are not well-capacitated to anticipate, prepare for and respond to the health impacts of a changing climate, communities too have low levels of capacity to address climate-related health impacts. Therefore, this Outcome seeks to empower community members regarding the nature of climate risks to health and what individuals and communities can do to better manage these risks. Given that the health surveillance and early warning system is a key component of the project, communities also must be capacitated to understand early warnings and alert protocols (Activity 4.1.2). Communities must also be trained more generally on climate change impacts on health (Activity 4.1.3), as well as empowered to reduce their vulnerability to the health impacts of climate change (Activity 4.1.5). The latter activity recognises that community-led gender equality and social inclusion interventions are required so that girls, boys, women, men, the elderly and people with disabilities have equal access to the health care they need and are equally protected from the impacts of climate change; the community-led processes followed in this activity lend themselves particularly well towards addressing the impacts of climate change on gender-related health issues, mental health and malnutrition. With respect to the latter health risk, given that the achievement of a sound nutritional basis occurs within the home, the project will also address malnutrition by supporting families with pregnant women, breastfeeding mothers and children under 2 to provide appropriate infant feeding and grow climate-resilient complementary nutritious food (Activity 4.1.4). Finally, given the importance of climate-resilient WASH facilities to reduce the likelihood of transmission of diarrheal diseases, the project will equip community structures with knowledge and skills for climate-resilient community WASH facilities (Activity

4.1.1).This outcome will be achieved by empowering communities to reduce the risks of climate change to their health (Output 4.1.) in terms of the project's key areas of early warning response (Activity 4.1.2), awareness and behaviour change (Activity 4.1.3), nutrition (Activity 4.1.4), gender (Activity 4.1.5) and WASH (Activity 4.1.1).

28. The total project budget is USD 36,315,599, of which USD 33,000,000 is to be provided by the GCF in the form of a grant. The co-financing amount is USD 3,315,599, provided by the Government of Malawi in the form of in-kind co-financing, GlaxoSmithKline foundation, Foundation S (Sanofi), and the British Foreign, Commonwealth and Development Office (FCDO).

3 Methodological Approach

3.1 Overview of the approach

29. The proposed project aims to build the adaptive capacity of vulnerable communities and to implement a variety of adaptation interventions to enhance the climate resilience of communities and the health sector.

30. The Economic and Financial Analysis is based on an integrated Cost-Benefit Analysis (CBA) of selected measures to be supported by the project. The CBA approach integrates both marketable and non-marketable benefits to assess ex-ante the investments envisioned by the project. Taking into consideration the public goods that are generated by the project interventions, the integrated CBA approach is appropriate to assess the overall economic impact of the project and provides significant investment insights that can guide decision making. Therefore, the CBA analysis assesses the societal (economic) value of the project interventions.

31. The CBA is based on a counterfactual analysis and assesses the avoided negative impacts of climate-related events. The counterfactual for each measure assumes that the investment would most likely not occur and therefore the associated costs would take place. Figure 1 is a schematic overview of the counterfactual costs (climate change impacts without adaptation) and the project scenario (investment costs and residual climate change impacts).

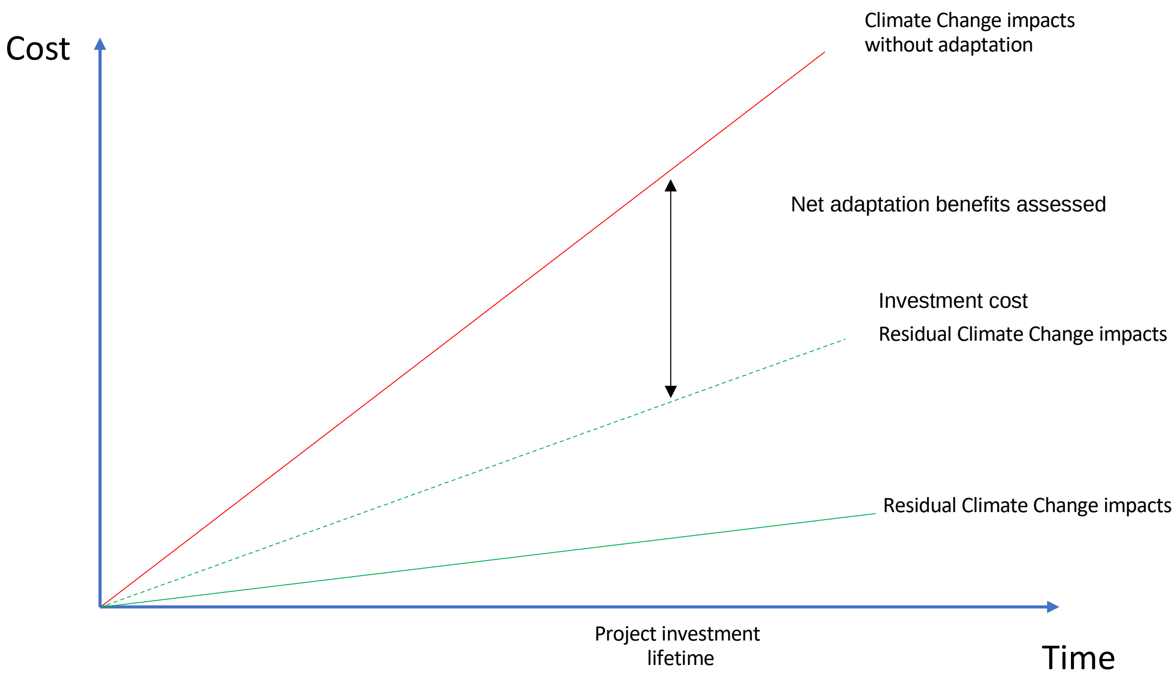

Figure 1: Schematic overview of the adaptation benefits assessed in the CBA

32. In our analysis we assess the economic net present value (ENPV) and the economic internal rate of return (EIRR) of the project interventions and the project as a whole. When the ENPV>0 for an appropriate discount rate the intervention/project is considered viable. The EIRR is defined as the discount rate (r) that produces a zero ENPV. Therefore, it represents the threshold interest rate in order for the intervention / project to be profitable.

33. To account for the scarcity of available data and provide robust results a sensitivity analysis is conducted for both the ENPV and the EIRR. The sensitivity analysis takes into consideration reductions and increases of the investment costs and benefits for each measure assessed and for the project as a whole.

34. The focus of the adaptation investments under this component is divided into five main categories:

- **Measure 1: Operational health Early Warning and Response System (EWARS) –** The measure includes the development of an operational climate-informed health Early Warning and Response System, including the identification of alert triggers for key climate-sensitive health conditions, the strengthening of the institutional architecture for managing the ongoing operation, and the establishment of sentinel sites to provide improved data for the EWARS.
- **Measure 2: Strengthen climate resilience of healthcare facilities** – The interventions will include: i) solar energy systems to improve energy supply in order to enhance climate resilience, i.e. solar energy for vaccine cold chains, lighting, water pumping and cooling fans (including the installation of PV cells and energy storage); and ii) improved WASH facilities, i.e. rainwater harvesting systems, water filters, hand-washing facilities. These physical interventions will be in line with Save the Children Australia's ESS Accreditation of Category C.
- **Measure 3: Improved climate resilience of schools –** This includes the implementation of rainwater harvesting and other small-scale WASH solutions at schools. The intervention will target 400 schools where 20,000 litre capacity rainwater harvesting systems will be installed.
- **Measure 4: Rollout medical supplies and technologies for climate health risk reduction and response** - This includes malaria prophylaxis (Long Lasting Insecticide Nets and Seasonal Malaria Chemoprevention (SMC)), cholera / diarrhoea treatment, and acute malnutrition treatment that address the projected increased prevalence of climate sensitive diseases/conditions due to the temperature and precipitation changes.
- **Measure 5: Reduced malnutrition through production of climate-resilient foods and quality complementary feeding for children under 2** – The impacts of increasing droughts under climate change on subsistence agriculture lead to increase malnutrition, especially among children who are the most vulnerable. The measure will address such impacts focusing on households with mothers of children under two years old, breastfeeding mothers and pregnant women. These households will be provided with a 'starter pack' to grow climate resilient, complementary nutritious food in their own homestead and to use improved nutrition practices. This will also include training on best practices as well as community-level tools.

35. Based on the above, the project has the potential to generate a broad range of environmental, social, and economic benefits and co-benefits, some of which include:

- Decreased burden of disease attributable to climate change due to an operational EWARS including:
  - improved capacity within health sector and epidemiological system;
  - avoided losses due to timely information on outbreaks. People are aware and can actively avoid possible infections and thus health costs;
  - improved capacity of the health surveillance system to monitor climate sensitive diseases;
  - avoided social and direct costs associated with the introduction of national standard for climate resilient healthcare facilities;
- Economic benefits related to economic value of harvested rainwater;
- Avoided health costs and loss of human life due to the improvement of sanitary conditions and access to clean water;
- Avoided GHG emissions due to the application of solar energy supply systems within health sector;
- Avoided health costs of infections with anti-microbial resistant pathogens;

- Avoided health costs and loss of life associated with cholera, malaria, and diarrheal diseases;
- Cost effectiveness in using seasonal malaria chemoprevention (SMC);
- Avoided health costs and loss of life due to reduced burden of disease resulting from malnutrition;
- Increased resilience of local subsistence farming – value of produced food.

36. Taxes, subsidies, and inflation have been excluded in the Economic Analysis.

3.2 Economic analysis

37. An economic analysis of the project has been performed to assess the incremental benefits of adaptation to climate change for communities. The economic cost-benefit analysis uses a cash flow model employing measure-specific investment lifetimes for the various adaptation measures. These periods include all investment and operational costs of the project, as well as the monetised revenues from resulting externalities such as avoided losses.

3.2.1 Evaluated measures

38. As described in the Funding Proposal and Annex 2: Feasibility Study, there is a significant lack of capacity related to health sector climate adaptation on all levels and among all stakeholders in Malawi's health sector. All the project's components are integrated and horizontal in their nature, focusing mainly on addressing climate-sensitive diseases and conditions. Malawi is extremely burdened with outbreaks of cholera, malaria infections, limited safe drinking water, and nutrition insecurity. **The proposed investments are necessary to help catalyse a paradigm shift in resilience in Malawi**. As already mentioned, all the components contain envisaged capital investments accompanied with comprehensive and tailored technical assistance.

39. The economic analysis covers the interventions for which the scale is known to some extent.

40. Therefore, the approach undertaken for economic analysis of this project was based on testing the adaptation interventions that would reflect the most pressing adaptation needs. **There are many activities under this project for which benefits will be achieved. However, it is not possible to monetise all of them and test it via economic and financial analysis.** For the purpose of the economic analysis, five measures were identified. These measures were selected based on the Malawi climate rationale, project design, the outcomes of stakeholder consultations, the literature review, and discussions with the AE – Save the Children Australia. The following measures were tested by the economic analysis:

- **Measure 1: Operational health Early Warning and Response System (EWARS).**
- **Measure 2: Improved climate resilience of healthcare facilities (solar energy supply and improved WASH infrastructure).**
- **Measure 3: Improved climate resilience of schools (rainwater harvesting)**
- **Measure 4: Reduced climate health risk and improved response through the provision of medical supplies and technologies (malaria prophylaxis, cholera/diarrhoea and malnutrition treatment)**
- **Measure 5: Reduced malnutrition through production of climate-resilient foods and quality complementary feeding for children under 2.**

3.2.2 Measure 1: Operational health Early Warning and Response System (EWARS)

41. The measure proposed in the project will develop an operational climate-informed health Early Warning and Response System (EWARS) through: i) strengthening the health surveillance system by identifying alert triggers for key climate-sensitive health conditions (Activity 1.1.1); ii) strengthening the institutional architecture for managing the ongoing operation of the climate-informed health Early Warning and Response System (EWARS) (Activity 1.1.2); iii) establishing sentinel sites at selected healthcare facilities to provide improved climate and health data for the health Early Warning and Response System (EWARS) (Activity 1.1.3); iv) building data collection capacity of staff to strengthen surveillance of climate-related diseases (Activity 3.1.1); v) building knowledge and capacity among district and community healthcare staff on climate and health and how to use the EWARS alerts (Activity 3.1.2).; and vi) embedding understanding of early warnings and alert protocols within communities (Activity 4.1.2).

42. These activities will: i) enable better surveillance of diseases and conditions related to climate change; ii) enhance the use of climate information in the health sector for effective health early warning; and iii) build institutional and human capacity to increase community health adaptive capacity in line with the draft GCF Sectoral Guide on Health & Well-being.

43. The main benefits from the operational climate-informed health EWARS will be the reduced burden of disease due to climate change and in the analysis is operationalised as a conservative reduction in the percentage of climate change attributable Disability Adjusted Life Years (DALYs).

3.2.2.1 Counterfactual analysis

44. The counterfactual analysis for this measure is based on the estimated negative impacts of climate-related events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the "climate change impact" situation and the "with project" situation.

3.2.2.2 Assumptions

45. The economic cost-benefit analysis, over a 15-year period, was conducted for the implementation of EWARS investments. Further details of assumptions are provided in Appendix A.

Table 1. Assumptions for Measure 1.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS (2019) Malawi Sustainable Energy Investments Study	%	9%
Total investment for the development of an operational climate-informed health EWARS	Project proposal	USD	$1,484,250
Lifetime of investment	Conservative estimation based on Climate Adapt Establishment of early warning systems	Years	15
Opex costs - as percentage of investment	Expert's Assumption	%	5%
Opex costs for the EWARS	**Calculated**	**USD**	**$74,213**
Investment costs (EWARS)	**Calculated**	**USD**	**$1,484,250**

Benefits			
Reduced healthcare cost from reduced burden of disease			
Total population in the 6 target districts	The World Bank (2023) Population, total - Malawi	#	4,157,812
Climate change attributable DALYs per 100,000 capita in low and middle-income countries in the African Region	WHO (2013) The Global Health Observatory	#	278
Number of DALYs attributable to climate change in Malawi	Calculated	DALYs	11,563

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9.	USD/DALY	$1,000
Percentage of reduction of burden of disease due to EWARS	Assumption; Conservative assumption based on Meckawy, R., Stuckler, D., Mehta, A., Al-Ahdal, T., & Doebbeling, B. N. (2022). Effectiveness of early warning systems in the detection of infectious diseases outbreaks: a systematic review. BMC public health, 22(1), 2216	%	6%
Total value of annual avoided costs due to reduced climate change attributable burden of disease	**Calculated**	**USD/year**	**$693,773**

3.2.2.3 Results

46. The benefits were calculated based on the development of an operational EWARS that will lead to the reduction of climate change attributable DALYs by 6%.

Table 2 Key Performance Indicators (KPIs) for measure 1.

Net costs / benefits	**USD**	Calculated	**$ 3,284,450**
EIRR	**%**	Calculated	**33%**
ENPV	**USD**	Calculated	**$ 1,098,211**
Net costs / benefits per year	**USD / year**	Calculated	**$ 131,378**

47. The results show that all KPIs are positive in terms of the economic feasibility of the proposed measure. The ENPV is substantial at USD 1,098,211 and the EIRR of 33% is much higher than the used discount rate of 9% making this measure, under presented assumptions, economically viable. The reason for a very high EIRR is that the measure is covering the total population in the 6 target districts and the high level of climate change attributable DALYs in Malawi. Even a modest reduction in DALYs has a very strong effect in the economic benefits.

48. Various scenarios were tested to establish the economic viability of Measure 1 based on either change in the costs of investment or changes in the level of benefits. The results are presented in the following table.

Table 3 Sensitivity analysis for Measure 1.

Project costs	ENPV of the investment	EIRR of the investment
60%	$ 1,707,253	104%
80%	$ 1,402,732	51%
100%	$ 1,098,211	33%
120%	$ 793,690	23%
140%	$ 489,169	16%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$ 49,884	10%
80%	$ 574,048	21%
100%	$ 1,098,211	33%
120%	$ 1,622,374	47%
140%	$ 2,146,538	66%

49. The results show a positive ENPV and EIRR in all scenarios with alternating level of costs and benefits, respectively. Based on the assumptions described above, Measure 1 can be justified on economic grounds.

3.2.3 Measure 2: Strengthened climate resilience of healthcare facilities

50. The measure proposed in the project aims to enhance the climate resilience of physical infrastructure at selected healthcare facilities in Malawi (Activity 2.1.2). This will include: i) solar energy systems to improve energy supply in order to enhance climate resilience (i.e., solar energy for vaccine cold chains, lighting, water pumping and cooling fans), and ii) improved WASH facilities (i.e., rainwater harvesting systems, water filters, hand-washing facilities).

51. This measure focuses on ensuring that healthcare system physical infrastructure (for example health centres and district hospitals) so that it can continue providing healthcare services in light of climate risk, for example increasing temperatures, variable rainfall and flood risk. There is a dual emphasis of this intervention. As well as delivering the physical improvements to build climate-resilience in health centres, the project will develop a national standard to highlight what these modifications should look like, so they can be used beyond the six target districts. The guidelines will also be used by the non-governmental healthcare providers to ensure that the wider population of Malawi that is not covered by government-funded facilities can also benefit.

52. The main benefits are related to providing sanitary clean water and thus avoiding cholera infections and other water-borne diseases, as well as providing a source of clean water in general. Additionally, solar energy systems will provide much needed access to energy and will support the effectiveness and efficiency of the provided healthcare due to, among others, reduced mortality of patients in critical condition, secured vaccine cold chains, improved lighting and water pumping. The benefits under this measure include:

- avoided costs due to improved water availability;
- improved healthcare provision due to avoided power outages; and
- non-marketable benefits from GHG emissions avoided;
- avoided health costs of infections with anti-microbial resistant pathogens.

3.2.3.1 Counterfactual analysis

53. The counterfactual analysis for this measure is based on the estimated negative impacts of climate-related events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the "climate change impact" situation and the "with project" situation.

3.2.3.2 Assumptions

54. The economic cost-benefit analysis, over a 15-year period was conducted for the implementation of healthcare centre climate resilience investments.

Table 4 Assumptions for Measure 2.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study	%	9%
Investment cost of rainwater harvesting per one health facility	Save The Children Cost Estimate RWHS Project	USD	$35,507
Total Investment cost of solar energy system to be installed (including PV and storage)	Project budget	USD	$5,161,352
# of health facilities to be retrofitted by the project	Project proposal	#	79
Total cost per one health facility for PV system	Calculated	USD	$65,334
Total budget allocation for WASH improvements	Project budget	USD	$2,805,083
Number of direct beneficiaries	Project proposal	#	1,798,650
# of beneficiaries per investment	Calculated	#	22,768
Lifetime of investment	Sodhia, M., Banaszeka, L., Mageeb, C., Rivero-Hudecc, M. (2022). Economic Lifetimes of Solar Panels. 29th CIRP Life Cycle Engineering Conference. Procedia CIRP 105 (2022) 782–787	Years	15
Opex costs - as percentage of investment	Assumption	%	5%
Opex costs for one health facility	**Calculated**	**USD/health facility**	**$3,289**

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
(all investments included)			
Investment costs per one healthcare facility (WASH and PV system)	**Calculated**	**USD/health facility**	**$65,783**

Benefits calculations on a per investment basis			
Annual water volume savings by rainwater – per rainwater harvesting system	Mloza-Banda, H. R., Chikuni, A., & Singa, D. D. (2006). Small Scale Rainwater Harvesting for Combating Water Deprivation at Orphan Care Centres in Peri-Urban Areas of Lilongwe, Malawi	Litres per annum	90,000
Total annual saving per investment	Calculated	Litres per annum	90,000
Benefits			
Economic water related benefits			
Import price of water per litre	The World Bank (2023) Improved Access to Potable Water in Malawi's Capital Improves Health and Erodes Gender Barriers Too	USD/l	$0.01
Benefits resulting in access to water per investment	**Calculated**	**USD/year**	**$810**
Value of Statistical Life (VSL) in Malawi	Conservative assumption based on Saluja, Saurabh & Rudolfson, Niclas & Massenburg, Benjamin & Meara, John & Shrime, Mark. (2020). The impact of physician migration on mortality in low and middle-income countries: An economic modelling study. BMJ Global Health	USD	$50,000
Improved healthcare delivery			
Increase in risk of mortality increases on days in which health facilities are affected by a power outage for 2 or more hours	Apenteng, B.A., Opoku, S.T., Ansong, D., Akowuah, E.A. and Afriyie-Gyawu, E., 2018. The effect of power outages on in-facility mortality in healthcare facilities: evidence from Ghana. Global Public Health, 13(5), pp.545-555.	%	43%
Average deaths per	Apenteng, B.A., Opoku, S.T., Ansong, D., Akowuah, E.A. and Afriyie-Gyawu, E., 2018. The	#	18

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
facility per year	effect of power outages on in-facility mortality in healthcare facilities: evidence from Ghana. Global Public Health, 13(5), pp.545-555.		
Percentage of patients in risk of mortality affected from power outages	Assumption	%	1%
Number of avoided deaths	Calculated	#	0.1
VSL avoided costs due to M2 - averaged on a yearly basis	**Calculated**	**USD/year**	**$3,870**
Social benefits of avoided GHG emissions			
Electricity demand of health centre	UNDP 2019. "Power for Health" Masterplan for Malawi - Energy Load Assessment, Efficiency Options and Sustainable Energy Solutions for Health Facilities in Malawi. Typical Malawian rural health centre energy demand per day is 13 kWh per day x 365 = 4745 kWh per year	kWh/year	4,745
Malawi grid emission factor	Low Carbon Power (2021) Average emissions from electricity	gCO2/kWh	120
Tonnes of CO2 emissions avoided - per investment	Calculated	tCO2/a	0,57
Social price of carbon	OECD The Social Cost of Carbon	USD/tCO2e	$35
Social costs of avoided GHG emissions - investment level	**Calculated**	**USD/year**	**$1,574**
Rate in Sub-Saharan Africa of mortality / morbidity attributable to bacterial antimicrobial resistance	ARC. (2022) Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. Antimicrobial Resistance Collaborators. PMC PubMed Central. Lancet. Elsevier.	#/100,000	1,436
Conservative assumption based on the effectiveness of Hand hygiene and environmental	Global report on infection prevention and control. Geneva: World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO.	%	10%

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
hygiene in health care facilities.			
DALYs avoided per investment	Calculated	DALY	33
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9.	USD/DALY	$1,000
Avoided health costs of infections with anti-microbial resistant pathogens	**Calculated**	**USD/year**	**$32,694**
Total benefits per one upgraded health facility	**Calculated**	**USD/per investment**	**$38,949**

3.2.3.3 Results

55. The benefits were calculated based on implementing retrofitting 79 health facilities (includes 79 rainwater harvesting systems and relevant WASH improvements and 79 solar systems including PV and battery installation). The following table presents the results of Key Performance Indicators (KPIs):

Table 5 KPIs for Measure 2.

Net costs / benefits	**USD**	Calculated	**$32,812,329**
EIRR	**%**	Calculated	**118%**
ENPV	**USD**	Calculated	**$13,407,941**
Net costs / benefits per year	**USD / year**	Calculated	**$1,312,493**

56. The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial at USD $13,407,941 and the EIRR is at 118%, much higher than the used discount rate of 9% making this measure, under presented assumptions, economically viable.

57. Various scenarios were tested to establish the economic viability of Measure 2 based on either change in the costs of investment or changes in the level of benefits. The results are presented in the following table.

Table 6 Sensitivity analysis for Measure 2.

Project costs	ENPV of the investment	EIRR of the investment
60%	$15,540,404	1482%
80%	$14,474,172	223%

Project costs	ENPV of the investment	EIRR of the investment
100%	$13,407,941	118%
120%	$12,341,710	80%
140%	$11,275,479	59%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$5,912,302	43%
80%	$9,660,122	73%
100%	$13,407,941	118%
120%	$17,155,761	195%
140%	$20,903,580	352%

58. The results show a positive ENPV and EIRR in all scenarios with alternating level of costs and benefits, respectively. Based on the assumptions described above, Measure 2 can be justified on economic grounds.

3.2.4 Measure 3: Improved climate resilience of schools (rainwater harvesting)

59. The measure includes the implementation of climate-resilient WASH solutions at public schools across the 25 target TAs, in selected villages. The measure will provide additional safe water supply for enhanced resilience to droughts, floods and heat, rainwater harvesting systems will be installed at schools. Rainwater harvesting systems will include the necessary filtration devices to provide water safe for drinking. In addition, small-scale water treatment solutions for existing water points at schools and hand washing facilities will also be installed where appropriate.
60. The provision of clean water will reduce the transmission of diseases such as cholera and is also a key component of adapting to high temperatures and extreme heat events, by allowing people to hydrate sufficiently. The benefits included under this measure include:

- avoided costs due to improved water availability; and
- reduced burden of disease from cholera/diarrhoea.

3.2.4.1 Counterfactual analysis

61. The counterfactual analysis for this measure is based on the estimated negative impacts of climate-related events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the "climate change impact" situation and the "with project" situation.

3.2.4.2 Assumptions

62. The economic cost-benefit analysis, over a 15-year period was conducted for the implementation of school WASH investments.

Table 7 Assumptions for Measure 3.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study	%	9%

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Investment cost of rainwater harvesting per school	Save The Children Cost Estimate RWHS Project	USD	$7,086.34
# of schools to be retrofitted by the project	Project proposal	#	400
# of pupils and teachers per school	Project proposal	#	981
Total cost or rainwater harvesting installations - All facilities	Calculated	USD	$2,834,537
Lifetime of investment	Muhirirwe, S. C., Kisakye, V., & Van der Bruggen, B. (2022). Reliability and economic assessment of rainwater harvesting systems for dairy production. Resources, Conservation & Recycling Advances, 14, 200079.	Years	15
Opex costs - as percentage of investment	Assumption	%	5%
Opex costs for one school (all investments included)	**Calculated**	**USD/school**	**$354**
Investment costs per school	**Calculated**	**USD/per school**	**$7,086**

Benefits calculations on a per investment basis			
Annual water volume savings by rainwater - per harvesting system	Mloza-Banda, H. R., Chikuni, A., & Singa, D. D. (2006). Small Scale Rainwater Harvesting for Combating Water Deprivation at Orphan Care Centres in Peri-Urban Areas of Lilongwe, Malawi	Litres per annum	60,000
Total annual saving per investment	Calculated	Litres per annum	24,000,000
Benefits			
Economic water related benefits			
Import price of water per litre	The World Bank (2023) Improved Access to Potable Water in Malawi's Capital Improves Health and Erodes Gender Barriers Too	USD/l	$0.01

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Benefits resulting from access to water per investment	**Calculated**	**USD/year**	**$216.00**
Reduced diarrhoeal disease morbidity			
DALYs of diarrhoeal diseases in Malawi	WHO, 2023. Global Health Estimates 2020: Disease burden by Cause, Age, *Sex*, by Country and by Region, 2000-2019.	#/100,000	519
Percentage of reduction of burden of disease	Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand-washing promotion for preventing diarrhoea. Cochrane Database Syst Rev. 2021 Jan 6;12(1):CD004265. doi: 10.1002/14651858.CD004265.pub4. PMID: 33539552; PMCID: PMC8094449.	%	30%
Number of avoided DALYs	Calculated	#	305
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9.	USD/DALY	$1,000
Avoided health costs due to M3 - averaged on a yearly basis	**Calculated**	**USD/year**	**$305,483**
Total avoided costs due to M3 - averaged on a yearly basis	**Calculated**	**USD/year**	**$521,483**

3.2.4.3 Results

63. The benefits were calculated on the basis of installing rainwater harvesting systems in 400 schools that each support on average 981 pupils. The following table presents the results of Key Performance Indicators (KPIs):

Table 8 KPIs for Measure 3.

Net costs / benefits	**USD**	**Calculated**	**$ 2,395,928**
EIRR	**%**	**Calculated**	**12%**
ENPV	**USD**	**Calculated**	**$ 268,119**
Net costs / benefits per year	**USD / year**	**Calculated**	**$ 95,837**

64. The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is high USD 268,119 and the EIRR is at also high in 12%, much higher than the used discount rate of 9% making this measure, under presented assumptions, economically not viable. The reason for a positive EIRR is the significant burden of diseases of diarrheal diseases in Malawi, the effectiveness of the improved sanitation measures and the high number of direct beneficiaries of the measure.

3.2.4.4 Sensitivity analysis

65. Various scenarios were tested to establish the economic viability of Measure 3 based on either change in the costs of investment or changes in the level of benefits. The results are presented in the following table.

Table 9 Sensitivity analysis for Measure 3.

Project costs	ENPV of the investment	EIRR of the investment
60%	$ 1,431,233	34%
80%	$ 849,676	20%
100%	$ 268,119	12%
120%	$ 313,439	6%
140%	$ 894,996	2%
Benefits	ENPV of the investment	EIRR of the investment
60%	$ 1,002,244	-2%
80%	$ 367,063	5%
100%	$ 268,119	12%
120%	$ 903,300	18%
140%	$ 1,538,481	25%

66. The results show a positive ENPV and EIRR in all scenarios with alternating level of costs and benefits, respectively. Based on the assumptions described above, Measure 3 can be justified on economic grounds.

3.2.5 Measure 4: Rollout medical supplies and technologies for climate health risk

67. Measure 4 includes malaria prophylaxis (Long Lasting Insecticide Nets, SMC), and cholera/diarrhoea treatment. The interventions are expected to reduce the burden of disease from malaria, and reduce the mortality from cholera/diarrhoea.

3.2.5.1 Counterfactual analysis

68. The counterfactual analysis for this measure is based on the estimated negative impacts of climate-related events. In the absence of the project, investment would most likely not occur and so benefits per unit of investment are based on the comparison of the "climate change impact" situation and the "with project" situation.

3.2.5.2 Assumptions

69. The economic cost-benefit analysis, over a 1.5-year period for malaria nets, and for the project duration of the cholera/diarrhoea treatment.

Table 10 Assumptions for Measure 4.

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study	%	9%
Investment cost of one long lasting insecticide treated net - anti malaria	Project budget	USD	$3.2
Number of nets to be bought and distributed by the project	Project budget	#	90,000
Total Investment cost of anti-malaria nets	Project budget	USD	$285,275
Number of SMC treatments	Project budget	#	75,000
Cost per child receiving a SMC	Conteh L, Shuford K, Agboraw E, Kont M, Kolaczinski J, Patouillard E. Costs and Cost-Effectiveness of Malaria Control Interventions: A Systematic Literature Review. Value Health. 2021 Aug;24(8):1213-1222. doi: 10.1016/j.jval.2021.01.013. Epub 2021 May 18. PMID: 34372987; PMCID: PMC8324482.	USD/child	$17
Months that require SMC treatment	Project proposal	month	4
Duration of SMC treatment coverage	WHO. 2023. Seasonal malaria chemoprevention with sulfadoxine–pyrimethamine plus amodiaquine in children: a field guide. 2nd ed. World Health Organization	month	1
Number of benefiting people from SMC	Calculated	#	18,750
Cost of SMC treatment	Project budget	USD	$318,887
Total number of ORS + zinc treatments	Project budget	USD	90,000
Cost per treatment with ORS and zinc	Project budget	USD	$1.6
Total cost ORS and zinc treatment	Project budget	USD	$142,745
Cost of severe acute malnutrition treatment	Project Budget	USD/year	$97

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
package per child			
Total budget for annual severe acute malnutrition treatment packages	Project budget	USD	$776,000
Total number of children benefitting from severe acute malnutrition treatment packages per year	Calculated	#	8,000
Lifetime of anti-malaria nets	Estimation based on: • Lifetime of nets is 3-5 years based on: WHO. 2017. WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control. World Health Organization • Most programmes use 2 years as lifetime, but retention time in Malawi is lower, we have opted to use 1.5 years lifetime of net based on: WHO. 2022. World Malaria Report 2022. World Health Organization	Years	1.5
Opex costs	Calculated	**USD/yearly**	**N/A**
Total investment costs for health supplies and technologies	**Calculated**	**USD/entire measure**	**$1,522,907**

Benefits calculations on a per investment basis			
Benefits			
Malaria - avoided costs/benefits			
Number of people benefiting from one anti malaria net	WHO (2017) WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control. Malaria Policy Advisory Committee meeting, background document for Session 9.	# of beneficiaries	1.8
Total number of people benefiting from anti malaria nets	Calculated	# of beneficiaries	162,000

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Malaria incidence per 1,000 people	The World Bank (2023) Incidence of malaria (per 1,000 population at risk) - Malawi	#/1000/year	219
Total estimated number of avoided malaria cases due to anti-malaria nets	Calculated	#/year	10,653
Cost of morbidity per case of malaria	Korenromp, E., Wong, B., Razvi, S., Dubosse, N., Muula, A.S., Kufeyani, L., Guys, A. (2021) The Cost-Benefit Analysis of Malaria Control Strategies in Malawi: A Scenario Comparison using the Spectrum-Malaria Impact Modelling Tool - Technical Report, National Planning Commission (Malawi), Copenhagen Consensus Center (USA) and African Institute for Development Policy (Malawi)	USD/person	$9.70
Total annual health avoided costs due to introduction of anti-malaria nets	Calculated	USD/year	$103,335
Number of deaths associated with malaria infection per 1,000 infected	Severe Malaria Observatory (n.d.) Malawi	#/1000	0.37
Number of people avoiding death due to anti malaria nets	Calculated	#	4
Value of Statistical Life (VSL) in Malawi	Conservative assumption based on Saluja, Saurabh & Rudolfson, Niclas & Massenburg, Benjamin & Meara, John & Shrime, Mark. (2020). The impact of physician migration on mortality in low and middle-income countries: An economic modelling study. BMJ Global He	USD	$50,000
Total social cost avoided due to avoided deaths - lifespan of investment	Calculated	USD	$197,083
Total social cost avoided due to avoided deaths - averaged per lifetime of investment	Calculated	USD/year	$131,388

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Benefits resulting from anti-malaria nets	**Calculated**	**USD/year**	**$234,724**
Months that require SMC treatment	Project proposal	month	4
Duration of SMC treatment coverage	WHO. (2023). Seasonal malaria chemoprevention with sulfadoxine–pyrimethamine plus amodiaquine in children: a field guide. 2nd ed. World Health Organization	month	1
Societal economic cost per episode averted via SMC treatment	Conteh L, Shuford K, Agboraw E, Kont M, Kolaczinski J, Patouillard E. Costs and Cost-Effectiveness of Malaria Control Interventions: A Systematic Literature Review. Value Health. 2021 Aug;24(8):1213-1222.	USD/child	$177
Cost effectiveness	Calculated	USD/child	$160
Benefits from SMC	Calculated	**USD/year**	**$2,004,159**
Cholera/diarrhoea avoidance related benefits			
Number of beneficiaries to receive treatment	Project document	#	30,000
Mortality rate among those who do not receive ORS	GBD (2017) Diarrhoeal Disease Collaborators. Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. Lancet Infect Dis. 2020 Jan;20(1):37-59.	Deaths per 100,000 children	78.4
Reduction in mortality rate due to ORS	Black, R., et al. (2019). Drivers of the reduction in childhood diarrhea mortality 1980-2015 and interventions to eliminate preventable diarrhea deaths by 2030. Journal of global health, 9(2), 020801. https://doi.org/10.7189/jogh.09.020801	%	31%
Avoided deaths	Calculated	#	7
VSL avoided costs	**Calculated**	**USD/year**	**$361,032**
Yearly VSL avoided costs	**Calculated**	**USD/year**	**$90,258**
Social benefits resulting from applying malnutrition food packages			
Total DALY related to severe acute malnutrition	WHO (2023) Burden of Disease 2000-2019	DALY/100,000	1,477
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-	USD/DALY	$1,000

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
	effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9.		
Total value of DALY - national level - children	Calculated	USD	$118,160
Total value of annual avoided health costs due to treatment of severe acute malnutrition	**Calculated**	**USD/year**	**$118,160**
Total annual benefits due to M4	**Calculated**	**USD/per investment**	**$2,447,300**

3.2.5.3 Results

70. The benefits were calculated on the basis of procuring 90,000 anti-malaria nets, applying 90,000 cholera treatments, and distributing 75,000 SMC. The following table presents the results of Key Performance Indicators (KPIs):

Table 11 KPIs for Measure 4.

Net costs / benefits	**USD**	**Calculated**	**$ 1,830,051**
EIRR	**%**	**Calculated**	**9%**
ENPV	**USD**	**Calculated**	**$ 1,139,387**
Net costs / benefits per year	**USD / year**	**Calculated**	**$ 73,202**

71. The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is substantial USD 1,139,387 and the EIRR is 9%, making this measure, under presented assumptions, economically viable. The reason for the EIRR is the low cost of the interventions and the high effectiveness of treatment that, especially in the case of children under 2, can decrease mortality significantly.

3.2.5.4 Sensitivity analysis

72. Various scenarios were tested to establish the economic viability of Measure 4 based on either change in the costs of investment or changes in the level of benefits. The results are presented in the following table.

Table 12 Sensitivity analysis for Measure 4.

Project costs	ENPV of the investment	EIRR of the investment
60%	$ 1,139,387	52%
80%	$ 1,139,387	24%
100%	$ 1,139,387	9%
120%	$ 1,139,387	0%
140%	$ 1,139,387	-7%

Benefits	ENPV of the investment	EIRR of the investment
60%	$ 683,632	-13%
80%	$ 911,510	-2%
100%	$ 1,139,387	9%
120%	$ 1,367,264	21%
140%	$ 1,595,142	33%

73. The results show a positive ENPV and EIRR in most scenarios with alternating level of costs and benefits, respectively. Based on the assumptions described above, Measure 4 can be justified on economic grounds.

3.2.6 Measure 5: Reduced malnutrition through production of climate-resilient foods and quality complementary feeding for children under 2

74. The calculations was undertaken under the assumption that the project will finance investments into climate resilient integrated homestead farming on a total of 1,251 ha, combined with improved nutrition practices, benefiting a total of 45,000 households and 105,000 children.

3.2.6.1 Counterfactual analysis

75. The economic analysis of the measure included a comparison of baseline and alternative scenarios. This counterfactual analysis compared the production of pigeon pea with and without introduced climate resilient interventions.

3.2.6.2 Assumptions

76. The economic cost-benefit analysis, over a 15-year period was conducted for the production of climate resilient crops in approximately 500 villages, covering 1,251 ha and combined with improved nutrition practices, which together will benefit a total of 45,000 households and 105,000 children.

Table 13 Assumptions for Measure 5. – Baseline scenario

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study	%	9%
Investment cost per starter pack	Project budget	USD	$29
Number of starter packs	Project budget	#	45,000
Total budget for starter packs for integrated homestead farming and improved nutrition practices	Project budget	USD	$1,305,539
Cost of per child of starter packs for integrated homestead	Calculated	USD	$12.43

Cost calculations on a per investment basis

Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
farming and improved nutrition practices			
Number of children to be supported by the project	Calculated	#	105,000
Number of mothers (households) to be supported by the project	Project Proposal	#	45,000
Number of villages to have farming demonstration plants set up	Project proposal	#	500
Average cost per ha to produce climate resilient crops (estimation based on pigeon pea production)	Cost per ha based on: IFPRI,2023. Employment options and challenges for rural households in Malawi An agriculture and rural employment analysis of the fifth Malawi Integrated Household Survey, 2019/20 Labour cost per ha based on: Remofirst. (2023) Employer of Record (EOR) in Malawi.	USD/ha	$723
Total budget for farming starter up packs	Project budget	USD	$904,424
Ha that can be covered with starter packs	Calculated	ha	1,251
Opex costs related to homestead farming - annual per ha	Experts assumption	USD/year	$100
Lifetime of homestead farming	Assumption	Years	15
Opex costs	Calculated	**USD yearly**	**$125,079**
Total investment costs for M5	**Calculated**	**USD/entire measure**	**$1,305,539**

Benefits calculations on a per investment basis

Benefits			
Reduced child malnutrition: reduced iron-deficiency anaemia from integrated homestead farming and improved nutrition practices			
Total DALY related to iron-deficiency anaemia	Michaux KD, Hou K, Karakochuk CD, Whitfield KC, Ly S, Verbowski V, Stormer A, Porter K, Li KH, Houghton LA, Lynd LD, Talukder A, McLean J, Green TJ. Effect of enhanced homestead food production on anaemia among Cambodian	DALY	262

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
	women and children: A cluster randomized controlled trial. Matern Child Nutr. 2019 May;15 Suppl 3(Suppl 3):e12757		
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9.	USD/DALY	$1,000
Total value of DALY - national level - children	Calculated	USD	$274,743
Total value of annual avoided costs due to reduced malnutrition (iron-deficiency anaemia)	**Calculated**	**USD/year**	**$274,743**
Homestead farming			
Gross value of climate resistant crops such as pigeon pea in Malawi	Benson, T and deWeerdt, J. 2023. Employment options and challenges for rural households in Malawi An agriculture and rural employment analysis of the fifth Malawi Integrated Household Survey, 2019/10. International Food Policy Research Institute.	USD/ha/annual	$1,260
Economic value of climate resistant crops such as pigeon pea	Calculated	USD/ha/annual	$1,260
Total economic value of produced crop (pigeon pea) - entire measure level	**Calculated**	**USD/year**	**$1,576,000**

3.2.6.3 Results

77. The benefits were calculated on the basis procuring and roll-out of climate resilient homestead farming starter packs that can cover 1,251 ha in 500 villages as well as climate-resilient nutrition practice packages that can support 105,000 children. The following table presents the results of Key Performance Indicators (KPIs):

Table 14 KPIs for Measure 5.

Net costs / benefits	**USD**	**Calculated**	**$21,978,415**
EIRR	**%**	**Calculated**	**172%**
ENPV	**USD**	**Calculated**	**$9,249,437**
Net costs / benefits per year	**USD / year**	**Calculated**	**$879,137**

78. The results show that all KPIs are positive in terms of the economic feasibility of the proposed project. The ENPV is USD 9,249,437 , and the EIRR is at 172%, higher than the used discount rate of 9% making this measure, under presented assumptions, economically viable.

3.2.6.4 Sensitivity analysis

79. Various scenarios were tested to establish the economic viability of Measure 5 based on either change in the costs of investment or changes in the level of benefits. The results are presented in the following table.

Table 15 Sensitivity analysis for Measure 5.

Project costs	ENPV of the investment	EIRR of the investment
60%	$9,671,579	352%
80%	$9,460,508	231%
100%	$9,249,437	172%
120%	$9,038,366	137%
140%	$8,827,295	113%
Benefits	**ENPV of the investment**	**EIRR of the investment**
60%	$5,127,521	92%
80%	$7,188,479	130%
100%	$9,249,437	172%
120%	$11,310,395	219%
140%	$13,371,353	271%

80. The results show a positive ENPV and EIRR in all scenarios with alternating level of costs and benefits, respectively. Based on the assumptions described above, Measure 5 can be justified on economic grounds.

3.2.7 Consolidated project level cost/benefit analysis

81. An economic analysis of the project as a whole has been performed to assess the incremental adaptation benefits to climate change. This analysis combines all five measures, scaled-up to the envisaged level of investment designated per measure within the project budget (Annex 4). Additionally, the project-level analysis takes into account the entire proposed project budget including the costs of all the components (i.e., non-investment components as well) and project management costs and co-finance. Please note that none of co-finance is envisaged for investments covered by this economic analysis.

3.2.7.1 Results

82. The following table presents the project level cost-benefit analysis that consolidates all four previously elaborated adaptation measures and includes the non-investment part of the programme budget. The discount rate of 9% used was the same as throughout the entire analysis.

Table 16 Consolidated economic analysis – entire project

Label	Unit	Source of information	Total
Year			
Costs - (OPEX costs - leveraged co-finance)			
M1 - CAPEX costs	USD	M1 - EWARS	$1,484,250
M1 - OPEX costs		M1 - EWARS	$920,235
M2 - CAPEX costs	USD	M2 - Health Infrastructure	$5,196,859
M2 - OPEX costs		M2 - Health Infrastructure	$3,222,053
M3 - CAPEX costs	USD	M3 - School WASH	$2,834,537
M3 - OPEX costs		M3 - School WASH	$1,757,413
M4 - CAPEX costs	USD	M4 - Medical supplies and tech	$1,522,907
M4 - OPEX costs		M4 - Medical supplies and tech	$-
M5 - CAPEX costs	USD	M5 - Homestead farming and improved nutrition practices	$1,305,539
M5 - OPEX costs		M5 - Homestead farming and improved nutrition practices	$125,079
Total	**USD**	**Calculated**	$18,368,873
Other project costs			
Total project budget	USD	Project proposal	$36,920,041
Total non-investment project costs	USD	Project proposal	$24,575,949
Percentage of the non-investment budget being spent on a yearly basis - equalised	%	Assumption	20%
Total non-investment project costs	**USD**	**Calculated**	$24,575,949
Total investment costs	**USD**	**Calculated**	$12,344,092
Total project costs	**USD**	**Calculated**	$36,920,041
Total costs (with OPEX leveraged co-finance)	**USD**	**Calculated**	$42,944,821
Benefits			
M1 - benefits	USD	M1 - EWARS	$5,688,935
M2 - benefits	USD	M2 - Health Infrastructure	$41,231,241
M3 - benefits	USD	M3 - School WASH	$6,987,878
M4 - benefits	USD	M4 - Medical supplies and tech	$1,830,051
M5 - benefits	USD	M5 - Feeding and homestead farm	$23,409,033
Total benefits	**USD**	**Calculated**	$79,147,137

Table 17 KPIs - Project level

Net costs / benefits	**USD**	**Calculated**	**$36,202,316**
EIRR	**%**	**Calculated**	**13%**
ENPV	**USD**	**Calculated**	**$5,142,472**
Net costs / benefits per year	**USD / year**	**Calculated**	**$1,448,093**

83. The results show a positive EIRR of 13% and ENPV is positive USD 5,142,472 . The big difference between the high ENPV and EIRR of the measures compared to the overall project are the expected costs in order to ensure the project's adaptation investments are implemented within a supportive enabling environment, have sufficient technical support for effective implementation, and include sufficient institutional capacity building to ensure the benefits are sustainable in the longer term. Essentially, these investments are necessary to catalyse a paradigm shift of health sector resilience in Malawi. While the full project shows a positive economic return on investment, each specific investment shows a high rate of return on investment and the non-investment costs will ensure the project leaves a substantial legacy of capacity for sustainability and more effective allocation and utilisation of future flows of climate finance.

3.3 Findings

84. The report shows that **all five of the adaptation measures analysed have either a very high or high economic internal rate of return and can be justified on economic grounds**. The analysis shows that the selected measures will have a significantly positive economic impact for the targeted communities over the life of the project and beyond.

85. The report also undertook assessment of the incremental adaptation benefits of the five selected measures in the context of the overall project budget. This analysis showed the project has an EIRR of 13%. The level of the EIRR is due to the size of the non-investment flows required to enable and support the adaptation investments, to ensure their long-term sustainability and to catalyse a paradigm shift in resilience in Malawi.In conclusion, **the analysis found that the project presents a strong investment for the GCF**. An economic analysis cannot assess the non-economic, non-investment components of the project and, therefore, shows a positive 13% EIRR.

86. While the types of benefits these activities generate are often non-monetary and have the characteristics of public goods (which are often challenging to quantify for any credible economic analysis), without these activities the project's economically quantifiable adaptation investments would be significantly less impactful in the immediate term, would be less sustainable in the longer term and would fail to generate transformational change.

3.4 Financial analysis

87. The project focuses exclusively on subsistence related beneficiaries. Given that most of the interventions planned are public sector projects that use grant funding and therefore do not generate any revenues, a financial analysis is largely infeasible. Given this, a focus has been put on the economic analysis of the project. Generally, these types of investments produce outputs and outcomes that meet the classical definition of public goods (non-rivalrous and non-excludable)[10].

88. The project is financed by grants (either from GCF or co-financing sources) and all activities covered with investments target health and sanitary sector as well as subsistence production of food that targets malnutrition of children. Therefore, the objective of the project is not to create market for any type of products nor any of the interventions will result in any revenue generating activities at any part of their implementation and lifetime.

4 Conclusion

89. The results of the economic and financial analysis show that the project generates robust economic benefits from a societal perspective, contributes to the long-term sustainability of health sector in Malawi, and supports the GCF's goal on climate resilient development.

[10] Non-rivalrous goods are public goods that are consumed by people but whose supply is not affected by people's consumption. In other words, when an individual or a group of individuals use a particular good, the supply left for other people to use remains unchanged. Therefore, non-rivalrous goods can be consumed over and over again without the fear of depletion of supply.

5 Bibliography

1. Akwee, E.P. *et al*. (2015) A critical review of the role of taro Colocasia esculenta L. (Schott) to food security: a comparative analysis of Kenya and Pacific Island taro germplasm. Scientia Agriculturae 9: 101-108. Doi: 10.15192/PSCP.SA.2015.9.2.101108.
2. Apenteng, B.A. *et al*. (2018) The effect of power outages on in-facility mortality in healthcare facilities: evidence from Ghana. Global Public Health 13: 545-555. Doi: 10.1080/17441692.2016.1217031.
3. Benson, T. & de Weerdt, J. (2023) Employment options and challenges for rural households in Malawi: an agriculture and rural employment analysis of the fifth Malawi Integrated Household Survey, 2019/10. MaSSP Working Paper 40. International Food Policy Research Institute (IFPRI), Washington D.C., U.S.A. Available at: https://doi.org/10.2499/p15738coll2.136607.
4. Berthe, S. *et al*. (2019) Poverty and food security: drivers of insecticide-treated mosquito net misuse in Malawi. Malaria Journal 18: 320. Doi: 10.1186/s12936-019-2952-2.
5. Black, R. *et al*. (2019). Drivers of the reduction in childhood diarrhea mortality 1980-2015 and interventions to eliminate preventable diarrhea deaths by 2030. Journal of Global Health 9: 020801. Available at: https://doi.org/10.7189/jogh.09.020801.
6. Climate Adapt (2023) Establishment of early warning systems. Available at: https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/establishment-of-early-warning-systems.
7. Conteh, L. *et al*. (2021) Costs and cost-effectiveness of malaria control interventions: a systematic literature review. Value Health 24:1213-1222. Doi: 10.1016/j.jval.2021.01.013.
8. Daroudi, R. *et al*. (2021) Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation 19: 1-9. Doi: 10.1186/s12962-021-00260-0.
9. Department of Disaster Management Affairs (2022) Emergency response plan: Tropical Cyclone Ana. Available at: https://www.shelterprojects.org/shelterprojects9/A.6-Malawi-SP9.pdf.
10. Korenromp, E., Wong, B., Razvi, S., Dubosse, N., Muula, A.S., Kufeyani, L., Guys, A. (2021) The Cost-Benefit Analysis of Malaria Control Strategies in Malawi: A Scenario Comparison using the Spectrum-Malaria Impact Modelling Tool - Technical Report, National Planning Commission (Malawi), Copenhagen Consensus Center (USA) and African Institute for Development Policy (Malawi)
11. GBD 2017 Diarrhoeal Disease Collaborators (2020) Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. The Lancet Infectious Diseases 20:37-59. Doi: 10.1016/S1473-3099(19)30401-3.
12. Global Health Estimates (2020) Disease burden by cause, age, sex, by country and by region, 2000-2019. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/data/global-health-estimates.
13. WHO (2022) Global report on infection prevention and control. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/publications/i/item/9789240051164.
14. Government of Malawi (2019) Malawi 2019 floods post disaster needs assessment report. Government of Malawi, Lilongwe, Malawi. Available at: https://www.unicef.org/malawi/media/1756/file/Malawi%202019%20Floods%20Post%20Disaster%20Needs%20Assessment%20Report.pdf.
15. IHME (2023) Malawi. Institute for Health Metrics and Evaluation, Seattle, USA. Available at: https://www.healthdata.org/malawi.
16. Institute for Health Metrics and Evaluation (IHME) (2023) Malawi. Institute for Health Metrics and Evaluation, Seattle, USA. Available at: https://www.healthdata.org/malawi.
17. Isanaka, S. *et al*. (2017) Cost analysis of the treatment of severe acute malnutrition in West Africa. Maternal & Child Nutrition 13: e12398. Doi: 10.1111/mcn.

18. Low Carbon Power (2021). Electricity in Malawi in 2021. Low Carbon Power, Taipei, R.O.C. Available at: https://lowcarbonpower.org/region/Malawi.
19. Caruso, G. & Sosa, L.C. (2022) Malawi poverty assessment: poverty persistence in Malawi - climate shocks, low agricultural productivity, and slow structural transformation. World Bank Group, Washington, D.C. Available at: http://documents.worldbank.org/curated/en/099920006302215250/P174948072f3880690afb70c20973fe214d.
20. Meckawy, R. *et al*. (2022) Effectiveness of early warning systems in the detection of infectious diseases outbreaks: a systematic review. BMC Public Health 22: 2216. Available at: https://doi.org/10.1186/s12889-022-14625-4.
21. Michaux, K.D. *et al.* (2019) Effect of enhanced homestead food production on anaemia among Cambodian women and children: a cluster randomized controlled trial. Maternal & Child Nutrition 15: e12757. Available at: https://doi.org/10.1111/mcn.12757.
22. Mloza-Banda, H.R. *et al*. (2006) Small scale rainwater harvesting for combating water deprivation at orphan care centres in peri-urban areas of Lilongwe, Malawi. ATPS Working Paper Series No. 46. African Technology Policy Studies Network, Nairobi, Kenya. Available at: https://atpsnet.org/wp-content/uploads/2017/05/working_paper_series_46.pdf.
23. Muhirirwe, S.C., *et al*. (2022) Reliability and economic assessment of rainwater harvesting systems for dairy production. Resources, Conservation & Recycling Advances 14: 200079. https://doi.org/10.1016/j.rcradv.2022.200079.
24. National Planning Commission (2021) The cost-benefit analysis of malaria control strategies in Malawi: a scenario comparison using the spectrum-malaria impact modelling tool – technical report. Malawi Priorities project technical report. National Planning Commission (Malawi), Copenhagen Consensus Center (USA) and African Institute for Development Policy (Malawi). Available at: https://www.afidep.org/publication/the-cost-benefit-analysis-of-malaria-control-strategies-in-malawi-a-scenario-comparison-using-the-spectrum-malaria-impact-modelling-tool-technical-report/.
25. National Statistical Office (2019) 2018 Malawi population and housing census. Main report. National Statistical Office, Zomba, Malawi. Available at: https://malawi.unfpa.org/sites/default/files/resource-pdf/2018%20Malawi%20Population%20and%20Housing%20Census%20Main%20Report%20%281%29.pdfOECD, (2006). The Social Cost of Carbon. Available at: https://www.oecd.org/env/cc/37321411.pdf.
26. Owino, V. *et al*. (2022) The impact of climate change on food systems, diet quality, nutrition, and health outcomes: a narrative review. Frontiers in Climate 4. https://www.frontiersin.org/articles/10.3389/fclim.2022.941842.
27. Pauw, K. *et al*. (2011) The economic costs of extreme weather events: a hydro-meteorological analysis for Malawi. Environment and Development Economics 16: 177-98. Doi:10.1017/S1355770X10000471.
28. Pouya, N. *et al*. (2022) Water yam (*Dioscorea alata* L.) growth and tuber yield as affected by rotation and fertilization regimes across an environmental gradient in West Africa. Agronomy 12: 792. https://doi.org/10.3390/agronomy12040792.
29. Saluja, S. *et al*. (2020) The impact of physician migration on mortality in low and middle-income countries: an economic modelling study. BMJ Global Health 5: e001535. Doi: 10.1136/bmjgh-2019-001535.
30. Severe Malaria Observatory (n.d.) Malawi. Severe Malaria Observatory, Medicines for Malaria Ventures, Geneva, Switzerland. Available at: https://www.severemalaria.org/countries/malawi.
31. Sodhia, M., Banaszeka, L., Mageeb, C., Rivero-Hudecc, M. (2022). Economic Lifetimes of Solar Panels. 29th CIRP Life Cycle Engineering Conference. Procedia CIRP 105 (2022) 782–787.
32. UNDP 2019. “Power for Health” Masterplan for Malawi - Energy Load Assessment, Efficiency Options and Sustainable Energy Solutions for Health Facilities in Malawi. Available here
33. The World Bank (2023) Improved access to potable water in Malawi’s capital improves health and erodes gender barriers too. The World Bank, Washington, D.C., USA. Available at: https://www.worldbank.org/en/news/feature/2023/05/04/improved-access-to-potable-water-in-afe-malawi-s-capital-improves-health-and-erodes-gender-barriers-too.
34. The World Bank (2023) Incidence of malaria (per 1,000 population at risk) – Malawi. The World Bank, Washington, D.C., USA. Available at:

https://data.worldbank.org/indicator/SH.MLR.INCD.P3?locations=MW.
35. The World Bank (2023) Population, total - Malawi. The World Bank, Washington, D.C., USA. Available at: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=MW.
36. Borgstein, E. *et al*. (2019) Malawi sustainable energy investment study: summary for decision makers. Rocky Mountain Institute, Basalt, Colorado, USA. Available at: https://rmi.org/wp-content/uploads/2018/10/RMI_SEED_Demand_Stimulation_2018.pdf.
37. WHO (2013) The global health observatory. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/data/gho.
38. WHO (2017) WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control. Malaria Policy Advisory Committee meeting, background document for Session 9. Available at: https://www.who.int/docs/default-source/malaria/mpac-documentation/mpac-oct2017-draft-updated-recommendations-universal-llin-coverage-session9.pdf?sfvrsn=5af603e8_2.
39. WHO (2023) Burden of disease 2000-2019. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/global-health-estimates-leading-causes-of-dalys.
40. WHO (2023) Cholera situation in Malawi. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON435.
41. WHO (2023) Seasonal malaria chemoprevention with sulfadoxine–pyrimethamine plus amodiaquine in children: a field guide. 2nd ed. World Health Organization, Geneva, Switzerland. Available at: https://www.who.int/publications/i/item/9789240073692.

Appendix A – Detailed explanation of assumptions used in the model

Assumptions for Measure 1. EWARS

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study. 9% discount rate used, to represent the weighted average cost of capital for the sector. Capital investment requirements are discounted at 9%. All costs are calculated at NPV, discounted at 9%.	%	9%
Total investment for the development of an operational climate-informed health EWARS	Project proposal	USD	$1,484,250
Lifetime of investment	Conservative estimation based on Climate Adapt Establishment of early warning systems	Years	15
Opex costs - as percentage of investment	Expert's assumption	%	5%
Opex costs for the EWARS	Calculated. = Total investment for the development of an operational climate-informed health EWARS * Opex costs - as percentage of investment	USD/health facility	**$74,213**
Investment costs per one healthcare facility (EWARS)	Calculated. = Total investment for the development of an operational climate-informed health EWARS	USD/per health facility	**$1,484,250**

Benefits			
Reduced healthcare cost from reduced burden of disease			
Total population in the 6 target districts	The World Bank (2022) Population, total - Malawi. This is the total population of the 6 target districts of the project. While some aspects of the health EWARS measure of the project will reach nationally, other important parts such	#	4,157,812

	as the sentinel sites are only in the 6 target districts.		
Climate change attributable DALYs per 100'000 capita in low and middle-income countries in the African Region	WHO (2013) The Global Health Observatory. Climate change attributable DALYs per 100'000 capita in low and middle-income countries in the African Region.	#	278
Number of DALYs attributable to Climate Change in Malawi	Calculated. = (Climate change attributable DALYs per 100'000 capita in low and middle-income countries in the African Region * Total population in the 6 target districts) / 100,000	DALYs	11,563
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9. The estimated cost per DALY averted was $998 in low HDI countries. On average, the cost per DALY averted was 0.34 times the GDP per capita in low HDI countries.	USD/DALY	$1,000
Percentage of reduction of burden of disease due to EWARS	Meckawy, R., Stuckler, D., Mehta, A., Al-Ahdal, T., & Doebbeling, B. N. (2022). Effectiveness of early warning systems in the detection of infectious diseases outbreaks: a systematic review. BMC public health, 22(1), 2216. This data is estimated based on the source. The source contains an overview of EWARS systems in other countries. Based on this analysis the estimate of 6% was derived.	%	6%
Total value of annual avoided costs due to reduced climate change attributable burden of disease	Calculated. = Number of DALYs attributable to Climate Change in Malawi * Monetary value of one DALY * Percentage of reduction of burden of disease due to EWARS	USD/year	$693,773

Assumptions for Measure 2. Health infrastructure

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study. 9% discount rate used, to represent the weighted average cost of capital for the sector. Capital investment requirements are discounted at 9%. All costs are calculated at NPV, discounted at 9%.	%	9%
Investment cost of rainwater harvesting per one health facility	This number is based on the project budget for the total WASH improvements costs in all facilities (2,805,083) divided to the number of health facilities to be retrofitted by the project (79) = $35,507	USD	$35,507
Total Investment cost of solar energy system to be installed (including PV and storage)	Project budget	USD	$5,161,352
# of health facilities to be retrofitted by the project	Project proposal	#	79
Total cost per one health facility for PV system	Calculated. = Total Investment cost of solar energy system to be installed (including PV and storage)	USD	$65,334
Total WASH improvements costs - All facilities	Calculated. = Number of health facilities to be retrofitted by the project * Total cost per one health facility for PV system	USD	$2,805,083
Number of direct beneficiaries	Project proposal	#	1,798,650
# of beneficiaries per investment	Calculated. = Number of direct beneficiaries / Number of health facilities to be retrofitted by the project	#	22,768
Lifetime of investment	Sodhia, M., Banaszeka, L., Mageeb, C., Rivero-Hudecc, M. (2022). Economic Lifetimes of Solar Panels. 29th CIRP Life Cycle Engineering Conference. Procedia CIRP 105 (2022) 782–787. This was based on the life cycle costs (LCC) and the accruing benefits for 15 years. The number of years the life cycle is considered over (15 years). The lifetime of the project adopted is 15 years.	Years	15
Opex costs - as percentage of investment	Expert's assumption	%	5%
Opex costs for one health facility (all investments included)	Calculated. = Investment costs per one healthcare facility (WASH and PV system) * Opex costs - as percentage of investment	USD/health facility	**$3,289**

Investment costs per one healthcare facility (WASH and PV system)	Calculated. = Investment cost of rainwater harvesting per one health facility + Total Investment cost of solar energy system to be installed (including PV and storage) / # of health facilities to be retrofitted by the project	USD/per health facility	**$65,783**

Benefits calculations on a per investment basis			
Annual water volume savings by rainwater - per harvesting system	Derived from the source. Mloza-Banda, H. R., Chikuni, A., & Singa, D. D. (2006). Small Scale Rainwater Harvesting for Combating Water Deprivation at Orphan Care Centres in Peri-Urban Areas of Lilongwe, Malawi. https://atpsnet.org/wp-content/uploads/2017/05/working_paper_series_46.pdf.	Litres per annum	90,000
Total annual saving per investment	Calculated. = Annual water volume savings by rainwater - per harvesting system	Litres per annum	90,000
Benefits			
Economic water related benefits			
Import price of water per litre.	The World Bank (2023) Improved Access to Potable Water in Malawi's Capital Improves Health and Erodes Gender Barriers Too. The price of water is $0.18 per 10 litres.	USD/l	$0.01
Benefits resulting in access to water per investment	**Calculated. = Total annual saving per investment * Import price of water per litre**	**USD/year**	**$810**
Value of Statistical Life (VSL) in Malawi	The VSL is estimated based on this source. The value was rounded. Saluja, Saurabh & Rudolfson, Niclas & Massenburg, Benjamin & Meara, John & Shrime, Mark. (2020). The impact of physician migration on mortality in low and middle-income countries: An economic modelling study. BMJ Global He.	USD	$50,000
Improved healthcare delivery			
Increase in risk of mortality increases on days in which health facilities are affected by a power outage for 2 or more hours	Apenteng B, Opoku S, Ansong D, Akowuah EA, Afriyie-Gyawu. The effect of power outages on in-facility mortality in healthcare facilities: evidence from Ghana. Glob Public Health. 2018;13(5):545–55. doi:10. 1080/17441692.2016.1217031. Findings revealed a positive association between the frequency of power outages and in-facility mortality, with the risk for mortality estimated to increase by 43% for each day the power was out for over 2 h.	%	43%
Average deaths per facility per year	Apenteng B, Opoku S, Ansong D, Akowuah EA, Afriyie-Gyawu. The effect of power outages on in-facility mortality in healthcare facilities: evidence from Ghana. Glob Public Health. 2018;13(5):545–55. doi:10. 1080/17441692.2016.1217031	#	18
Percentage of patients in risk of mortality affected from power outages	Expert's assumption	%	1%
Number of avoided deaths	Calculated. = Increase in risk of mortality increases on days in which health facilities	#	0.1

	are affected by a power outage for 2 or more hours * Average deaths per facility per year * Percentage of patients in risk of mortality affected from power outages		
VSL avoided costs due to M2 - averaged on a yearly basis	**Calculated. Number of avoided deaths * Value of Statistical Life (VSL) in Malawi**	**USD/year**	**$3,870**
Social benefits of avoided GHG emissions			
Electricity demand of rural health centre	UNDP 2019. "Power for Health" Masterplan for Malawi - Energy Load Assessment, Efficiency Options and Sustainable Energy Solutions for Health Facilities in Malawi. Typical Malawian rural health centre energy demand per day is 13 kWh per day x 365 = 4745 kWh per year	kWh/year	4,745
Malawi grid emission factor	Low Carbon Power (2021) Average emissions from electricity	gCO2/kWh	120
Tonnes of CO2 emissions avoided - per investment	Calculated. = (Electricity demand of rural health centre * Malawi grid emission factor) / 1,000,000 Health centres in Malawi on average have demand of 4,745 kWh/year. For simplicity, it is assumed that all this demand will be covered by PVs, as the project is targeting mostly non-grid connected facilities within Malawi. It is assumed that those facilities would require the same amount of PV-based electricity. The demand was multiplied by national grid emission factor and amount of tCO2/a was calculated. It is assumed that savings occur due to no usage of conventional alternative (connecting to grid). Results are provided in grams of CO2 – so it is divided by a million to express it in tonnes.	tCO2/a	0,57
Social price of carbon	Watkiss, P. (2003). The Social Cost of Carbon. OECD. In 2002, the UK Government Economic Service (GES) recommended an illustrative estimate for the SCC of £70/tonne of carbon (tC), within a range of £35 to £140/tC (for year 2000 emissions), for use in policy appraisal across Government, and that these values should be increased at the rate of £1/tC per year1 . The GES also recommended that these values should be subject to periodic review.	USD/tCO2e	$35
Social costs of avoided GHG emissions - investment level	**Calculated. = Social price of carbon * Tonnes of CO2 emissions avoided - per investment * Number of health facilities to be retrofitted by the project**	**USD/year**	**$1,574**
Rate in Sub-Saharan Africa of mortality / morbidity attributable to bacterial antimicrobial resistance	https://www.thelancet.com/action/showFullTableHTML?isHtml=true&tableId=tbl2&pii=S0140-6736%2821%2902724-0 DALYs in Sub-Saharan Africa is 1,436 per 100,000	#/100,000	1,436

Conservative assumption based on the effectiveness of Hand hygiene and environmental hygiene in health care facilities.	Global report on infection prevention and control. Geneva: World Health Organization; 2022. Licence: CC BY-NC-SA 3.0 IGO. The assumption is based on the reduction of AMR pathogens impact up to 40%. The reason why it is only 10% and not 40% is that the study was worldwide and for the EFA the non-marketable benefits should be assessed based on conservative assumptions.	%	10%
DALYs avoided per investment	Calculated. = (Rate in Sub-Saharan Africa of mortality / morbidity attributable to bacterial antimicrobial resistance) * Number of beneficiaries per investment * Conservative assumption based on the effectiveness of Hand hygiene and environmental hygiene in health care facilities	DALY	33
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9. The estimated cost per DALY averted was $998 in low HDI countries. On average, the cost per DALY averted was 0.34 times the GDP per capita in low HDI countries.	USD/DALY	$1,000
Avoided health costs of infections with anti-microbial resistant pathogens	**Calculated. = DALYs avoided per investment * 1,000**	**USD/year**	**$32,694**
Total benefits per one upgraded health facility	**Calculated. = VSL avoided costs due to M2 - averaged on a yearly basis + Benefits resulting in access to water per investment + Social costs of avoided GHG emissions - investment level + Avoided health costs from attributable to bacterial antimicrobial resistance**	**USD/per investment**	**$38,949**

Assumptions for Measure 3. Schools

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study. 9% discount rate used, to represent the weighted average cost of capital for the sector. Capital investment requirements are discounted at 9%. All costs are calculated at NPV, discounted at 9%.	%	9%
Investment cost of rainwater harvesting system per school	Save The Children Cost Estimate from the RWHS Project in Malawi. In GCF project budget allocation is:	USD	$7,086.34

	$2,834,537 / 400 = 7,086.34 per school. This includes school assessment, equipment, training, maintenance and provides for handwashing facilities as well as the rainwater harvesting tanks.		
# of schools to be retrofitted by the project	Project proposal	#	400
# of pupils per school	Project proposal	#	981
Total cost or rainwater harvester installations - All facilities	Calculated. = Investment cost of rainwater harvesting per school * Number of schools to be retrofitted by the project	USD	$2,834,537
Lifetime of investment	Muhirirwe, S. C., Kisakye, V., & Van der Bruggen, B. (2022). Reliability and economic assessment of rainwater harvesting systems for dairy production. Resources, Conservation & Recycling Advances, 14, 200079. This was based on the life cycle costs (LCC) and the accruing benefits for 15 years. The number of years the life cycle is considered over (15 years). The lifetime of the project adopted is 15 years.	Years	15
Opex costs - as percentage of investment	Expert's Assumption	%	5%
Opex costs for one school (all investments included)	**Calculated. = Investment costs per school * Opex costs - as percentage of investment**	**USD/ school**	**$354**
Investment costs per school	**Calculated. = Investment cost of rainwater harvesting per school**	**USD/ per school**	**$7,086**

Benefits calculations on a per investment basis			
Annual water volume savings by rainwater - per harvesting system	Mloza-Banda, H. R., Chikuni, A., & Singa, D. D. (2006). Small Scale Rainwater Harvesting for Combating Water Deprivation at Orphan Care Centres in Peri-Urban Areas of Lilongwe, Malawi. Assume roof area of 250 m2, and average rainy season rainfall of 700 mm. This provides 175,000 L harvested water that is used continually. Tank capacity installed is 20,000 L, that means tank could be filled and emptied as many as 8 x. To be conservative – assume tank is filled and emptied 3 x in a year. Thus 60,000 L annual water savings per tank installation per year.	Litres per annum	60,000
Total annual saving per investment	Calculated. = Annual water volume savings by rainwater - per harvesting system * Number of schools to be retrofitted by the project	Litres per annum	24,000,000
Benefits			
Economic water related benefits			
Import price of water per litre	The World Bank (2023) Improved Access to Potable Water in Malawi's Capital	USD/l	$0.01

	Improves Health and Erodes Gender Barriers Too. The price of water is $0.18 per 20 litres.		
Benefits resulting in access to water per investment	**Calculated. Total annual saving per investment * Import price of water per litre**	**USD/ year**	**$216,000**
Reduced diarrhoeal disease morbidity			
DALYs of diarrhoeal diseases in Malawi	WHO (2023) Burden of Disease 2000-2019. Top 10 causes of DALY in Malawi for both sexes aged 10 to 14 years (2019) are 519 DALYs per 100,000.	#/100,000	519
Percentage of reduction of burden of disease	Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand-washing promotion for preventing diarrhoea. Cochrane Database Syst Rev. 2021 Jan 6;12(1):CD004265. doi: 10.1002/14651858.CD004265.pub4. PMID: 33539552; PMCID: PMC8094449. Hand-washing promotion reduces diarrhoea episodes in both child day-care centres in high-income countries and among communities living in LMICs by approximately 30%. The included trials do not provide evidence about the long-term impact of the interventions.	%	30%
Number of avoided DALYs	Calculated. = (DALYs of diarrhoeal diseases in Malawi / 100,000) * Number of total direct beneficiaries * (Percentage of reduction of burden of disease / 2) While school settings where many people share spaces and facilities are expected to be responsible for a large proportion of diarrheal disease transmission via lack of hand washing and drinking unsafe water at school (19% of school children drink from unprotected water sources at school in Malawi), teachers and pupils only spend part of their total time at school, hence it is assumed that 50% of total cases can be attributed to transmission at school.	#	305
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9. The estimated cost per DALY averted was $998 in low HDI countries. On average, the cost per DALY averted was 0.34 times the GDP per capita in low HDI countries.	USD/DALY	$1,000
Avoided health costs due to M3 - averaged on a yearly basis	**Calculated. =** Number of avoided DALYs * Monetary value of one DALY	**USD/ year**	**$305,483**
Total avoided costs due to M3 - averaged on a yearly basis	**Calculated. = Benefits resulting in access to water per investment +**	**USD/ year**	**$521,483**

	Avoided health costs due to M3 - averaged on a yearly basis		

Assumptions for Measure 4. Medical supplies and technologies

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study. 9% discount rate used, to represent the weighted average cost of capital for the sector. Capital investment requirements are discounted at 9%. All costs are calculated at NPV, discounted at 9%.	%	9%
Investment cost of one long lasting insecticide treated net - anti malaria	Project budget	USD	$3.2
Number of nets to be bought and distributed by the project	Project budget	#	90,000
Total Investment cost of anti-malaria nets	Calculated. = Investment cost of one long lasting insecticide treated net - anti malaria * Number of nets to be bought and distributed by the project	USD	$285,275
Number of SMC treatments	Project proposal	#	75,000
Cost per child receiving a SMC	Project budget and Calculated. = $241,326 total budget for SMC treatment / 18,750 people benefiting = 12.87 per child.	USD/child	$17
Months that require SMC treatment	Project proposal	month	4
Duration of SMC treatment coverage	Estimation based on the WHO. 2023. SMC with sulfadoxine–pyrimethamine plus amodiaquine in children: a field guide. 2nd ed. World Health Organization	month	1
Number of benefiting people from SMC	Calculated. = (Number of SMC treatments / Months that require SMC treatment) * Duration of SMC treatment coverage	#	18,750
Cost of SMC treatment	Calculated. = Cost per child receiving a SMC * Number of benefiting people	USD	$318,887
Total number of treatments with ORS and zinc	Project budget	USD	90,000
Cost per treatments with ORS and zinc	Project budget	USD	$1.6
Total cost ORS and zinc treatment	Calculated. = Total number of treatments with ORS and zinc * Cost per treatment with ORS and zinc	USD	$142,745

Cost of severe acute malnutrition treatment package per child	Based on Project budget and Save the Children Malawi data, 2023: In project target districts, estimate c. 2,000 children with SAM (Save the Children Malawi data 2023) Cost of treatment package for a child with SAM = 97 dollars (including distribution cost) (Save the Children Malawi data 2023)"	USD/year	$97
Total budget for annual severe acute malnutrition treatment packages	Project budget	USD	$776,000
Total number of children benefitting from severe acute malnutrition treatment packages per year	Calculated. = Total budget for annual malnutrition food packages / Total cost of malnutrition child package - annual dose per child	#	8,000
Lifetime of anti-malaria nets	Estimation based on: • Lifetime of nets is 3-5 years based on: WHO. 2017. WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control. World Health Organization • Most programmes use 2 years as lifetime, but retention time in Malawi is lower, we have opted to use 1.5 years lifetime of net based on: WHO. 2022. World Malaria Report 2022. World Health Organization	Years	1.5
Opex costs	Calculated	**USD/yearly**	**N/A**
Total investment costs for health supplies and technologies	**Calculated. = Total Investment cost of anti-malaria nets + Cost of SMC treatment + Total cost ORS and Zinc treatment + Total budget for annual malnutrition food packages**	**USD/entire measure**	**$1,522,907**

Benefits calculations on a per investment basis			
Benefits			
Malaria - avoided costs/benefits			
Number of people benefiting from one anti-malaria net	According to WHO one net benefits 1.8 people. WHO. 2017. WHO recommendations for achieving universal coverage with long-lasting insecticidal nets in malaria control. World Health Organization	# of beneficiaries	1.8
Total number of people benefiting from anti-malaria nets	Calculated. Number of nets to be bought and distributed by the project * Number of people benefiting from one anti-malaria net	# of beneficiaries	162,000
Malaria incidence per 1,000 people	The World Bank (2023) Incidence of malaria (per 1,000 population at risk) - Malawi. Incidence of malaria (per 1,000 population at risk) in Malawi is 219.2	#/1000/year	219

Total estimated number of avoided malaria cases due to anti-malaria nets	Calculated. = (Total number of people benefiting from anti-malaria nets * Malaria incidence per 1,000 people) / 1,000 * 30%. Based on: Lindblade, K.A., Mwandama, D., Mzilahowa, T. et al. (2015) A cohort study of the effectiveness of insecticide-treated bed nets to prevent malaria in an area of moderate pyrethroid resistance, Malawi. Malar J 14, 31.	#/year	10,653
Annual malaria cost - per beneficiary (Cost of morbidity per case of malaria)	Korenromp, E., Wong, B., Razvi, S., Dubosse, N., Muula, A.S., Kufeyani, L., Guys, A. (2021) The Cost-Benefit Analysis of Malaria Control Strategies in Malawi: A Scenario Comparison using the Spectrum-Malaria Impact Modelling Tool - Technical Report, National Planning Commission (Malawi), Copenhagen Consensus Center (USA) and African Institute for Development Policy (Malawi). With reference to Table 4 in the cited report, assume that a third of the 162,000 beneficiaries would fall in each of the 3 groups: children 0-5, children 5-15, and adults. Assume equal distribution of Uncomplicated episode not receiving formal health care and Uncomplicated episode receiving formal health care. 2.8% of all cases are severe (Taylor et al. 2012. Estimating the Fraction of Severe Malaria among Malaria-Positive Children: Analysis of Household Surveys in 19 Malaria-Endemic Countries in Africa. Am J Trop Med Hyg. 104(4):1375-1382.). Thus, cost of 6950 MWK in 2020 per person for treating illness (direct household costs, indirect household costs and health provider cost), which in 2020 exchange rate is USD 9.70.	USD/person	$9.70
Total annual health avoided costs due to introduction of anti-malaria nets	Calculated. = Total estimated number of avoided malaria cases due to anti-malaria nets * Annual malaria cost - per beneficiary	USD/year	$103,335
Number of deaths associated with malaria infection per 1,000 infected	Severe Malaria Observatory (n.d.) Malawi Malaria Facts. Between 2020 and 2021, the case burden for malaria stagnated at 219 per 1000 of the population at risk, while deaths fell by 2.7% from 0.38 to 0.37 per 1000 of the population at risk.	#/1000	0.37
Number of people avoiding death due to anti-malaria nets	Calculated. = (Number of deaths associated with malaria infection per 1,000 infected * Total estimated number of avoided malaria cases due to anti-malaria nets) / 1,000	#	4
Value of Statistical Life (VSL) in Malawi	Rounded value based on the following source. Saluja, Saurabh & Rudolfson, Niclas & Massenburg, Benjamin &	USD	$50,000

	Meara, John & Shrime, Mark. (2020). The impact of physician migration on mortality in low and middle-income countries: An economic modelling study. BMJ Global He.		
Total social cost avoided due to avoided deaths - lifespan of investment	Calculated. = Value of Statistical Life (VSL) in Malawi * Number of people avoiding death due to anti-malaria nets	USD	$197,083
Total social cost avoided due to avoided deaths - averaged per lifetime of investment	Calculated. = Total social cost avoided due to avoided deaths - lifespan of investment / Lifetime of anti-malaria nets	USD/year	$131,388
Benefits resulting in anti-malaria nets	**Calculated. = Total social cost avoided due to avoided deaths - averaged per lifetime of investment + Total annual health avoided costs due to introduction of anti-malaria nets**	**USD/year**	**$234,724**
Months that require SMC treatment	Project proposal	month	4
Duration of SMC treatment coverage	Estimated based on the WHO. 2023. Seasonal malaria chemoprevention with sulfadoxine–pyrimethamine plus amodiaquine in children: a field guide. 2nd ed. World Health Organization	month	1
Societal economic cost per episode averted via SMC treatment	Conteh L, Shuford K, Agboraw E, Kont M, Kolaczinski J, Patouillard E. Costs and Cost-Effectiveness of Malaria Control Interventions: A Systematic Literature Review. Value Health. 2021 Aug;24(8):1213-1222. Societal economic cost per episode averted via SMC treatment is 177.34 (From Table 1).	USD/child	$177
Cost effectiveness	Calculated. = Societal economic cost per episode averted via SMC treatment - Cost per child receiving a SMC	USD/child	$160
Benefits from SMC	Calculated. = (Cost effectiveness * Number of benefiting people) / Lifetime of anti-malaria nets	**USD/year**	**$2,004,159**
Cholera/diarrhea avoidance related benefits			
Number of beneficiaries to receive treatment	Project document	#	30,000
Mortality rate among those who do not receive ORS	GBD (2017) Diarrhoeal Disease Collaborators. Quantifying risks and interventions that have affected the burden of diarrhoea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. Lancet Infect Dis. 2020 Jan;20(1):37-59. Global mortality from diarrhoeal diseases and associated risk factors by GBD super-region and region, in 2017.	Deaths per 100,000 children	78.4

Reduction in mortality rate due to ORS	Black, R., et al. (2019). Drivers of the reduction in childhood diarrhea mortality 1980-2015 and interventions to eliminate preventable diarrhea deaths by 2030. Journal of global health, 9(2), 020801. https://doi.org/10.7189/jogh.09.020801. The contribution of ORS from 2000 to 2015 is 30.7%.	%	31%
Avoided deaths	Calculated. = Number of beneficiaries to receive treatment * (Mortality rate among those who do not receive ORS / 100,000) * Reduction in mortality rate due to ORS	#	7
VSL avoided costs	**Calculated. = Avoided deaths * Value of Statistical Life (VSL) in Malawi**	**USD/year**	**$361,032**
Yearly VSL avoided costs	**Calculated. = VSL avoided costs / 4**	**USD/year**	**$90,258**
Social benefits resulting from applying malnutrition food packages			
Total DALY related to severe acute malnutrition	WHO (2023) Burden of Disease 2000-2019. Top 10 causes of DALY in Malawi for both sexes aged 1 to 4 years (2019): for protein-energy malnutrition (i.e. severe acute malnutrition) the DALY per 100,000 is 1,477	DALY/100,000	1,477
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9. The estimated cost per DALY averted was $998 in low HDI countries. On average, the cost per DALY averted was 0.34 times the GDP per capita in low HDI countries.	USD/DALY	$1,000
Total value of DALY - national level - children	Calculated. = (Total DALY related to malnutrition / 100,000) * Monetary value of one DALY * Total number of children benefit from annual malnutrition food packages	USD	$118,160
Total value of annual avoided health costs due to treatment of severe acute malnutrition	**Calculated. =** Total value of DALY - national level – children Total value of DALY - national level – children". This is calsulated based on: Total DALY related to malnutrition / 100,000 (1,477 / 1,000) x Monetary value of one DALY (1,000) x Total number of children benefit from annual malnutrition food packages (8,000) = $118,160	**USD/year**	**$118,160**
Total annual benefits due to M4	**Calculated. = Benefits resulting in anti-malaria nets + Benefits from SMC + Yearly VSL avoided costs + Total value of annual avoided costs due to avoiding malnutrition**	**USD/per investment**	**$2,447,300**

Assumptions for Measure 5. Integrated homestead farming and improved nutrition practices

Cost calculations on a per investment basis			
Parameter	**Sources and assumptions elaboration**	**Unit**	**Value**
Input data			
Discount rate	UN-OHRLLS Malawi Sustainable Energy Investments Study. 9% discount rate used, to represent the weighted average cost of capital for the sector. Capital investment requirements are discounted at 9%. All costs are calculated at NPV, discounted at 9%.	%	9%
Number of starter packs	Project budget	#	45,000
Total budget for starter packs for integrated homestead farming and improved nutrition practices	Project budget	USD	$1,305,539
Cost per child of starter packs for integrated homestead farming and improved nutrition practices	Calculated. Total budget for starter packs / number of children supported by the project intervention	USD	$12.43
Number of children supported by the project intervention	Calculated. Total budget for the starter packs / Cost per child of starter packs for integrated homestead farming and improved nutrition practices Calculated. = 105,000 children from 45,000 mothers i.e. households = 12.43	#	105,000
Number of mothers (households) to be supported by the project	Calculated. = Number of starter packs	#	45,000
Number of villages to have farming demonstration plots set up	Project budget	#	500
Average cost per ha to produce climate resilient crops (estimation based on pigeonpea production)	Cost per ha based on: IFPRI,2023. Employment options and challenges for rural households in Malawi An agriculture and rural employment analysis of the fifth Malawi Integrated Household Survey, 2019/20 Labour cost per ha based on:	USD/ha	$723

	Remofirst. (2023) Employer of Record (EOR) in Malawi. Cost of pigen pea production (excludes labour cost) = 17,730 MWK = 10.52 USD. Minimum labour cost in Malawi is 50,000 MWK = 29.69 USD / month. Assume 2 labourers per 1 ha, the labour cost/ha should be $29.69 x 12 month x 2 labourers = $713. So, the total cost should be $10.52 + 713 = $723.		
Total budget for farming starter packs	Project budget	USD	$904,424
Ha that can be covered with starter packs	Calculated. = Total budget for farming starter packs / Average cost per ha to produce climate resilient crops (estimation based on pigeon pea production)	ha	1,251
Opex costs related to homestead farming - annual per ha	Experts assumption	USD/year	$100
Lifetime of investment - DALY related to improved child nutrition	Expert's assumption	#	15
Lifetime of homestead farming	Expert's assumption	Years	15
Opex costs	Calculated. = Opex costs related to homestead farming - annual per ha * (Ha that can be covered with starter packs)	**USD/yearly**	**$125,079**
Total investment costs for M5	Total budget for starter packs for integrated homestead farming and improved nutrition practices	**USD/entire measure**	**$1,305,539**

Benefits calculations on a per investment basis			
Benefits			
Malnutrition - reduced iron-deficiency anaemia among children as result of integrated homestead farming combined with improved nutrition practices			
Total DALY related to iron-deficiency anaemia	Michaux KD, Hou K, Karakochuk CD, Whitfield KC, Ly S, Verbowski V, Stormer A, Porter K, Li KH, Houghton LA, Lynd LD, Talukder A, McLean J, Green TJ. Effect of enhanced homestead food production on anaemia among Cambodian women and children: A cluster randomized controlled trial. Matern Child Nutr. 2019 May;15 Suppl 3(Suppl 3):e12757. Top 10 causes of DALY in Malawi for both sexes aged 1 to 4 years (2019) = 1246 per 100,000.	DALY	262

	Project intervention will reduce anaemia DALY's in children by 20%, so it is assumed project will reduce anaemia DALYs by 20%		
Monetary value of one DALY	Daroudi, R., Akbari Sari, A., Nahvijou, A., & Faramarzi, A. (2021). Cost per DALY averted in low, middle-and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Effectiveness and Resource Allocation, 19(1), 1-9. The estimated cost per DALY averted was $998 in low HDI countries. On average, the cost per DALY averted was 0.34 times the GDP per capita in low HDI countries.	USD/DALY	$1,000
Total value of DALY - national level - children	Calculated. = (Total DALY related to iron-deficiency anaemia / 100,000) * Monetary value of one DALY * Number of infants to be supported by the project	USD	$274,743
Total value of annual avoided costs due to reduced malnutrition (iron-deficiency anaemia)	**Calculated. =** Total value of DALY - national level - children	**USD/year**	**$274,743**
Homestead farming			
Gross value of climate resistant crops such as pigeon pea in Malawi	Estimation of annual gross value of climate resistant crops such as pigeon pea in Malawi is USD 1,260 per hectare, based on: Benson, T and deWeerdt, J. 2023. Employment options and challenges for rural households in Malawi An agriculture and rural employment analysis of the fifth Malawi Integrated Household Survey, 2019/10. International Food Policy Research Institute.	USD/ha/annual	$1,260
Economic value of climate resistant crops such as pigeon pea	Calculated = Gross value of climate resistant crops such as pigeon pea in Malawi	USD/ha/annual	$1,260
Total economic value of produced crop (pigeon pea) - entire measure level	**Calculated. = Economic value of climate resistant crops such as pigeon pea in Malawi * (Number of ha to be supported by the project - demonstration sites + Ha that can be covered with starter packs)**	**USD/year**	**$1,576,000**

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