

Annex 22: Assessment of GHG Emission Reductions and Their Monitoring and Reporting

Project Title: Building Climate Change Resilience of Vulnerable Households in Selected Localities of Ethiopia

Accredited Entity: Ministry of Finance

Country: Ethiopia

GCF Modality: SAP

Implementation Period: 4 years

Project Lifetime: 20 years (for emission calculations)

Expected Mitigation Result: Approximately 32,293 tCO₂e avoided over 20-year lifetime

1. Mitigation Context

The proposed project is primarily designed as a climate adaptation intervention aimed at strengthening the resilience of vulnerable rural communities to climate change impacts, particularly recurrent droughts, water scarcity, and declining agricultural productivity in selected regions of Ethiopia. At the same time, the project generates important mitigation co-benefits by promoting the adoption of renewable energy technologies and climate-smart land management practices that reduce greenhouse gas (GHG) emissions associated with rural water supply and agricultural production systems.

In many rural areas of Ethiopia, access to reliable electricity infrastructure remains limited. As a result, communities frequently rely on diesel-powered pumps and generators to extract groundwater for potable water supply and small-scale irrigation. These diesel pumping systems are typically inefficient, costly to operate, and highly carbon intensive. Combustion of diesel fuel releases carbon dioxide (CO₂) and other greenhouse gases, contributing to climate change while also generating local air pollutants that affect human health and environmental quality.

Under the baseline scenario, rural water supply and irrigation systems in the targeted kebeles would continue to depend on these fossil fuel-based pumping technologies. Diesel pumps are commonly used to supply water for irrigation schemes and community water systems, particularly in areas lacking grid electricity access. These systems require continuous fuel consumption during operation, resulting in significant cumulative emissions over time. The dependence on diesel pumps also exposes rural communities to volatile fuel prices and supply constraints, which can undermine the reliability and affordability of water services.

The project addresses this challenge by replacing conventional diesel-powered pumping systems with solar photovoltaic (PV)-powered water pumping technologies. Solar-powered pumps provide a clean and sustainable alternative energy source for groundwater extraction and irrigation water delivery. By harnessing solar energy, these systems eliminate the need for diesel fuel combustion during water pumping operations. As a result, the project directly reduces fossil fuel consumption and associated GHG emissions.

The deployment of solar pumping systems under the project will support both potable water supply systems and small-scale irrigation schemes, enabling communities to access reliable water services while simultaneously transitioning toward low-carbon rural energy solutions. Solar pumping technology is particularly well suited for rural Ethiopian contexts due to the

country's high solar irradiation levels and the increasing affordability and reliability of solar PV systems.

The mitigation impact of the project arises primarily from avoided diesel fuel combustion that would otherwise occur in the absence of the project. By replacing diesel pumps with solar-powered alternatives, the project prevents emissions associated with diesel fuel use for water pumping operations. The cumulative emission reductions generated by these systems are estimated based on the quantity of diesel fuel displaced over the operational lifetime of the project infrastructure.

Based on the estimated number and capacity of solar-powered pumps installed, the project is expected to achieve approximately 32,293 tonnes of carbon dioxide equivalent (tCO₂eq) in avoided emissions over a 20-year lifetime. These emission reductions represent a meaningful mitigation co-benefit, particularly considering that the primary objective of the project is climate adaptation.

The mitigation co-benefits generated by the project align with Ethiopia's national climate policy framework, including the Climate Resilient Green Economy (CRGE) Strategy and the country's Nationally Determined Contribution (NDC) under the Paris Agreement. These national strategies emphasize the expansion of renewable energy technologies, sustainable land management, and climate-smart agricultural practices as key pillars of Ethiopia's transition toward a low-emission and climate-resilient development pathway.

By integrating renewable energy solutions into rural water supply and agricultural systems, the project demonstrates how adaptation investments can simultaneously support climate mitigation objectives. The intervention therefore contributes to the achievement of GCF mitigation result area MRA1: Energy generation and access, while also strengthening resilience in vulnerable communities.

Overall, the project illustrates the potential for adaptation-focused investments to generate meaningful mitigation co-benefits, supporting both national climate goals and global efforts to reduce greenhouse gas emissions.

2. Source of Emission Reductions

The primary source of GHG emission reductions under the project arises from the displacement of fossil fuel-based energy used for water pumping systems in rural communities. Specifically, the project replaces diesel-powered pumping technologies with solar PV-powered water pumping systems, thereby eliminating the combustion of diesel fuel that would otherwise be required to operate irrigation and potable water supply infrastructure. Diesel fuel combustion in water pumping systems represents a significant source of CO₂ emissions in rural off-grid areas. These emissions occur when diesel engines or generators are used to power pumps that extract groundwater for agricultural irrigation and community drinking water supply. The combustion of diesel fuel releases CO₂ as well as other greenhouse gases and air pollutants, contributing to climate change and environmental degradation.

The project addresses this emissions source by installing solar PV-powered pumping systems that utilize renewable energy to generate electricity for water extraction. Solar-powered pumps operate without fossil fuels, thereby avoiding the emissions that would otherwise occur from

diesel fuel combustion. The emission reductions generated by the project are therefore directly attributable to the avoided consumption of diesel fuel in pumping operations.

The principal sources of emission reductions under the project include the following:

2.1 Replacement of Diesel Irrigation Pumps: Small-scale irrigation systems in many rural areas of Ethiopia rely on diesel-powered pumps to lift and distribute water for crop production. These pumps typically operate during the irrigation season and consume significant quantities of diesel fuel, depending on pump capacity, irrigation demand, and operating hours. Under the project, diesel-powered irrigation pumps of varying capacities will be replaced by solar PV-powered pumping systems designed to provide equivalent or improved water delivery services. Each solar pump installed effectively displaces the diesel fuel that would otherwise have been consumed by the conventional pumping system. The resulting reduction in diesel consumption translates directly into avoided CO₂ emissions. The magnitude of emission reductions depends on several factors, including the number of pumps installed, their power capacity, annual operating hours, and the fuel consumption characteristics of the diesel pumps that would have been used under the baseline scenario.

2.2 Replacement of Diesel-Powered Water Supply Systems: In addition to irrigation pumps, many rural drinking water systems rely on diesel generators or diesel-driven pumps to extract groundwater and supply community water points. These systems require continuous fuel input and are associated with substantial operational costs and GHG emissions. The project will install solar-powered pumping systems to replace diesel-based energy supply for these potable water systems. Solar PV panels generate electricity that powers submersible pumps, enabling reliable water supply without the need for diesel fuel. By eliminating diesel generator operation, the project avoids the associated combustion emissions that would otherwise occur during water supply operations.

2.3 Quantification of Emission Reductions: For each pumping system replaced, the amount of diesel fuel displaced can be estimated based on the following parameters:

- Pump capacity and power requirements
- Average operating hours per year
- Typical diesel fuel consumption rates of comparable pumps
- Number of systems installed under the project

The total quantity of diesel fuel avoided is then converted into carbon dioxide emission reductions using standard emission factors derived from the IPCC Guidelines for National Greenhouse Gas Inventories. The default emission factor for diesel fuel combustion is applied to estimate the amount of CO₂ emissions avoided per litre of diesel displaced.

In summary, the emission reductions generated by the project arise primarily from avoided diesel fuel combustion in water pumping systems, resulting from the transition to solar-powered pumping technologies. The cumulative impact of these avoided emissions across all installed pumping systems over the project lifetime forms the basis for the project's estimated mitigation co-benefits.

3. GHG Emissions Baseline and Project Scenario

3.1 Baseline Scenario

The baseline scenario represents the continued provision of potable water and irrigation pumping services through diesel-powered pumps in the absence of the project. Because detailed historical fuel records are not consistently available across all planned intervention sites, the ex-ante baseline is derived from representative service-equivalent diesel pump assumptions, using conservative values for pump size, annual operating hours, and fuel consumption.

The baseline is structured around two pump types corresponding to the project design: (i) 21 potable water pumping systems under Output 2.1, and (ii) 150 irrigation pump systems distributed across the project's small-scale irrigation investments under Output 2.2. For ex-ante estimation purposes, the equivalent baseline diesel pumps are represented by an average 8 hp diesel pump for potable water systems and an average 10 hp diesel pump for irrigation systems. A conservative diesel consumption factor of 0.17 litres per horsepower-hour is applied.

Pump type	No. of systems	Representative baseline diesel-equivalent size (hp)	Annual operating hours	Diesel consumption factor (L/hp-hour)	Annual diesel avoided per system (L/year)	Total annual diesel avoided (L/year)	Lifetime diesel avoided (L/20 years)
Potable water systems	21	8	3,600	0.17	4,896	102,816	2,056,320
Irrigation systems	150	10	1,942	0.17	3,301.4	495,210	9,904,200
Total	171	–	–	–	–	598,026	11,960,520 (~11.96 million litres)

Using an IPCC Tier 1 default diesel emission factor of 2.70 kg CO₂ per litre, the lifetime baseline emissions are calculated as follows:

Baseline emissions = 11,960,520 litres × 2.70 kg CO₂/litre ÷ 1,000 = approximately 32,293 tCO₂eq over the 20-year lifetime.

This litres-based derivation is the single primary basis for the mitigation estimate reported in this annex and in the funding proposal package.

3.2 Project Scenario

Under the project scenario, solar PV-powered pumping systems provide the required potable water and irrigation services without diesel combustion during normal operation. Direct operational project emissions are therefore assumed to be negligible. The ex-ante calculation assumes that solar systems operate without routine fossil-fuel backup. If any project-supported system uses diesel backup during implementation or operation, that fuel use will be monitored and deducted from reported emission reductions.

3.3 Estimation of Emission Reductions:

Emission reductions are calculated as $ERY = BEy - PEy - LEy$, where BEy is baseline emissions, PEy is project emissions, and LEy is leakage emissions. For this project, PEy is

assumed to be zero during normal operation and LE_y is assumed to be zero unless any material residual diesel use or other leakage source is identified during monitoring. Accordingly, ex-ante ER_y equals BE_y.

The emission reductions are calculated as:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y = Emission reductions in year y (tCO₂e)

BE_y = Baseline emissions in year y (tCO₂e)

PE_y = Project emissions in year y (tCO₂e)

LE_y = Leakage emissions in year y (tCO₂e)

For this project, PE_y is assumed to be zero during normal operation and LE_y is assumed to be zero unless any material residual diesel use or other leakage source is identified during monitoring. Accordingly, ex-ante ER_y equals BE_y.

3.4 Key Assumptions

The emission calculation applies a single litres-based primary approach. It is grounded in the IPCC 2006 Guidelines for National Greenhouse Gas Inventories using a Tier 1 diesel emission factor, while remaining conceptually consistent with the principles of CDM AMS-I.B for renewable energy replacing diesel-powered mechanical pumping. The annex no longer reports a parallel MWh/default-factor estimate.

The key assumptions used for the ex-ante estimate are as follows: (i) 21 potable water solar pumping systems and 150 irrigation solar pumping systems are implemented as per the project design; (ii) the equivalent baseline diesel pumps are represented by conservative average sizes of 8 hp for potable water systems and 10 hp for irrigation systems; (iii) average annual operating hours are 3,600 for potable water systems and 1,942 for irrigation systems; (iv) diesel consumption is estimated at 0.17 litres per horsepower-hour; (v) the diesel emission factor is 2.70 kg CO₂ per litre; and (vi) the technical lifetime used for the ex-ante estimate is 20 years.

These assumptions are intentionally conservative and are used only to establish the ex-ante mitigation estimate. During implementation, reported annual reductions will be based on actual commissioned systems and monitored operational evidence.

3.5 Summary of Baseline and Project Emissions

Indicator	Value
Total lifetime diesel displaced	11.96 million litres (11,960,520 litres)
Baseline emissions (20-year lifetime)	Approximately 32,293 tCO ₂ eq
Project emissions (20-year lifetime)	0 tCO ₂ eq during normal operation
Net lifetime emission reductions (Core Indicator 1)	Approximately 32,293 tCO ₂ eq
Average annual emission reductions over the 20-year lifetime	Approximately 1,615 tCO ₂ eq/year
Primary quantified source of mitigation	Direct diesel combustion avoided from potable water and irrigation pumping

4. Leakage Assessment

Leakage refers to any unintended increase in greenhouse gas emissions outside the project boundary that occurs as a result of project activities. Potential sources of leakage could include:

- Relocation of diesel pumps to other locations
- Increased fossil fuel consumption elsewhere due to project activities

For this project, leakage emissions are considered negligible for the following reasons:

- Diesel pumps replaced by solar systems are expected to be retired or rendered obsolete.
- The project does not stimulate additional diesel consumption elsewhere.
- The project does not induce land-use changes or activities that could increase emissions outside the project boundary.

Therefore:

$$LE_y = 0$$

However, the project expands the irrigated area in the target kebeles from an estimated 250 hectares under the baseline to 630 hectares under the project scenario. This expansion of irrigated area may induce rebound effects in the form of increased use of agricultural inputs, particularly fertilisers and pesticides, associated with higher cropping intensity, more frequent cropping cycles, and higher-yielding crop varieties adopted under irrigated production. The upstream and downstream emissions associated with increased fertiliser use represent a potential indirect emission increase that is not captured in the direct diesel displacement calculation.

Magnitude assessment: Published evidence on irrigation-induced fertiliser use intensification in smallholder systems in East Africa suggests an average increase of 15–20 kg of nitrogen fertiliser per hectare per year when transitioning from rain-fed to irrigated production.¹ Applying a conservative 15 kg N/ha/year increase over 380 additional irrigated hectares (630 ha project – 250 ha baseline), the associated N₂O emissions are estimated as follows:

Additional fertiliser use: 380 ha × 15 kg N/ha/year = 5,700 kg N/year

N₂O emission factor (IPCC Tier 1): 1% of applied nitrogen → 57 kg N₂O-N/year

N₂O molecular weight conversion: 57 kg N₂O-N × 44/28 = 89.6 kg N₂O/year

GWP100 for N₂O: 273 (IPCC AR6)

Annual rebound emission: 89.6 kg × 273 / 1,000 = 24.5 tCO₂eq/year

Lifetime rebound (20 years): 490 tCO₂eq

This represents approximately **1.5% of the gross emission reduction estimate of 32,293 tCO₂eq and is therefore not material enough to alter the project's mitigation result. Nevertheless, it is included as a documented and quantified leakage element for transparency.**

5. Barrier Analysis Framework

- The additionality of the project's solar pumping investments is assessed through a barrier analysis consistent with the CDM Tool for the Demonstration and Assessment of Additionality.² Four categories of barriers are identified that prevent the widespread deployment of solar pumping systems in the target woredas in the absence of the project:
 - Observed Technology Penetration: Diesel vs Solar Pumps in Target Woredas**
- Field surveys conducted in all seven target woredas during the pre-feasibility study (2023–2024) found that diesel-powered pumps account for over 90% of mechanised irrigation pump

¹Dreschel, P., et al. (2021). The economics of irrigation intensification in Sub-Saharan Africa: Input use, yield responses, and fertilizer uptake. *Agricultural Water Management*, 245, 106594. A 15–20% increase in fertilizer application per hectare is commonly observed in smallholder systems transitioning from rain-fed to irrigated production, owing to higher cropping intensity and yield response.

²CDM Executive Board (2012). *Tool for the Demonstration and Assessment of Additionality* (Version 06.0.0). Bonn: UNFCCC. The barrier analysis test is the most widely applied additionality test for small-scale renewable energy projects under the CDM and GCF, identifying investment barriers, prevailing practice barriers, and other barriers that prevent the technology from being deployed without project support.

capacity and over 85% of mechanised rural water supply pump capacity in the target areas.³⁴ Solar pump penetration is estimated at below 5% of total installed pump capacity in all seven target woredas.

- The following table presents the observed technology baseline across the target woredas:

Woreda / Region	Total irrigation pumps (est.)	Diesel-powered (#)	Solar-powered (#)	Diesel share (%)
Tenta (Amhara)	~180	~168	~12	~93%
Wahil (Dire Dawa)	~95	~90	~5	~95%
Erer (Harari)	~120	~112	~8	~93%
Adama (Oromia)	~210	~188	~22	~90%
Aleltu (Oromia)	~155	~146	~9	~94%
Lok Abeya (Sidama)	~140	~132	~8	~94%
Raya Azebo (Tigray)	~165	~158	~7	~96%
Total / Average	~1,065	~994	~71	~93%

- *Source: Pre-feasibility study field surveys (2023–2024), regional bureau records, and woreda-level agricultural extension officer consultations.*
- The negligible solar pump penetration (below 7%) across all seven woredas demonstrates that voluntary market-driven uptake of solar pumping has not occurred and is not occurring at meaningful scale. This establishes a strong baseline from which to demonstrate that the project's solar pump installations are additional to prevailing practice.

b. Financing and Credit Constraints

- **Investment barrier:** A solar pump system suitable for smallholder irrigation in Ethiopia (5–15 kW capacity) requires an upfront capital investment of approximately USD 2,500–6,500 per unit, compared to USD 400–900 for a comparable diesel pump.⁵ This capital cost differential of 5–8 times is the primary structural barrier to solar pump adoption among smallholder farmers in the target woredas.
- **Credit market constraints:** Rural credit markets in Ethiopia do not offer financial products suited to solar pump financing. Commercial microfinance products available in the target areas carry interest rates of 18–22% per annum with repayment tenures typically below 18 months and collateral requirements of up to 150% of loan value.⁶ These terms make solar pump investment commercially unviable for smallholder households and small rural water management committees in the absence of concessional financing. Even under optimistic assumptions, the payback period for a solar pump financed at commercial rates is 8–12 years, far exceeding the typical planning horizon and risk tolerance of smallholder farmers.
- The project addresses this barrier by providing grant financing for the upfront capital cost of solar pump procurement and installation, reducing the effective cost to beneficiaries to zero. Without this grant, the investment barrier would remain prohibitive for the target communities,

³International Finance Corporation (IFC) / World Bank Group (2022). Off-Grid Solar Market Trends Report. Washington, DC: World Bank. Diesel pump market share in sub-Saharan African smallholder irrigation systems estimated at 85–90% in countries with low rural electrification rates comparable to Ethiopia.

⁴GIZ / Ethiopian Ministry of Water and Energy (2021). Rural Electrification and Off-Grid Renewable Energy Assessment: Ethiopia. Addis Ababa: MoWE. Solar irrigation pump penetration in the target regions estimated at below 5% of installed irrigation pump capacity at the time of the pre-feasibility study (2023–2024).

⁵IRENA (2021). Renewable Power Generation Costs in 2020. Abu Dhabi: International Renewable Energy Agency. Upfront capital cost of solar pump systems (including PV panels, pump, controller, civil works): USD 2,500–6,500 per unit depending on capacity; typical diesel pump equivalent: USD 400–900 per unit. Payback period for solar pump under concessional finance: 4–7 years; without subsidy: 8–12 years.

⁶World Bank (2022). Ethiopia Financial Sector Assessment. Washington, DC: World Bank Group. Rural credit markets for agricultural equipment: average interest rate on smallholder agricultural loans 18–22% per annum; average loan tenure for equipment finance under 18 months; collateral requirements typically 150% of loan value, inaccessible for most smallholders.

and diesel-powered pumping would continue as the prevailing and only financially accessible technology.

4.5.4 Procurement and O&M Constraints

- Procurement barrier: Solar pump systems require access to a reliable supply chain for PV panels, pump controllers, submersible motors, and associated balance-of-system components. In all seven target woredas, no established local or regional supply chain for solar pump systems exists. The nearest suppliers are located in regional capitals or Addis Ababa, and woreda-level procurement of solar systems has not been conducted by government agencies at the scale required by the project. Without the project's structured international and national competitive procurement process, individual communities and woreda offices would be unable to source appropriately specified systems at competitive prices.
- O&M constraint: Operation and maintenance of solar pump systems requires technical skills that are not currently available at woreda or kebele level in the target areas. Woreda water offices and IWUAs lack trained personnel for routine solar PV system maintenance, fault diagnosis, and pump servicing. This skills gap represents a structural barrier to the voluntary adoption of solar pumping even where upfront financing might theoretically be available. The project addresses this constraint through dedicated O&M training programmes (Activity 2.1.6) and spare parts provision (Activities 2.1.5 and 2.2.5), which together create the enabling conditions for sustainable system operation — conditions that do not exist under the current baseline.

c. Policy and Programme Context: Project is Incremental to Existing Programmes

- No overlap with existing programmes: A review of ongoing and pipeline investments in the target woredas by CRGE Facility, development partners, and bilateral donors confirms that no existing programme is financing solar irrigation pump deployment at the scale proposed under this project. The project is therefore fully incremental to the existing policy and programme landscape and does not displace or replicate any funded activity already underway.
- In summary, the barrier analysis demonstrates that financial, technical, supply chain, and policy barriers jointly prevent the voluntary uptake of solar pumping in the target areas. The project directly addresses each of these barriers through concessional grant financing, structured procurement, technical training, and spare parts support, confirming that the solar pump deployments under the project are additional and would not occur in the absence of GCF support.

6. Monitoring, Reporting and Verification (MRV) Plan

6.1 Selected Quantification Approach

The project uses the **litres-based diesel displacement approach** as the sole primary methodology for quantifying annual and lifetime GHG emission reductions. This approach directly measures the volume of diesel fuel displaced by solar pumping systems and converts it to CO₂ equivalent emissions using the IPCC Tier 1 default emission factor. The MWh/CDM Tool 33 grid emission factor approach has been removed from the calculation framework. All monitoring parameters, data sources, and verification procedures described in this section are aligned with the litres-based formula.

6.2 Annual Emission Reduction Formula

The annual emission reduction in year y is calculated as:

$$ER_y = (\sum_i OH_{i,y} \times P_i \times FCF_i \times EF_{diesel}) - LE_y$$

Where:

- ER_y = Net emission reductions in year y (tCO₂eq)
- i = individual solar pump system ($i = 1$ to 171)
- $OH_{i,y}$ = Operating hours of pump i in year y (hours/year) — MONITORED PARAMETER

- P_i = Rated power capacity of pump i (kW) — FIXED AT INSTALLATION
- FCF_i = Diesel fuel consumption factor for pump i (litres/kWh) — FIXED FROM BASELINE SURVEY
- EF_{diesel} = Diesel emission factor = $2.70 \text{ kgCO}_2/\text{litre} \div 1,000 = 0.00270 \text{ tCO}_2/\text{litre}$ — FIXED (IPCC Tier 1)

LE_y = Leakage emissions in year y (tCO_2eq) — calculated per Section 4.2.3 above

6.3 Monitored Parameters and Data Sources

The table below specifies each parameter required for the annual ER calculation, confirming which parameters are fixed (established at installation or baseline) and which are actively monitored during operation:

Parameter	Description	Unit	Type	Data Source	Monitoring Frequency
$OH_{i,y}$	Annual operating hours per pump	hrs/year	MONITORED	Hour meters on pump controller; O&M logbooks maintained by IWUA / water management committee	Recorded monthly by IWUA; compiled annually by woreda technical office
P_i	Rated power capacity of solar pump	kW	FIXED	Equipment supplier technical specifications and commissioning records	Established at installation; verified at mid-term evaluation
FCF_i	Diesel fuel consumption factor of displaced pump	l/kWh	FIXED	Baseline field surveys; manufacturer specifications for pump models in use; standard engineering tables	Established at baseline survey; reviewed every 3 years
EF_{diesel}	CO_2 emission factor for diesel combustion	$\text{tCO}_2/\text{litre}$	FIXED	IPCC 2006 Guidelines, Vol. 2, Chapter 3 (Table 3.2.2): $0.00270 \text{ tCO}_2/\text{litre}$	Fixed for project lifetime; updated only if revised IPCC guidance is issued
LE_y	Leakage emissions (redeployment + rebound)	$\text{tCO}_2\text{eq}/\text{year}$	MONITORED	Diesel pump retirement register; annual redeployment survey; agricultural monitoring (fertiliser use)	Annual diesel pump survey; annual agricultural M&E report
Diesel pump retirement count	Number of diesel pumps formally decommissioned	units	MONITORED	Woreda retirement register; decommissioning certificates	Updated at installation; verified annually

6.4 Monitoring Responsibilities

- **Kebele / IWUA level:** Monthly recording of pump operating hours in O&M logbooks. Maintenance of diesel pump retirement registers. Reporting to woreda technical office quarterly.
- **Woreda technical office (Agriculture / Water):** Annual compilation of operating hours from all installed systems in the woreda. Annual diesel pump redeployment survey. Preparation of woreda-level annual monitoring report.
- **Regional bureaus:** Consolidation of woreda monitoring reports. Quality review of data consistency across woredas. Submission of regional MRV report to CRGE Facility.
- **CRGE Facility (MoF):** Calculation of annual emission reductions using the formula in Section 6.2. Preparation of Annual Project Report mitigation section (Core Indicator 1). Facilitation of independent verification.

6.5 Quality Assurance and Verification

Internal QA: Cross-checking of operating hours against pump technical specifications and water output records (where flow meters are available). Consistency checks of fuel consumption factors against manufacturer data. Validation of leakage survey findings through woreda field visits.

External verification: An independent technical review of the MRV records and emission reduction calculations will be conducted at mid-term (Year 2–3) and at project completion (Year 4–5) as part of the project's evaluation programme. The verification will include field inspection of a sample of installed systems, review of O&M logbooks, and audit of the retirement register.

6.6 Annual Reporting to GCF

Annual emission reductions will be reported to the GCF under Core Indicator 1 (GHG emissions reduced, avoided, or removed) in the Annual Project Report. The report will include: (i) number of solar pump systems operational in the reporting year; (ii) total operating hours recorded; (iii) diesel litres displaced (calculated); (iv) gross emission reductions (tCO₂eq); (v) leakage deductions applied (tCO₂eq); (vi) net emission reductions (tCO₂eq); (vii) cumulative lifetime emission reductions to date; and (viii) explanation of any deviations from projected mitigation outcomes.