Clean Impact Bond: Mobilizing Finance for Clean Cooking

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About BIX Capital: BIX Capital is an $18 million debt fund for small and medium enterprises (SMEs) in Sub-Saharan Africa that supplies low-income people with products that have a high development impact, such as clean cooking solutions and water purifiers. For more information, visit https://www.bixcapital.nl/.

About Osprey Foundation: Osprey Foundation is a philanthropic impact investor based in the United States. For more information, visit http://www.ospreyfdn.org/.

About Sistema.bio: Sistema.bio is a global supplier of biogas products that installs, services, and finances systems for smallholder farmers in Latin America, Asia and Africa. For more information, visit https://sistema.bio/.

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2121 Pennsylvania Avenue, N.W.
Washington, D.C. 20433

www.ifc.org

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# Contents

Acknowledgments 02

Abbreviations and Acronyms 03

Boxes, Tables, and Figures 03

Introduction 06

Context 08

The Clean Impact Bond 12

- Structure 13
- Partners 14
- Financial Flows and Terms 16
- Co-benefit Certification 17

Quantifying and Measuring Health and Gender Outcomes 18

- Key Findings 19
  - Health
  - Gender

Lessons Learned 24

Conclusion 28

Appendixes 30

- A. Methodology of Baseline Assessment 31
- B. Metrics and Standards 34
- C. Outcome Results 35
  - Health
  - Gender

Endnotes 40
Acknowledgments

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This brief was developed under the overall guidance of Mary Porter Peschka (Director, Sustainability and Gender Solutions Department, IFC), Henriette Kolb (Manager, Gender and Economic Inclusion Group, IFC), Heather Kipnis (Global Product Lead, Gender and Economic Inclusion Group, IFC), and Anup Jagwani (Global Manager, Climate Finance & Policy, Climate Business Department, IFC); led by Kiyoshi Okumura (Senior Investment Officer, Climate Business Department, IFC), Shino Saruta (Operations Officer, Gender and Economic Inclusion Group, IFC), Jeroen Blüm (Managing Director, BIX Capital), Fleur Henderson (Senior Project Director, Cardano Development), Claudia Doets (Managing Director, Cardano Development), Maaike Veen (Consultant, Cardano Development), Louis Boorstin (Managing Director, Osprey Foundation), Alex Eaton (CEO, Sistema.bio), Stephanie Zayed (Carbon and Impact Lead, Sistema.bio), and Esther Altorfer (Chief Strategy Officer, Sistema.bio).

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About this brief

This IFC brief introduces the Clean Impact Bond (CIB), a results-based financing (RBF) instrument that Cardano Development, IFC, BIX Capital, the Osprey Foundation, and Sistema.bio structured to mobilize finance based on the sales of certified health and gender credits in the modern energy cooking sector for the first time. Along with the context for the CIB, this brief presents evidence that clean cooking can achieve measurable health and gender benefits, and summarizes lessons learned from structuring the CIB. Findings are drawn from IFC’s technical assistance, through the process of the CIB structuring, desk research, interviews with market leaders, and analysis of survey data collected from rural households in Kenya. The target audiences of this brief are investors, financial intermediaries, multilateral/development finance institutions, outcome buyers, clean cooking companies, and other market players that have an interest in increasing the availability of clean cooking solutions, supporting inclusive businesses that are serving the base of the economic pyramid, addressing climate change, and advancing gender equality.

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*a All of this assessment’s procedures and protocols were approved by the Amref Health Africa Ethics and Scientific Review Committee (https://esrc.amref.org/eafq/) in Kenya, and all participants gave their informed consent prior to the collection of data.
Abbreviations and Acronyms

aDALY  averted disability-adjusted life year
ALRI  acute lower respiratory infection
CIB  Clean Impact Bond
COPD  chronic obstructive pulmonary disease
dFI  development finance institution
DIB  development impact bond
GHG  greenhouse gas
GS  Gold Standard for the Global Goals
HAPIT  Household Air Pollution Intervention Tool
IFC  International Finance Corporation
IHD  ischemic heart disease
LC  lung cancer
LPG  liquefied petroleum gas
LSM  Living Standards Measure
µg/m³  micrograms per cubic meter
N  sample size
PE  personal exposure
PM₁₀  particulate matter smaller than 10 microns in diameter
RBF  results based financing
SIB  social impact bond
SD  standard deviation
SDG  Sustainable Development Goal
SME  small and medium enterprise
WHO  World Health Organization

All dollar amounts are US dollars unless otherwise indicated.

Boxes, Tables, and Figures

List of Boxes
Box 1: The Impact of Traditional Cookstoves on Women and Girls
Box 2: Unlocking the Outcome Market Opportunity
Box 3: IFC’s Experience with RBFs
Box 4: aDALYS and Quality Time
Box 5: Biogas Technology
Box 6: Impact of Biogas on End-customers
Box 7: Time Use Agency
Box 8: Application of aDALYS

List of Tables
Table 1: Overview of the Main Parties Involved and Their Function
Table 2: Overview of Agreed Financial Terms and Conditions for the Clean Impact Bond
Table 3: The Health and Gender Co-benefits of Using Biogas for Cooking
Table 4: Key Metrics for Health and Gender Co-benefits
Table 5: Eligibility Criteria for Participating Households
Table 6: Time Use

List of Figures
Figure 1: Clean Impact Bond Structure
Figure 2: Financial Flows of the Clean Impact Bond
Figure 3: Process to be Certified Gold Standard
Figure 4: Schematic of Sample Sizes and Data Collection
Figure 5: PM₁₀ Exposure Monitor
Figure 6: HAPIT
Figure 7: PM₁₀ Exposure
Figure 8: Disease-Specific Contributions to Averted Deaths and DALYS
(Output from HAPIT tool)

List of Map
Map 1: Map of the Assessment Area
Introduction

Biodigester in a garden

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Clean cooking fuel, stoves, and related technology have great potential to improve households’ health and livelihoods, empower women, and reduce negative climate and environmental impacts. However, worldwide, more than 2.4 billion people lack access to clean cooking technology. Annually, this costs our society more than $2.4 trillion globally, driven by adverse impacts on health, climate, and gender equality, and contributes to 3.2 million premature deaths.\(^1\)\(^,\)\(^2\)\(^,\)\(^3\)

Clean cooking solutions\(^4\) (such as ones that use biogas, ethanol, liquid petroleum gas, or electricity) are proven solutions for addressing these problems in low-income countries; however, they are often too expensive for poor households. For this to change, business models to manufacture, sell, and/or distribute clean cooking solutions must be scalable. Unfortunately, lack of financing is a major barrier to scaling up the production of existing solutions. Research suggests that $25 billion is needed annually to achieve universal access to clean cooking by 2030 — yet only $133 million has been committed towards clean cooking investment.\(^5\)

To address the finance gap in producing clean cooking solutions for consumers at the base of the economic pyramid,\(^6\) Cardano Development, International Finance Corporation (IFC), and partners (BIX Capital, the Osprey Foundation, and Sistema.bio) launched the Clean Impact Bond (CIB) in 2022. This development impact bond (DIB) is designed to mobilize finance from a variety of partners to support scaling up the production of clean cooking solutions, by quantifying and selling health and gender co-benefits to outcome buyers (organizations that commit to purchasing development impacts such as gender equality and health benefits).

The fundamental objectives of the CIB are:
1) Provide a results-based finance (RBF) instrument to finance clean cooking solutions that achieve development impacts — improving health and women’s empowerment (health and gender co-benefits) — in the households that use these solutions.
2) Develop a replicable approach to monetizing health and gender co-benefits, in the same way that carbon credits are available to willing buyers.
3) Demonstrate the potential for health and gender outcome markets, which could attract development funders and impact investors that could provide financing to scale up the production of clean cooking solutions that low-income consumers can afford.

This learning brief, which shows how an innovative RBF instrument can be structured, illustrates how issuing and selling tradable and verifiable health and gender certificates can generate additional cash flow for the small and medium enterprises (SMEs) that manufacture and distribute clean cooking solutions (the underlying investees of the RBF instrument).

The brief summarizes the findings of a study assessing the measurable health and gender co-benefits from using a clean cooking biogas system. This study found that a biogas cooking system can reduce women's risk of illness from cooking-related air pollution, as well as increase time saved that women would spend on cooking-related tasks, which they can then spend on income generation and education.

This brief concludes with a summary of lessons learned from the CIB to inform future RBF projects and generate interest among key stakeholders, such as impact investors, outcome buyers, and the SMEs that manufacture, sell, and distribute clean cooking solutions.

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About the Clean Impact Bond (CIB):

The Clean Impact Bond DIB is a partnership among Cardano Development, IFC, BIX Capital, the Osprey Foundation, and Sistema.bio. BIX Capital, as the investor, provided upfront working capital financing in the amount of $300,000 to Sistema.bio, the cooking enterprise, which used the financing to scale up operations to reach low-income customers. Outcomes of the CIB aimed for an improvement in averted ill health and mortality, and an increase in women’s Quality Time\(^7\) through the use of the biogas digesters, provided by Sistema.bio to rural families across 10 regions of Kenya. The Osprey Foundation, as the outcome buyer, committed up to $500,000 to pay for health and gender outcomes after they had been independently verified and certified to have been achieved. The outcome payments from the Osprey Foundation will cover delivery costs of the CIB, including measurement, reporting, and verification, and the repayment of BIX Capital’s investment. The Clean Impact Bond was officially launched in 2022, when Cardano Development, the impact manager, and the Osprey Foundation signed an outcomes contract, and BIX Capital and Sistema.bio signed a loan agreement. The launch of the Clean Impact Bond was announced in Accra, Ghana, at the Clean Cooking Alliance’s Clean Cooking Forum in 2022.
Context
Despite the increased focus on Sustainable Development Goal 7 (SDG 7 - Affordable and clean energy), 2.4 billion people worldwide lack access to clean cooking. SDG 7 aims to achieve universal access to affordable, reliable, and modern energy services by 2030.

Annually, the lack of access to clean cooking costs more than $2.4 trillion, driven by adverse impacts on health, climate, and gender equality, and contributes to 3.2 million premature deaths. The lack of access to clean cooking is greatest in Sub-Saharan Africa, where only 10 percent of the population has access to such clean cooking systems. As a result, traditional cooking practices – using open fires or stoves fueled with wood, charcoal, or kerosene – are a major source of toxic air pollution.

Lack of financing hinders progress in scaling up the production of clean cooking solutions

Clean cooking appliances are in high demand in low-income countries, but their price point remains a barrier for low-income customers. This is due to challenges faced by the SMEs that manufacture and distribute these appliances. They cannot afford to scale up and produce their products for a lower price. These manufacturers usually neither earn enough to finance their expansions themselves, nor have access to affordable working capital, because they lack the credit history and collateral that lenders usually require. Of the $25 billion required annually to achieve universal access for clean cooking by 2030, only $133 million was committed by bilateral/multilateral development finance institutions (DFIs) and international donors, private capital sources, carbon markets, and multilateral climate funds in 2019. An innovative financing solution is required so that the clean cooking sector can access financing to enable expansion.

A development impact bond can mobilize finance for the clean cooking sector

Cardano Development, IFC, and partners launched the Clean Impact Bond (CIB) in 2022. It is a development impact bond (DIB) designed to mobilize finance from a variety of partners to scale up the production of clean cooking solutions, by quantifying and selling the health and gender co-benefits to outcome buyers (see Box 2). A DIB was chosen as the model for the CIB because it allows partners to focus on the outcomes that clean cooking solutions can generate, rather than paying for the inputs or outputs. Also, a DIB offers SMEs the working capital they need upfront.

The CIB is a results-based financing (RBF) instrument, which is an emerging solution that companies have begun using to provide energy and clean cooking access for underserved consumers in developing countries. RBF is a form of financing mechanism, and specific applications can evolve over time. Currently, RBF instruments include social impact bonds (SIBs), development impact bonds (DIBs), results-based climate finance, clean cooking funds, output-based aid, and social impact incentives. RBFs provide financial rewards to companies after they achieve agreed-upon and verified results. To test RBF mechanisms, IFC has partnered with stakeholders in both the modern energy cooking and the distributed renewable energy (DRE) sectors (see Box 3).
Box 2: Unlocking Outcome Market Opportunities

In recent years, the types of outcome markets available for the impacts of clean cooking have been evolving. The relevant ones include voluntary carbon markets, potential markets for social impacts, and capital markets where buyers are seeking environmental-, social-, and governance-related returns. Outcome buyers are the critical enablers for RBF instruments, because they will pay for the pre-agreed outcomes that companies commit to achieving. For example, it has been estimated that the volume of voluntary carbon credits will grow to $50 billion by 2030. Carbon buyers, which include corporations, donors, and foundations, are also interested in high-quality carbon projects that achieve social benefits (co-benefits) such as gender equality. However, work on gender outcomes is still at an early stage, because few projects have applied any of the available methodologies for assessing their gender impacts in a way that monetizes them in outcome markets. Since 2010, the market for impact bonds has been steadily growing. By early 2023, more than $460 million had been invested in 239 SIBs and DIBs in 39 countries. However, only 17 DIBs were issued in emerging markets. Thus, there is an opportunity to leverage these outcome markets to address the significant financing gap for businesses that produce and distribute climate-smart household appliances, including cookstoves, for low-income consumers. As noted, such financing could not only improve households’ health (SDG 3), but also advance gender equality (SDG 5).

Box 3: IFC’s Experience with RBFs

In 2018, IFC invested in BIX Capital, which provides financing for SMEs that manufacture or distribute clean cookstoves. These SMEs then repay their loans by selling the carbon credits that households generate by using their clean cookstoves. These transactions leverage the existing carbon market infrastructure. The outcome buyers of these carbon credits include governments and international organizations – such as the World Bank’s Carbon Initiative for Development (CI-Dev) – that operate in the compliance market as well as those that operate in the voluntary carbon market. Additionally, IFC is also developing a new verifiable and tradable Distributed Renewable Energy Certificate (D-REC) that will monetize the climate impact benefits from DRE projects, such as small solar home systems and off-grid solar, wind, and small hybrid projects.
The Clean Impact Bond
The CIB is a financial model that contributes to the wider use of clean cooking technologies through the following three objectives:

1) Provide an RBF instrument to finance clean cooking solutions that achieve important development impacts – improving health and women’s empowerment (health and gender co-benefits) – in the households that use these systems.

2) Develop a replicable approach to monetizing health and gender co-benefits, in the same way that carbon credits are available to willing buyers.

3) Demonstrate the potential for health and gender outcome markets, which could attract the development funders and impact investors that could provide the financing needed to accelerate scaling up the production of clean cooking solutions that low-income consumers can afford.

The CIB is the first global initiative to monetize the gender and health co-benefits of clean cooking solutions, alongside the more commonly available carbon credits. The CIB transaction structure has been successfully tested using existing carbon transactions in carbon markets, such as those that fall under the World Bank’s Ci-Dev and that provide a solid foundation for replication in health and gender co-benefits. Through the CIB, stakeholders provide financial support to the manufacturers and distributors of clean cooking solutions, by measuring and certifying the outcomes they create.

**Structure**

The CIB structure comprises five key roles, which are shown in Figure 1. These roles illustrate the five main parties and elements involved in the transaction:

A) **The impact manager**, which sells at a fixed price the so-called “development impacts” on health using a metric of healthy life saved called aDALYs and on gender using a metric of Quality Time (see the details in box 4) to an outcome buyer, to be delivered at the future date. Development Impacts are certified by standards such as Gold Standard.

B) **The investor**, which provides working capital for the cooking enterprise, based on the offtake agreement between the outcome buyer, the cooking enterprise, and the impact manager.

C) **The cooking enterprise**, which uses the loan to scale up and increase the sale of clean cooking solutions to low-income customers, and monitors the use of these at the customer level.

D) **The impact certifier**, which certifies the outcomes based on the certification framework that the impact manager and the cooking enterprise jointly develop per the guidance of the Gold Standard.

E) **The outcome buyer**, which pays for the certified outcome that the cooking enterprise uses to repay its loan.

**Figure 1: Clean Impact Bond Structure**

![Clean Impact Bond Structure Diagram]

**Box 4: aDALYs and Quality Time**

- The disability-adjusted life year (DALY) is a metric that combines years of life lost due to premature mortality and years of healthy life lost due to disability/ill health. The averted DALY (aDALY) metric comprises the amount of healthy life saved due to an intervention (including time spent free of illness and avoided premature death).

- Quality Time is the number of minutes per day that a woman spends on income generation, the production of goods that otherwise would be bought, education, rest, and/or leisure.

*Source: Adapted from Cardano Development 2021.*
# Partners

Beyond the five main parties, several partners were engaged to develop, launch, and operationalize the CIB. Table 1 outlines the main parties and the partners involved and their functions.

## Table 1: Overview of the Main Parties Involved and Their Functions

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact manager</td>
<td><strong>Cardano Development</strong> is an incubator and fund manager for innovative financial sector solutions that accelerate the sustainable development of financial and local capital markets in frontier economies.</td>
<td>Cardano Development initiates the CIB and supplies cash and in-kind funding for its development. Cardano manages the CIB.</td>
</tr>
<tr>
<td>Investor</td>
<td><strong>BIX Capital</strong> is an $18 million debt fund for SMEs in Sub-Saharan Africa that supplies low-income people with products that have a high development impact such as clean cooking solutions and water purifiers.</td>
<td>BIX Capital provides loans to Sistema.bio to fund its operations to manufacture and distribute domestic biogas digesters to target customers and refinancing to scale up Sistema.bio operations in Meru and Embu counties in Kenya.</td>
</tr>
<tr>
<td>Cooking enterprise</td>
<td><strong>Sistema.bio</strong> is a global supplier of biogas products that installs, services, and finances systems for smallholder farmers in Latin America, Asia and Africa.</td>
<td>Sistema.bio borrows working capital and uses the certified health and gender credits as collateral for its loan. Sistema.bio sells the gender and health co-benefits to the outcome buyer (the Osprey Foundation) via the impact manager.</td>
</tr>
<tr>
<td>Impact certifier (independent outcome evaluator)</td>
<td><strong>Gold Standard</strong> (for the Global Goals) is a non-governmental organization based in Switzerland that has developed a globally accepted set of standards for quantifying and certifying development impacts.</td>
<td>Gold Standard certifies the CIB's health (SDG 3) and gender (SDG 5) impacts, together with the CIB’s environmental impact (SDG 13).</td>
</tr>
<tr>
<td>Outcome buyer</td>
<td><strong>Osprey Foundation</strong> is a philanthropic impact investor based in the United States (US).</td>
<td>The Osprey Foundation purchases the health and gender credits based on the results, against the pre-agreed prices, and pays Cardano Development the pre-agreed purchase price for the respective aDALYs and SDG 5 Impact Statements.</td>
</tr>
<tr>
<td>Technical assistance provider and investor</td>
<td><strong>International Finance Corporation (IFC)</strong> – a member of the World Bank Group – is the largest global development institution focused on the private sector in emerging markets. IFC works in more than 100 countries, using its capital, expertise, and influence to create markets and opportunities in developing countries.</td>
<td>IFC invests in BIX Capital and advises on the CIB's design, collection, analysis, and reporting of the baseline data, which are used for impact certification.</td>
</tr>
<tr>
<td>Impact assessor</td>
<td><strong>Berkeley Air Monitoring Group</strong> is a US-based research company with expertise in assessing impacts of cooking energy transition programs in Sub-Saharan Africa and globally.</td>
<td>Berkeley Air Monitoring Group designs the baseline assessment, and gathers and analyzes the initial health and gender data in the project area in Kenya.</td>
</tr>
<tr>
<td>Carbon developer</td>
<td><strong>South Pole</strong> is a Swiss company that develops and implements carbon reduction projects and strategies worldwide.</td>
<td>South Pole is the project developer and owner of the Gold Standard-certified carbon project with Sistema.bio, and it purchases the carbon credits.</td>
</tr>
<tr>
<td>Advisor</td>
<td><strong>Shell Foundation</strong> is a United Kingdom-registered charity that supports people living in low-income communities to help them to escape poverty and other hardships.</td>
<td>The Shell Foundation provides strategic advice on the CIB’s design and preparations through the foundation’s Foreign, Commonwealth &amp; Development Office, and its Transforming Inclusive Energy Markets program.</td>
</tr>
<tr>
<td>Advisor</td>
<td><strong>Modern Energy Cooking Services (MECS)</strong> is a five-year program funded by UK Aid Direct with a mission to leverage investments in renewable energy by integrating modern energy cooking services into the planning for electricity access, quality, reliability, and sustainability.</td>
<td>MECS provides strategic advice and funding to support the development of the CIB.</td>
</tr>
<tr>
<td>Legal advisor</td>
<td><strong>Baker McKenzie</strong> is an international law firm that provides advice based on its sector expertise and local market knowledge.</td>
<td>Baker McKenzie reviews all of the CIB’s legal contracts (Loan Agreement, SDG Impact Purchase Agreement, Third Party Rights Agreement, and Security Assignment Agreement).</td>
</tr>
</tbody>
</table>

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14 CLEAN IMPACT BOND
Financial Flows and Terms

Figure 2 gives an overview of the CIB’s financial terms and conditions and provides a list of main parties and their roles in the financial flows of the CIB.

Figure 2: Financial Flows of the Clean Impact Bond

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**1 Investor**  
**BIX Capital**
- 1) A non-recourse loan by BIX Capital is disbursed to Sistema.bio. This loan is collateralized by the SDG Impact Purchase Agreement between the Osprey Foundation and Cardano Development.

**2 Borrower:**  
**Cooking Enterprise** (Sistema.bio)
- 2) Sistema.bio uses the BIX Capital funds to finance manufacturing and distributing biogas digesters to underserved, low-income customers.

**3 Impact Manager**  
**Cardano Development**
- 3) Sistema.bio’s operations generate aDALYs and SDG 5 Impact Statements through a program that is registered with Gold Standard.

**4 Outcome Buyer**  
**Osprey Foundation**
- 4) Cardano Development delivers the health and gender credits to the Osprey Foundation.

**6a On behalf of Sistema.bio, Cardano Development transfers the received purchase price, minus the agreed costs, to BIX Capital.**

**6b Cardano Development transfers the agreed costs, plus residual amounts (if any), to Sistema.bio, after the company’s full repayment of BIX Capital’s loan.**

**Impact Certifier**  
**Gold Standard** for the Global Goals
- Advisory services  
- Working capital loan  
- SDG 3 (Health) & 5 (Gender) credits  
- Impact payments

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Source: Adapted from Cardano Development 2021.
The Osprey Foundation purchases the health and gender co-benefits from Cardano Development.

- Price for health credits: $1,816/aDALY\textsuperscript{37}
- Price for gender credits: $1 per added Quality Hour\textsuperscript{38}
- Three-year contract
- Disbursed upon reaching the pre-agreed amount of credits

BIX Capital’s loan to Sistema.bio provides working capital.

- Gender and health benefit revenues are part of the collateral
- Three to four years
- Market-based interest rate
- Disbursement in tranches based on milestones related to distribution and program approval

Co-benefit Certification

The Clean Impact Bond utilized Gold Standard (for the Global Goals)\textsuperscript{39} to certify the CIB’s health and gender co-benefits. Gold Standard sets standards for climate and development interventions to quantify, certify, and maximize their impact, as well as stringent rules for stakeholder inclusivity. These standards, which create a platform for results-based financing, can be used by project developers and implementers (e.g., cooking enterprises) to assess the quality of their activities, as well as by donors to ensure that they invest in projects that meet their objectives. To make sure that funders are supporting real GHG emissions reductions, and verified SDG impacts, Gold Standard requires local stakeholder engagement; extensive documentation, including regular field data collection; and the use of independent, third-party auditors. Although originally focused solely on climate impacts through the reduction of carbon emissions (SDG 13), Gold Standard expanded its services in 2017 to provide standards and methodologies for measuring and certifying the impacts of SDGs related to improving health, gender equality, clean water, and renewable energy.

Certification Process

Figure 3 describes the basic process by which health and gender certificates are created for sale and trading (only for aDALYs) using the Gold Standard for the Global Goals.

Figure 3: Process to Be Certified Gold Standard\textsuperscript{40}

Source: Adapted from Gold Standard.
Quantifying and Measuring Health and Gender Outcomes
A key aspect of making the CIB feasible is capturing measurable evidence of biogas users’ health and gender outcomes that can be sold to outcome buyers. To obtain Gold Standard’s certification of these outcomes for the CIB, an assessment was required to estimate the health and gender outcomes, by comparing the difference between the “business as usual” or baseline scenario (cooking predominantly with wood, charcoal, or kerosene), and the project scenario (cooking with biogas produced by a Sistema.bio digester).

With support from the Government of Japan and the Osprey Foundation, IFC and Cardano Development commissioned the baseline assessment to measure and quantify the health and gender co-benefits from using biogas (see Box 5). The goal was to use Gold Standard’s methodologies to translate these co-benefits into clearly certifiable outcomes. (For the methodology of the research, metrics used to measure co-benefits as well as the detailed results of the assessment, see the Appendixes.)

The key outcomes assessed in the baseline assessment were female cooks’ health and Quality Time:

- **Health:** Through use of a biogas stove, averted ill health and mortality (associated with reducing cooks’ exposure to PM$_{2.5}$) were estimated.
- **Gender:** Through use of a biogas stove, an increase in the time cooks spent on productive tasks and/or rest and leisure (“Quality Time”) was measured.

**Key Findings**

The assessment confirmed that the health and gender co-benefits of using biogas for cooking are measurable and noticeably positive (see Table 3). It is worth noting that these results fall within the same range as they did in another similar study that was conducted by the World Health Organization, suggesting the need to address other sources of air pollution in order to maximize health benefits.

**Health**

The personal exposure data gathered in this assessment were appropriate for certifying a positive health outcome. Measured personal exposure to PM$_{2.5}$ decreased to a range that can be associated with appropriate for certifying a positive health outcome. Measured personal exposure to PM$_{2.5}$ decreased to a range that can be associated with evidence of biogas users’ health and gender outcomes that can be sold to outcome buyers. To obtain Gold Standard’s certification of these outcomes for the CIB, an assessment was required to estimate the health and gender outcomes, by comparing the difference between the “business as usual” or baseline scenario (cooking predominantly with wood, charcoal, or kerosene), and the project scenario (cooking with biogas produced by a Sistema.bio digester).

**Lower PM$_{2.5}$ Exposure:** The personal exposure to PM$_{2.5}$ of female cooks in the project scenario (“biogas-using households”) was 68% lower than in the baseline scenario (“biomass-using households”), averaging 113 µg/m$^3$ in biomass-using households, versus 36 µg/m$^3$ in biogas-using households.

**Healthy Life Gains:** The reduction in personal exposure to PM$_{2.5}$ of approximately 77 µg/m$^3$ was estimated to avert 578 disability-adjusted life years (DALYs) and 16 deaths per year for every 10,000 homes with a biodigester; in other words, for an average household, each year of biodigester use would be expected to yield an additional 21 days of healthy life, spread across the lifetimes of the household’s members.

Although exposure to PM$_{2.5}$ was lower for the biogas-using households than the biomass-using households, the reduced exposure level still exceeds the latest guidelines for global PM$_{2.5}$ air quality established by the World Health Organization, suggesting the need to address other sources of air pollution in order to maximize health benefits.

**Gender**

This assessment is one of the first to define and quantify the gender outcome of a clean cookstove intervention by using shifts in time use toward productive and/or restful activity. If women’s saved time is used for more unpaid care work, saving time will not likely lead to improvements in gender equality and women’s empowerment. Conversely, a shift from lower-valued to higher-valued activities in terms of income generation may achieve these benefits.

The assessment’s quantification of the gender equality outcomes of biogas technology was successful.

**Time savings:** The female cooks in biogas-using households in the project scenario spent less time, on average, on cooking and fuel-related activities than was the case with female cooks in biomass-using households in the baseline scenario, accounting for a total of 99 fewer minutes per day across the assessed activities.

This amount was more than the estimate in some other studies on cookstove use, but well within the range of time savings observed in other settings associated with biogas adoption. Saving time has been reported in several studies on improved cookstoves and Sistema.bio’s staff report that customers frequently state that saving time is a key benefit of using biogas.

**Quality Time:** When female cooks’ Quality Time was assessed, it showed that the biogas-using households in the project scenario spent an average of 47 more minutes of Quality Time per day (285 hours – or approximately 12 days – of Quality Time per year) than the biomass-using households in the baseline scenario.

This finding is a novel contribution to the literature on the time-use benefits achieved when women cook with improved cookstoves. The few studies that have attempted to measure increases in women’s productive time and/or rest and leisure when women use improved cookstoves have shown both positive and negative results. However, prior to this study, the “Quality Time” metric was not assessed.

“Since I prepare every meal using the biogas stove, the time spent looking for other fuels like firewood is less.” — Biogas-using participant
Box 5: Biogas Technology

Biogas is a primarily methane-based byproduct when livestock manure breaks down in biodigester systems. To provide households with this clean gas for stoves, water heaters, and other appliances, biogas is transferred from the biodigester via a system of pipes. Biodigesters also produce organic fertilizer that can be used to improve soil for farming.

A technical platform to convert waste to household energy

- Durable
- Easy to install
- Diversity of sizes
- Modular
- Easy maintenance

- Single burner cooker
- Double burner cooker
- Water heater
- Chaff cutter
- Milking machine

About 25 percent of the Kenyan population could benefit from the use of biogas technology, yet total market penetration is well below 1 percent of that addressable market.

Sistema.bio’s biogas systems ingest climate-damaging animal waste, capture the gas, and deliver the gas to household burners, where it can be used to cook food and heat water in place of traditional climate-damaging biomass fuel. See Box 6 for the impact of biogas on end-customers. Below illustrates the pathways through which biogas interventions produce the co-benefits for health and gender.

Theory of change

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Activities</th>
<th>Outputs</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock</td>
<td>Biodigesters are installed</td>
<td>Reduced exposure to health damaging pollutants such as particulates and carbon monoxide</td>
<td>Reduced mortality and morbidity from respiratory infections, lung cancer, stroke, heart disease and COPD</td>
</tr>
<tr>
<td>Water</td>
<td>Households are trained in manure management</td>
<td>Faster cooking, Easier cooking, Reduced need to procure fuel</td>
<td>Women have more time for productive activities and rest/leisure, Women’s time poverty and drudgery reduced, Men more inclined to use gas technology.</td>
</tr>
<tr>
<td>Land</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Image Source: Adapted from Sistema.bio and World Bank, 2023.
### Table 3: Health and Gender Co-benefits of Using Biogas for Cooking

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Achieved per biogas stove, per year</th>
<th>Certified SDG contribution with the Clean Impact Bond</th>
<th>Impact value: dollars generated per stove installation, per year (see Table 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Averted disability adjusted life years (aDALYS)</td>
<td>21.2 days (about three weeks) of healthy life added to the household per year of biodigester use</td>
<td>SDG 3 (0.058 aDALYS per household, per year)</td>
<td>$105 per household, per year</td>
</tr>
<tr>
<td>If the CIB supports the sale of 12,000 stoves, this would contribute 696 aDALYS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in women’s time used for productive tasks and/or rest/leisure, “Quality Time.”</td>
<td>285 hours (about 12 days) of Quality Time added for women and girls in the household</td>
<td>SDG 5: 285 productive hours of Quality Time freedup for the female cook per household, per year</td>
<td>$285, per household, per year</td>
</tr>
<tr>
<td>If CIB supports the sale of 12,000 stoves, this would result in the addition of 3,420,000 productive hours</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For the key outcomes and metrics related to health and gender co-benefits, see Table 4 and the Metrics and Standards section in the Appendix.

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b Projected number of customers added and included in the DIB (for three years).
Box 6: Impact of Biogas on End-customers

The biogas customers surveyed in this study expressed a high degree of satisfaction with biogas as a cooking fuel. They emphasized the ease and speed of cooking with biogas, and they appreciated feeling less pressure to find and prepare firewood. This is consistent with other studies, which show that biogas is a popular household energy choice in rural areas. However, biogas technology can present challenges too, which relate to functionality and adoption. To address these potential barriers, Sistema.bio has conducted extensive field monitoring and financed third-party evaluations. For example, 60 Decibels collected data from 278 Sistema.bio customers in Kenya in January and February 2022. This evaluation found that 92 percent of the customers reported saving money with their biogas system, and 88 percent reported improvements in their quality of life. However, some respondents expressed concerns about affordability, the payment plans offered, and how quickly technicians responded to requests for help. Sistema.bio has used this feedback to adjust its payment models, speed up technicians’ response times, and train users to avoid common biosystem problems.

Table 4: Key Metrics for Health and Gender Co-benefits

<table>
<thead>
<tr>
<th>Co-benefit</th>
<th>Outcomes</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>Averted disability adjusted life years (aDALYs)</td>
<td>• Personal exposure to PM$_{2.5}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Population demographics (e.g. household size, number of children under 5, and national background disease rates)</td>
</tr>
<tr>
<td>Gender</td>
<td>Increase in women’s time used for productive tasks and/or rest/leisure, which together are termed “Quality Time”</td>
<td>• Time spent actively cooking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Time spent cleaning utensils and the kitchen area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Time spent procuring and preparing fuel for use in the stoves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Proportion of women’s time engaged in income-generating tasks or rest and leisure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Use of any saved time (biogas-using households only)</td>
</tr>
</tbody>
</table>

“Before getting a biogas system, I spent a lot of time searching for wood and dry leaves to burn in the fire. But now I waste no time preparing a cooking fire. Also biogas cooks faster.”

– Biogas-using participant
Sistema.bio’s technicians visiting a farm for a biodigester installation, Kericho, Kenya 2019. Copyright © Sistema.bio
Lessons Learned

Several lessons were learned from developing and structuring the CIB, and opportunities were identified for improving the design of future RBFs. The key lessons learned were the importance of: establishing effective partnerships to structure the RBF; designing the RBF so that it reaches targeted underserved customers; and effectively assessing, validating, and certifying the gender and health outcomes.
1. Establish effective partnerships to structure the RBF

i) Focus on funders and/or donors as outcome buyers that are open to innovation and have a strong interest in supporting projects with social outcomes.

What we expected: Identifying outcome buyer(s) to purchase health and gender credits that also generate health and gender co-benefits. Now that the potential health and gender benefits of clean cooking solutions have been demonstrated, donors and funders could be persuaded to invest in RBFs that deliver these benefits, rather than just donate money.

What actually happened: Because health and gender outcomes from clean cooking solutions had never been transacted before, this initiative proved to be too innovative for many funders/donors. Measuring the indirect health outcomes of clean air required their climate and health departments to internally collaborate. Also, funders/donors usually have long-term programs, so it takes several years for them to add a new program to their budget. Funders/donors with a commitment and openness to innovative approaches to expand health and gender outcomes showed the greatest interest.

Lessons for the future: Focus on emerging outcome buyers such as foundations, corporations, bilateral donors, and multilateral development banks with a strong interest in supporting projects with social outcomes (including health improvement and gender equality), including existing carbon buyers that are seeking high-quality carbon credits that also generate health and gender co-benefits. Now that the potential gender and health benefits of clean cooking solutions have been demonstrated, donors and funders could be persuaded to invest in RBFs that deliver these benefits, rather than just donate money.

ii) Engage with committed and flexible partners.

What we expected: This pioneering transaction would require learning by doing, and flexible adjustment during implementation.

What actually happened: As expected, implementing the CIB pilot required a good deal of patience and persistence, a long-term perspective, and sufficient resources from all stakeholders involved. Fortunately, the CIB’s partners were strongly committed to launching an innovative financing market that could generate public good. The CIB team was also flexible with regard to the type of outcome buyers, and the types of SDG outcomes to be sold, such as Energy access (SDG 7) and Life on land (SDG 15).

Lessons for the future: Engage with committed and flexible partners and donors when structuring an RBF. It is also key to keep all parties engaged by celebrating small wins, acknowledging partners’ commitments in public, encouraging ownership of the tasks led by each organization, and embracing innovation that takes determination for partners involved in an RBF.

iii) Work with enterprises/project implementers that are at the appropriate stage of business development and meet key criteria.

What we expected: Identifying the enterprise that could implement the RBF project would be straightforward, as long as it could meet operational and technical criteria including appropriate clean technology solutions to reach target customers under the RBF.

What actually happened: The investor/project developer approached cookstove producers and/or distributors in a variety of countries; the producers used different clean cooking solutions and were in various stages of business development. Some of the enterprises did not have the capacity to implement the RBF, and others were so mature that they did not need the RBF funding to scale up their operations.

Lessons for the future: Select enterprises/project implementers that are at the appropriate stage of business development and that meet key criteria beyond technology, especially in the following areas:

a. Business sustainability: The chosen enterprise should have a strong track record of providing effective, high-quality, and responsive services for its customers, as well as a good financial track record. Enterprises should be operational, have established business goals, and have financing secured to support these goals, so that it is not necessary for the company to depend on the RBF for its initial cash flow. The ideal choices are enterprises that are relatively mature but that still need RBF funding to scale up.

b. Additionality, scalability, and impact: The RBF funding should stimulate the type and scale of outcomes envisaged by the project implementer and also leverage private investment. The funding should also increase the breadth and depth of the project implementer’s impact, particularly for underserved segments.

c. Allow a longer start up period and bring in all project parties early on, so they can budget upstream time and resources.

What we expected: The CIB team initially expected a one-year preparation phase.

What actually happened: Getting more than eight parties on board, and especially the outcome buyer, took about two and a half years (though the COVID-19 crisis played a big role in the delay) and required a lot of stakeholder management, affecting the allocation of staff, time, and funding resources.

Lessons for the future: Expect the mobilization of outcome buyers for an innovative transaction to take a good amount of time. Allocate adequate time, upfront, to define the roles and responsibilities of each partner, establish an effective framework, align incentives for all stakeholders, and negotiate the project’s terms and conditions. Stakeholders need to understand the challenges involved in operating in impoverished, rural areas, and be willing to accept that this could impact the project’s timeline and financing.
2. Design the RBF so that it reaches targeted underserved customers

i) Develop a more sustainable and cost-effective approach while keeping the transaction costs low.

What we expected: Structuring an RBF using health and gender credits would require a variety of resources and support from different partners.

What actually happened: Because this development impact bond was a pilot, the transaction costs for assessing the health and gender co-benefits were nearly half of the transaction’s total costs, exceeding the expectations of what would be required. These were covered by the CIB’s various partners, including Cardano Development, IFC, and the Osprey Foundation.

Lessons for the future: Develop a more sustainable and cost-effective approach. When the impact bond scales up, a cost-effectiveness analysis should be conducted to compare the costs of implementing the bond with its expected outcomes. Ways to cut costs include using technology that enables households to measure and monitor their household air quality themselves and developing a module for training local consultants to implement Gold Standard’s methodologies. The World Bank recommends reducing transaction costs by combining field work activities (such as data management, logistics and training sessions for enumerators) when the project is pursuing multiple co-benefits. Although the cost of setting up the RBF is high, as the market develops and the transactions become larger, transactions’ assessment costs should decline, and more of the costs could be included in the transaction itself.

ii) Work with partners to set the right outcome targets and funding level for the health and gender co-benefits.

What we expected: An important element of the RBF was setting the funding level for outcome targets of the health and gender co-benefits. For health, the aDALY calculation was an outcome quantification tool widely used for primary health care and poverty-related diseases such as malaria, HIV AIDS, and tuberculosis. For gender, setting the outcome targets and funding level required a new calculation for the clean cooking sector. The CIB team expected that this would be the area that required extensive thinking and appropriate expertise.

What actually happened: For health, in order to set an appropriate funding level for the CIB, the team used per capita gross domestic product – a benchmark that changes, annually. For gender, it was generally accepted that “time saving and quality time” is one of the best indicators in this context. To set fair and reasonable outcome targets and the funding level, the CIB team referred to various studies that explored setting a value on women’s time overall, and existing RBFs that used the W+ Standard (the first women-specific standard that measures women’s empowerment) created by the Women Organizing for Change in Agriculture and Natural Resource Management (WOCAN), and Gold Standard’s gender methodology. The team also obtained advice from gender experts in the World Bank Group and the Clean Cooking Alliance. (See Box 7 for findings from the World Bank’s new study on time-use agency to measure women’s empowerment and the multidimensional impact of cookstove adoption.)

Lessons for the future: Identify the right partners early on and collaborate with them to set the right outcome targets and funding level for the health and gender co-benefits. The experience we gained through this CIB would be a useful guide for future RBFs.

iii) Integrate health and gender certification with the existing carbon reduction component from the outset.

What we expected: Adding health and gender outcomes to the existing carbon transaction might add more complexity for buyers, project developers, and cooking enterprises.

What actually happened: Throughout the transaction, the team found that the added complexity was offset by the advantages that health and gender co-benefits added, including allowing the enterprise to diversify the source of income (e.g., working capital) and mitigate the risks of carbon price volatility.

Lessons for the future: Integrate health and gender certification with the existing carbon reduction component from the outset because health and gender certifications provide added value. Safeguarding the cooking enterprise’s ownership of the health and gender outcomes needs to be carried out together with the carbon waiver.

Box 7: Time Use Agency

A new study, “Building Evidence to Unlock Impact Finance: A Field Assessment of Clean Cooking Co-Benefits for Climate, Health, and Gender,” which the World Bank conducted with Sistema.bio in 2022, found that, in addition to time use changes (such as time saving, Quality Time), time-use agency (for example, satisfaction with the time available for rest/leisure) is effective for measuring women’s empowerment and the multidimensional impact of cookstove adoption. Although there were no validated tools to assess the time-use agency, and the results of the World Bank’s field survey were not available when the CIB was being developed, the CIB team recommends incorporating this finding into the future project design and the indicators used to measure the gender co-benefit.
3. Effectively assess, validate, and certify the gender and health outcomes

i) Design indicators that balance the costs and feasibility of data generation and verification, while remaining robust.

What we expected: The costs and choice of methodologies in gathering and verifying the relevant data would pose challenges.

What actually happened: To ensure accurate and robust results when assessing the health and gender co-benefits of cooking with biogas, the CIB chose Gold Standard’s widely recognized methodologies which were also aligned with the requirements of the outcome buyer.

Lessons for the future: Design indicators that balance the costs and feasibility of data generation and verification, while remaining robust in terms of data collection or the quality of indicators. The key outcome metrics should not be complex, because such metrics generally tie repayment to measurable outcomes.

ii) Balance measurement rigor and the costs of measurement.

What we expected: Per Gold Standard’s methodology, the baseline assessment aimed to enroll lower-income, biomass-using households that are representative of the CIB’s future target beneficiaries, which would gain access to biogas technology thanks to additional financial incentives provided by the CIB.

What actually happened: This goal necessitated stringent inclusion criteria, such as low liquefied petroleum gas (LPG) use, which led to more screen-outs and thus a longer-than-expected recruitment phase to onboard both biogas-using households and biomass-using households.68

Lessons for the future: For future studies, balance the value of maximizing the representativeness of the baseline study’s participants with the extra cost of recruiting them.

iii) Clearly define the targeted underserved population and their selection criteria at the outset.

What we expected: The CIB team expected that defining the list of customers and the control group for the baseline data collection would be straightforward and executed in a short period of time.

What actually happened: This assessment reached its findings only after considerable discussion about the characteristics that would be the most suitable to match the low-income households that will be targeted in future results-based financing efforts.

Lessons for the future: Prior to launching an assessment for impact quantification, clearly identify the target population’s definition and inclusion criteria—their socioeconomic characteristics as measured by the Living Standards Measure, LPG/stove/fuel use, income level, and ownership of assets.

“Since I installed the biogas, cooking has been so easy, and faster, creating time for other work.” – Biogas-using participant
Conclusion

With less than a decade remaining to achieve the 2030 Sustainable Development Goals, financing solutions that help achieve universal access to clean cooking – as well as gender equality and health improvements – must be accelerated.

In recent years, the types of outcome markets for the impacts of clean cooking have been growing. These outcome markets include voluntary carbon markets; potential markets for social impact; and capital markets where buyers are seeking environmental, social, and governance-related returns. The Clean Impact Bond’s model presents possible avenues for leveraging these markets. The outcome markets represent additional sources of capital that the private sector can use to facilitate access to clean cooking solutions for the underserved, particularly women at the base of the pyramid (BOP).

In conclusion, the authors of this brief hope that it will spur future results-based financing projects; generate interest among outcome buyers, SMEs, and impact investors; and encourage stakeholders across the world’s markets to go beyond “business as usual” and be spurred to unlock financing opportunities for those reaching the world’s underserved.
Appendixes

Carrying firewood

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A. Methodology of Baseline Assessment

Assessment Design

The assessment design was cross-sectional and carried out with two groups of participants to compare the project scenario with the baseline scenario. The households assessed in this study were in Meru, Embu, and Tharaka Nithi counties (see Map 1) in rural Kenya, where Sistema.bio has approximately 700 biodigester customers. This is a productive region where farmers grow cash crops that include tea, miraa/khat, and bananas. They also grow vegetables and raise livestock."
Sampling Strategy

The biogas-using households (“biogas-using households”) in the project scenario were randomly selected from the sales lists of Sistema.bio, and the biomass control households (“biomass-using households”) in the baseline scenario were randomly selected from a list of households that share key demographic characteristics with the CIB’s target population for future biogas system sales. Table 5 lists the eligibility criteria for both the biogas-using and biomass-using households. The photograph below shows the stove types commonly used by the biomass-using households, as well as Sistema.bio’s biogas stove.

A total of 126 biogas-using households in the project scenario and 115 biomass-using households in the baseline scenario participated in this assessment. This met Gold Standard’s minimum for sample sizes—100 households for the survey, and 30 for monitoring personal exposure to fine particulate matter (PM$_{2.5}$).

Socioeconomic Characteristics of Participants

According to the Living Standards Measure (LSM), both the biomass-using households in the baseline scenario and the biogas-using households in the project scenario rank as “lower middle class” in Kenya. The biomass-using households’ average LSM of 153 puts them in Group 7 of the 12 LSM groups ranked in Kenya, whereas the biogas-using households’ average LSM of 224 places them two levels higher, in Group 9. Both groups’ demographics were well matched on age, household size, children under age 5, and marital status. However, on average, along with a lower score on the LSM, the biomass-using households in the baseline scenario had less education, fewer jobs outside the home, and a lower income from casual labor/salaried work.

Table 5: Eligibility Criteria for Participating Households

<table>
<thead>
<tr>
<th>Biogas-using Households</th>
<th>Biomass Control/Biomass-using Households</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Sistema.bio biogas system installed at least 6 months prior (earlier than March 2021)</td>
<td>• Household has interest in installing a biogas digester, and access to sufficient land and water to support it</td>
</tr>
<tr>
<td>• Not delinquent on payments for the biogas system (to avoid a high refusal rate in this group)</td>
<td>• Household has sufficient livestock to feed a biogas digester (minimum 2 cows, 16 pigs, or a combination of livestock, or the intent to expand their livestock sufficiently)</td>
</tr>
<tr>
<td>• No household members are employed by Sistema.bio</td>
<td>• No household members are employed by Sistema.bio</td>
</tr>
<tr>
<td>• Household does not use its stove primarily for commercial cooking</td>
<td>• Household does not use its stove primarily for commercial cooking</td>
</tr>
<tr>
<td>• Household has no plans to relocate during the data gathering time frame</td>
<td>• Household has no plans to relocate within the data collection window</td>
</tr>
<tr>
<td>• Participant is female and the main cook for the household, age &gt; 18</td>
<td>• Participant is female and the main cook for the household, age &gt; 18</td>
</tr>
<tr>
<td>• Participant does not smoke (if selected for personal exposure - PE)</td>
<td>• Participant does not smoke (if selected for PE)</td>
</tr>
<tr>
<td>• Not cooking for an atypical event/large gathering during PE</td>
<td>• Not cooking for an atypical event/large gathering during PE</td>
</tr>
<tr>
<td></td>
<td>• Household does not use LPG or household uses LPG less than seven times per week</td>
</tr>
<tr>
<td></td>
<td>• Participant age and household size within the range of biogas customers</td>
</tr>
</tbody>
</table>

Note, In Phase II, participants also did not have chimneys and did not cook outside.

Data Collection

Recruitment and data collection were conducted in two phases – from September through November 2021, and April through June 2022 – and both phases included dry and rainy months (see Figure 4).

Two main types of data were collected for this assessment. First, a household survey was conducted with all participants to gather data on the primary metric for measuring the gender outcome – Quality Time. As previously noted, this is time spent on income generation, producing goods that otherwise would be bought, education, rest, and/or leisure. The survey also collected demographic information, assessed typical stove and fuel use, and explored time spent on cooking-related tasks (including fuel acquisition, fuel preparation, biodigester maintenance, food preparation, cooking, and cleanup).

Second, a subset of both groups in the assessment was randomly selected to estimate the health outcome by measuring cooks’ personal exposure to fine particulate matter (PM$_{2.5}$). Personal exposure measurement was conducted using a gravimetric PM$_{2.5}$ sampler, which is a small portable device that participants wore in a custom-designed apron (see Figure 5). For details on the health measurement methodology, see the Health section under Metrics and Standards.
Figure 4: Schematic of Sample Sizes and Data Collection

<table>
<thead>
<tr>
<th>Biogas-using households</th>
<th>Biomass-using households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer list provided by Sistema.bio (n=250)</td>
<td>Customer list provided by Sistema.bio (n=250)</td>
</tr>
<tr>
<td>Randomly selected customer HH (n=125)</td>
<td>Exposed to HH survey (n=125)</td>
</tr>
<tr>
<td>Exposure monitoring (n=50)</td>
<td>Exposure monitoring (n=50)</td>
</tr>
<tr>
<td>Phase I (September - November 2021)</td>
<td>Phase I subset</td>
</tr>
</tbody>
</table>

Phase II (April - June 2022) (N/A)

Included in analysis:
- All biogas project households;
- Biomass control households meeting baseline definition (target of N=100 for survey and N=30 for exposure monitoring)

Figure 5: PM$_{2.5}$ Exposure Monitor

How to measure exposure to PM$_{2.5}$ using gravimetric PM$_{2.5}$ samplers (UPAS)

1. Forty-eight-hour deployment of the ultrasonic personal aerosol sampler (UPAS) personal air pollution monitor (measures PM$_{2.5}$)
2. PM$_{2.5}$ collects on a filter and must be pre- and post-weighted at the same facility.

Note: All fieldwork was done under strict COVID-19 protocols.

Stove Use

Survey data on stove use in assessment participants’ households showed that 121 of the 126 biogas-using households (96 percent) in the project scenario used a biogas stove as their primary stove, but 94 (75 percent) also reported using a biomass stove (wood or charcoal) as a secondary or tertiary stove, and 23 (18 percent) reported using an LPG stove as well. As expected, all of the participants in the biomass-using households (115) in the baseline scenario reported using a biomass stove as their primary stove.
B. Metrics and Standards

Health

Gold Standard’s methodology for assessing the health improvements from household energy interventions relies on field measurements of exposure to fine particulate matter ($\text{PM}_{2.5}$), and the known epidemiologic relationships between $\text{PM}_{2.5}$ exposure and a number of negative health outcomes—lung cancer, ischemic heart disease, strokes, chronic obstructive pulmonary disease, and acute lower respiratory infections. The health outcome of a particular intervention (such as a biogas system) is estimated by using the Household Air Pollution Intervention Tool (HAPIT) (see Figure 6) that applies a combination of measured and default parameters to estimate ill health averted by the intervention, which is quantified as averted deaths and averted disability-adjusted life years (aDALYs) (see Box 8).

Box 8: Application of aDALYs

The disability-adjusted life year (DALY) is a metric that combines years of life lost due to premature mortality and years of healthy life lost due to disability/ill health. The averted DALY (aDALY) metric comprises the amount of healthy life saved due to an intervention (including time spent free of illness and avoided premature death. Using aDALYs to quantify the health outcome in the target population is more practical than attempting to measure the actual health outcome. The aDALY metric facilitates easy comparison of the health outcomes across many different types of interventions—for example, comparing the impact of a sanitation program with a clean cooking intervention.

Figure 6: HAPIT

The HAPIT tool estimates ADALYs:

http://householdenergy.shinyapps.io/hapit3/

Inputs: $\text{PM}_{2.5}$ exposure reductions, lifespan of the intervention, the number of homes targeted, and the percentage of homes using the intervention.

Applies integrated $\text{PM}_{2.5}$ exposure-risk curves for: acute lower respiratory infections, chronic obstructive pulmonary disease (COPD), ischemic heart disease, lung cancer, and stroke.

Aggregates impact into averted disability-adjusted life years (DALYs), a metric that combines years of life lost to death, and years of healthy life lost due to illness.

Gender

The Gold Standard Gender Equality Requirements & Guidelines have two components: the Gender-sensitive Requirements (mandated for all Gold Standard-certified projects) and the optional Gender-responsive Guidelines. Sistema.bio met the Gender-sensitive Requirements by documenting female cooks’ benefits from using a biogas system and building women’s capacity to sell biodigesters in Kenya. The Gender-responsive Guidelines require program developers to create their own specific gender methodology based on the hypothesized gender outcomes of their project. As of August 2022, only one project (the Lango Safe Water Project in Uganda) had applied Gold Standard’s Gender-responsive Guidelines.

For the CIB, the team developed the gender outcome metric Quality Time because there is no standard metric to measure the gender outcome resulting from cookstove adoption. In line with Sistema.bio’s observation and Gold Standard gender methodology (Gold Standard Gender-responsive Guidelines), this captured the extent to which biogas use progressed households toward achieving SDG 5. It served as the primary outcome metric for the gender outcome that captured the redeployment of women’s saved time on productive and/or valued activities (see Box 7 in the main report for findings from a new study on time use agency to measure women’s empowerment and the multidimensional impact of cookstove adoption).

Quality Time is the number of minutes per day that a woman spends on income generation, the production of goods that otherwise would be bought, education, rest, and/or leisure.

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C. Outcome Results

This section features more details on the outcome results of health and gender co-benefits under the baseline assessment.

Health

- The personal exposure to PM$_{2.5}$ of female cooks in biogas-using households was 68% lower than in biomass-using households (averaging 113 μg/m$^3$ in biomass-using households, versus 36 μg/m$^3$ in biogas-using households).
- The reduction of personal exposure to PM$_{2.5}$, at approximately 77 μg/m$^3$, was estimated to avert 578 disability-adjusted life years (DALYs) and 16 deaths per year for every 10,000 homes with a biodigester, or 21 days of healthy life added to each household per year.

Interpretation of the health result

The exposure to PM$_{2.5}$ was lower in female cooks in biogas-using households in the project scenario than in female cooks in biomass-using households in the baseline scenario. On average, PM$_{2.5}$ exposure was 113 micrograms per cubic meter (μg/m$^3$) in the biomass-using households in the baseline scenario, and 36 μg/m$^3$ in the biogas-using households in the project scenario, accounting for a difference of 77 μg/m$^3$, or a 68 percent reduction in exposure between the two groups (see Figure 7). When this difference in average PM$_{2.5}$ exposure was translated into estimates of averted ill health (see Figure 8) using the Household Air Pollution Intervention Tool (HAPIT) ($^*$) (see Figure 6), this assessment found that, per year, for every 10,000 homes using a biogas system, 16 deaths (4 for children + 12 for adults) would be averted, and the total for averted disability-adjusted life years would be 578 (309 for children + 269 for adults). This is equivalent to 0.016 averted deaths, and 0.058 aDALYs per household, per year, respectively. Also, overall, more than half of the ill health averted would accrue to children under age 5, because they would have fewer acute lower respiratory infections.

The Gold Standard aDALY methodology stipulates that the 90 percent confidence interval’s margin of error of the sample should be less than 30 percent of the mean. (It does not require statistical significance.) All values are less than 30 percent, meeting this guideline.
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Averted ill-health due to the proposed intervention. Each panel represents a specific health measure. Lightly shaded bars are the total avertable ill-health by an intervention that has perfect usage and reduces exposures to the counterfactual. Estimates of ill-health assume that each year of exposure reduction provides five years of benefit.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Age</th>
<th>Mean Averted</th>
<th>Minimum Averted</th>
<th>Max Averted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Averted DALYs</td>
<td>Child</td>
<td>309</td>
<td>224</td>
<td>356</td>
</tr>
<tr>
<td>Averted Deaths</td>
<td>Child</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Averted DALYs</td>
<td>Adult</td>
<td>269</td>
<td>133</td>
<td>350</td>
</tr>
<tr>
<td>Averted Deaths</td>
<td>Adult</td>
<td>12</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

Panels represent different measures of averted ill health. Darkly shaded areas are the mean amount of averted ill health by disease type, and the lightly shaded areas are what could be avertable by a “perfect” intervention. ALRI is acute lower respiratory infection, COPD is chronic obstructive pulmonary disease, IHD is ischemic heart disease, and LC is lung cancer.

Based on available literature, we initially expected to see slightly higher personal exposure to PM$_{2.5}$ in this assessment. For example, PM$_{2.5}$ exposures for women using traditional stoves in Rwanda were reported at 223 μg/m$^3$, and a systematic review by Pope et al. (2017) of household air pollution found most studies reported traditional biomass user groups had means above 200 μg/m$^3$.

The assessment found that air quality was much cleaner than originally anticipated. For example, the results show 36 μg/m$^3$ for the biogas-using household group, and 113 μg/m$^3$ for the biomass-using household group. These findings are very encouraging from a health standpoint. However, the lower exposure level in the baseline scenario for the biomass-using household group means that the transition from cooking with traditional biomass methods to cooking with biogas had a smaller impact on health than expected.

“A perfect” intervention is defined by HAPIT as one that reduces exposures to the counterfactual of 7 μg/m$^3$, and is used for 100 percent of cooking (7 μg/m$^3$ was selected based on the 2010 Global Burden of Disease counterfactual estimate; in 2021, the World Health Organization (WHO) guideline for ambient air pollution exposure was revised downward to 5 μg/m$^3$).
**Interpretation of the gender result**

This assessment found that in comparison to the biomass-using households’ cooks in the baseline scenario\(^2\), cooks in biogas-using households in the project scenario reported spending less time on cooking and all fuel related tasks, and more time on Quality Time activities. For example, cooks in the biogas-using households in the project scenario saved, on average, 77 minutes per day on cooking, and 22 minutes per day on fuel-related tasks — a total of 99 minutes. This assessment also found that, on average, biogas-using households in the project scenario spent an average of 47 more minutes per day on Quality Time activities, which suggests that approximately half of the time saved when cooking with biogas is redeployed to Quality Time activities (see Table 6 for detailed results for Time Use).

**Table 6: Time Use (via survey of female primary cooks)**

<table>
<thead>
<tr>
<th></th>
<th>Biogas-using households</th>
<th>Biomass-using households</th>
<th>Difference in means (as compared to biomass group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = Observations</td>
<td>126</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Cooking time (all tasks, min.(^d)/day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>146.1 (71.8)</td>
<td>222.9 (140.5)</td>
<td>-76.8</td>
</tr>
<tr>
<td>90% precision(^e)</td>
<td>7%</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>P-value for the difference between biogas- and biomass-using households</td>
<td></td>
<td></td>
<td>&lt;0.001(^f)</td>
</tr>
<tr>
<td>All-fuel related tasks(^g) (all tasks, min./day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>36.6 (56.6)</td>
<td>58.4 (73.6)</td>
<td>-21.8</td>
</tr>
<tr>
<td>90% precision</td>
<td>23%</td>
<td>21%</td>
<td></td>
</tr>
<tr>
<td>P-value for the difference</td>
<td></td>
<td></td>
<td>0.02(^g)</td>
</tr>
<tr>
<td>Quality Time(^h) (min./day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>412 (266.7)</td>
<td>365.4 (239.2)</td>
<td>+46.6</td>
</tr>
<tr>
<td>90% precision</td>
<td>9%</td>
<td>11%</td>
<td></td>
</tr>
<tr>
<td>P-value for the difference</td>
<td></td>
<td></td>
<td>0.17(^h)</td>
</tr>
</tbody>
</table>

\(^d\) Min. stands for minutes.

\(^e\) The Gold Standard aDALY methodology stipulates that the 90 percent confidence interval's margin of error of the sample should be less than 30 percent of the mean. The Gold Standard methodology does not require statistical significance. All values presented above are less than 30 percent, meeting this guideline.

\(^f\) This difference is statistically significant.

\(^g\) This difference is statistically significant.

\(^h\) Although this difference is not statistically significant, the 90/30 precision guideline was met for each of these groups.
Setting up a biodigester

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Endnotes


4 Per the Clean Cooking Alliance, clean cooking solutions refer to a suite of fuel–stove combinations with emissions performance that meets the World Health Organization’s guidelines for indoor air quality. They include high-efficiency charcoal and biomass pellet stoves, liquefied petroleum gas (LPG), biogas, ethanol, and electric stoves and pressure cookers.


6 The term “base of the economic pyramid” is used to describe men and women who are low-income and/or who lack access to basic goods and services. The low-income segment is commonly considered to include people earning up to $8 per day in terms of their purchasing power parity (PPP). Setting the maximum in PPP terms adjusts the real figure to equate the PPPs of different countries. G20 Development Working Group. 2015. “G20 Inclusive Business Framework.” http://g20.org.tr/wp-content/uploads/2015/11/G20-Inclusive-Business-Framework.pdf.

7 Quality Time is defined as the sum of time spent on income generating activities, producing goods that would otherwise be bought, education, rest and leisure.


11 Any positive outcomes or impacts, other than direct GHG emissions’ mitigation, resulting from carbon offset projects.


13 Because cooking with a traditional stove takes more time, cooks spend more than 3.3 hours per day on cooking.


17 They cannot meet the criteria (substantial collateral and/or high interest rates) to access debt from local banks, and they are not eligible for international investments because the amounts they borrow are much smaller than the ticket size offered by international investors. There are local currency risks as well.


23 Brookings Institution. 2022. Impact bonds fund services through contracts where private investors provide upfront flexible funding to service providers, and outcome funders repay these investors based on the outcomes achieved by the people receiving the services. Since 2010, 239 impact bonds have been launched across 39 countries. https://www.brookings.edu/research/social-and-development-impact-bonds-by-the-numbers.


27 Any RBF scheme requires: 1) measurable outcomes that would allow attribution of results to the funding inputs, 2) adoption of widely agreed-upon methodologies for quantifying results from an intervention, 3) a reasonable evidence base for those interventions, 4) credible, independent, third-party verification of results, and 5) demand for verified results targeted to close access gaps from donors and/or the private sector.


30 IFC’s market sounding consultation with 35 leading market players in the carbon space and 10 development finance institutions/multilateral development banks/impact investors. The WOCAN survey mentioned above found that 65 percent of respondents believe the demand for carbon credits with women’s empowerment will grow once buyers are aware of the opportunity to purchase offsets with a “co-benefit” of women’s empowerment/gender equality.


38 Price per Quality Hour (for gender) was based on three available references: 1) W+ units issued using the W+ standard by WOCAN (using the Nepal transaction $0.60 per hour), 2) gross domestic product (GDP) per capita in Kenya as of 2019, and 3) the living wage for rural Kenya in 2016. These references yielded a price range of: $0.60 to $1.02 per added Quality Hour (QH) and worked with the high-end price of $1 per QH.


45 The assessment found that air quality was much cleaner than originally anticipated. For example, the results show 36 μg/m³ for the biogas-using households group, and 113 μg/m³ for the biomass-using control group. These findings are very encouraging from a health standpoint, because exposure in the project scenario for the biogas-using households group was close to the World Health Organization’s first interim guideline of 35 μg/m³. However, the lower exposure level in the baseline scenario for the biomass-using control group means that the transition from cooking with traditional biomass methods to cooking with biogas had a smaller impact on health than expected.

46 Note that this is the interim guideline according to the World Health Organization. The World Health Organization global air quality guidelines for PM₁₀ exposure were revised downward in 2021 to 15 μg/m³ (24-hour average) and 5 μg/m³ (annual average).

47 The W+ domains created by Women Organizing for Change in Agriculture and Natural Resource Management (WOCAN) show various methodologies to measure and quantify projects’ outcomes on women’s lives. For example, one of the W+ Time methods for time savings enables project developers to document the increase in women’s discretionary time, by measuring shifts in the use of time away from lower-value activities toward higher-value activities. WOCAN (Women Organizing for Change in Agriculture and Natural Resource Management). https://www.wplus.org/w-domains/.

48 For example, a meta-analysis of multi-tier framework (MTF) data on time use across six countries estimated that the time savings of users of improved cookstoves was 23 minutes per day in rural areas, and 41 minutes per day in urban areas. This was across all cooking and fuel-preparation tasks. Krishnapriya, P.P., Maya Chandrasekaran, Marc Jeuland, and Subhrendu K. Pattanayak. 2021. “Do Improved Cookstoves Save Time and Improve Gender Outcomes? Evidence from Six Developing Countries.” Energy Economics 102, October: 105456. https://doi.org/10.1016/j.eneco.2021.105456. Notably, the study combined “improved” biomass stove users with users of biogas and other clean-fuel stoves. When the data were disaggregated by gender, the savings for women were reduced in this study to 11 minutes per day in rural areas (range: 8 to 21 minutes). Studies focused on biogas technologies have occasionally reported larger time savings: for example, 110 minutes per day for women using biogas stoves in South India (Anderman, Tal Lee, Ruth S. DeFries, Stephen A. Wood, Roseline Remans, Richie Ahuja, and Shujayath E. Ulla. 2015. “Biogas Cook Stoves for Healthy and Sustainable Diets? A Case Study in Southern India.” Frontiers in Nutrition 2, September. https://doi.org/10.3389/ fnut.2015.00028); and 136 minutes per day for women using biogas in Nepal (Gurung, Barun, and Shreya Thakali. 2014. “Monitoring Report: Women’s Time Savings from Biogas in Nepal.” Kailua Kona: WOCAN. https://mer.markit.com/hr-reg/public/project.jsp?project_id=104000000015320). However, other studies have reported lower time savings—about 14 minutes per day (Krishnapriya et al. 2021).


52 Finally, a study in Nepal reported that biogas users spent 66 more minutes per day engaged in non-cooking-related productive activities, and eight more minutes per day on rest or leisure than was the case with non-adopters. Gurung, Barun, and Shreya Thakali. 2014. “Monitoring Report: Women’s Time Savings from Biogas in Nepal.” Kailua Kona: WOCAN. https://mer.markit.com/hr-reg/public/project.jsp?project_id=104000000015320.

53 According to the most recent World Bank study in 2023, the time use surveys did not yield significant differences between primary cooks in the biogas and control households in terms of time spent on Quality Time, or an association between biogas use and increased time spent on income-generating activities for women. However, the team has confirmed that the slightly different results observed in the World Bank and IFC studies for health and gender are within the range of what might be expected when conducting sequential studies using similar methods (i.e., they are within the range of natural sampling variability, especially because the two studies were conducted in slightly different locations). Nonetheless, there were a few key differences in how the participant groups were defined, and how the methods were applied, which may play a role in the observed differences. These specific differences would be available upon request. These are the first two studies to assess Quality Time in order to measure the impact on women; more studies need to be conducted to test the robustness of the indicator to measure the gender benefits of using biogas.


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The amount of money generated per stove installation based on the CIB.

The result was generated by multiplying 0.058 aDALYs per household by 365 days.

The result was generated by multiplying 0.058 aDALYs per household by the price $1.816 per aDALY set by the CIB.

The result was generated by multiplying 0.78 hours of Quality Time per day per household by 365 days.

The result was generated by multiplying 285 hours by the price of $1 per QH set by CIB.


For these Gold Standard project documents, see https://registry.goldstandard.org/projects/details/2198.


Companies that are already bankable can attract working capital from banks/local mainstream investors. If a company is too small, its operations are not sufficiently organized to meet due diligence requirements from the impact investors and standards including Gold Standard.


Because the negative health impacts of damaging environmental exposure can take years to develop, using aDALYs to quantify the health impact in the target population is more practical than attempting to measure the actual health impact. This methodology has been implemented at least twice previously – once for a cookstove program in the Lao People’s Democratic Republic (Hill, Lawson, Ajay Pillariseti, Kirk R. Smith, Samantha Delapena, Charity Garland, Kirstie Jago, David Pennise, Mette Rohr Boatman, Philipp Koetting, and Aurelie Pelletreau. 2015. Air Pollution and Impact Analysis of a Pilot Stove Intervention: Report to the Ministry of Health and Inter-Ministerial Clean Stove Initiative of the Lao People’s Democratic Republic. Berkeley: University of California, Berkeley, and Berkeley Air Monitoring Group); and once for a public health intervention in Rwanda.

The World Bank’s 2023 study finding suggests that time use agency, in addition to time use, is an effective way to measure women’s empowerment and the multidimensional impact of cookstove adoption.

The W+ Standard, created by WOCAN, is the first women-specific standard that measures women’s empowerment in a transparent and quantifiable manner, gives a monetary value to results, and creates a new channel to direct financial resources to women. https://www.wplus.org/about-the-w-standard/.


This means that cooking enterprises need to understand, based on the terms and conditions at the time of sale, that they have waived their rights to the GHG reduction, health, and/or gender outcomes. Also, at the time of sale, the additional revenue from the sale of these outcomes should be worked into the offering to the enterprise.

The study required two data collection phases in order to meet the minimum sample size required by Gold Standard. This was necessary because the study collected an over-representation of control households that use LPG at least seven times per week, and an unreported number of households with chimneys that could affect household air quality.


LSM was calculated using a procedure developed by the Marketing & Social Research Association-Kenya (MSRA-Kenya). The measure borrowed heavily from ESOMAR South Africa (http://www.eighty20.co.za/lsm-calculator/), but it was customized for Kenyan households. For the definition of social classes, see https://en.wikipedia.org/wiki/NRS_social_grade.

72 The monitoring device was worn continuously by subjects for 48 hours, except when bathing or sleeping. The device collected PM$_{2.5}$ on a filter that measured the concentration of PM$_{2.5}$ before and after the participant began wearing the device.


74 Pillarisetti, A., S. Mehta, and K. R. Smith. 2016. “HAPIT, the Household Air Pollution Intervention Tool, to Evaluate the Health Benefits and Cost-Effectiveness of Clean Cooking Interventions.” In Broken Pumps and Promises – Incentivizing Impact in Environmental Health, edited by Evan A. Thomas. Switzerland: Springer, 2016, 147–169. Note that as of January 2023, HAPIT is still available but no longer updated or supported. ABODE is the successor model to HAPIT and incorporates the most updated and internally consistent evidence linking exposure to health impacts. Therefore, it has been recommended that Gold Standard update its aDALY methodology to use ABODE rather than HAPIT as the modeling tool going forward (as of January 2023).


79 Pillarisetti, A., S. Mehta, and K. R. Smith. 2016. “HAPIT, the Household Air Pollution Intervention Tool, to Evaluate the Health Benefits and Cost-Effectiveness of Clean Cooking Interventions.” In Broken Pumps and Promises – Incentivizing Impact in Environmental Health, edited by Evan A. Thomas. Switzerland: Springer, 2016, 147–169. Note that as of January 2023, HAPIT is still available but no longer updated or supported. ABODE is the successor model to HAPIT and incorporates the most updated and internally consistent evidence linking exposure to health impacts. Therefore, it has been recommended that Gold Standard update its aDALY methodology to use ABODE rather than HAPIT as the modeling tool going forward (as of January 2023).


82 In total, 115 biomass-using households were enrolled in this study. In Phase 1, all of these households took part in the household survey, whereas in Phase 2, only a subset of biomass users were surveyed because the focus was assessing personal exposure to PM$_{2.5}$. Thus, although demographic information was collected from all 115 of the biomass-using households, the household survey collected time-use data from only 102 biomass-using participants.

83 Fuel-related tasks were defined as the sum of time spent on wood fuel collection, wood fuel purchase, charcoal purchase, LPG purchase, wood fuel preparation, water collection, and (for biogas) 50 percent of the time spent collecting manure, adding water, and maintaining the biodigester.

84 Quality Time is defined as the sum of time spent on income generating activities, producing goods that would otherwise be bought, education, rest and leisure. Production of goods that would otherwise be bought was defined as: growing food that you eat, producing milk that you drink, making baskets used in the house woven from your own grasses, and (for biogas-using households) production of organic fertilizer, including 50 percent of the time spent collecting manure, adding water, and maintaining the biodigester and 100 percent of the time spent agitating the slurry.
Contact Information

Bhatti Murti
Communication Lead, Gender & Economic Inclusion
International Finance Corporation
2121 Pennsylvania Avenue NW, Washington, DC 20433
www.ifc.org