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Short Communication

Effects of Solar Power on Chick Brooding Efficiency in Rural Ethiopia: A Case Study under Micro-pilot Interventions

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Abstract

Limited access to reliable and affordable energy has long constrained productivity among smallholder farmers in Ethiopia, particularly in the poultry sector, where modern production requires continuous energy for brooding, lighting, ventilation, incubation, and cooling. Most exploratory reports and observations indicated that a significant portion of the chicks' mortality was attributable to insufficient and irregular heat supply during the brooding period. To cope with those challenges, many small and medium poultry enterprises relied on charcoal, which is costly, hazardous, and emits harmful gases. On the other hand, charcoal prices have increased by nearly 300% between 2022 and 2023, which further erodes profitability. To address these challenges, a micro-pilot initiative was introduced using solar-powered brooding and lighting systems to smallholder poultry enterprises in rural Ethiopia to create viable, climate-smart poultry business models at strategic locations. The results were transformative and scalable. Farmers adopting solar-powered systems increased their income by 42% over 45 days (batch) due to reduced mortality, minimised brooding costs, and reduced labour required for attendance. Related to chick mortality, it was reduced by 400% (from 5 to less than 1%). Charcoal use dropped by 90%, and respiratory health issues among farm workers also improved significantly. Improved profitability and reliability boosted farmers' confidence to scale their businesses, with one enterprise expanding production from 2,000 chicks per batch to as many as 5,000 chicks/batch (150% increase). The success of the project motivated other peers around the project intervention areas. Some started talking with a solar supplier by themselves, but the upfront costs of solar energy are still on the higher side. The initiative also informed policymakers about the inclusion of solar energy solutions in modern poultry business expansion to the rural areas. With a payback period of less than three years, solar-powered brooding systems proved economically viable. During this micro-pilot phase, financial institutions also showed interest to loan, but they still need viable financial business models as per the context. Strengthening partnerships between solar technology suppliers, financial institutions, and rural farmers will be critical to scale. Future opportunities that become imminent include applying solar energy solutions to hatcheries, egg production, and feed processing units, are open for further research.

Introduction

Insufficient access to reliable and affordable energy remains a major constraint to productivity among smallholder farmers in Ethiopia. More than 80% of the population depends on agriculture, largely dominated by smallholder producers who face energy poverty and rely on inefficient and costly fuel sources. The Current energy sources, such as charcoal and diesel generators, are expensive, environmentally harmful, and contribute to greenhouse gas emissions. These limitations reduce productivity, compromise product quality, affect the health of poultry attendants and chicks, and ultimately constrain income generation, rural development, and food security. Moreover, such energy systems are neither climate-friendly nor adequately adapted to the needs of smallholder farmers, including women and youth engaged in modern poultry farming. Most exploratory reports and observations indicated that the reason for higher chick mortality during brooding is related to insufficient and irregular heat supply. To address challenges related to energy access, security, and poverty among small and medium enterprises engaged in chick brooding and lighting, a micro-pilot project was designed to demonstrate renewable energy and energy-efficient technologies within rural poultry value chains. Implemented as a micro-pilot, the project aims to generate practical evidence and a business case showing how renewable energy-powered technologies can improve productivity, reduce costs, reduce environmental impact, and enhance livelihoods for smallholder farmers in Ethiopia. Modern poultry farming is inherently energy-intensive due to requirements for ventilation, cooling, lighting, brooding, and energy storage systems. Consequently, energy consumption, CO_2 emissions, and operating costs in poultry houses are often high. There is therefore a pressing need for innovative, environmentally friendly, and cost-effective energy-saving solutions that reduce operational costs, improve farm profitability and resilience, and create healthier production environments.

Evidence from Nigeria shows that solar-powered brooding systems result in lower chick mortality and reduced energy costs compared to kerosene and combined kerosene-electricity systems [1]. Solar brooding also improves air quality within poultry houses and enhances chick health, leading to higher profitability. Studies indicate that brooding 100 chicks costs approximately USD 65.11 using kerosene and USD 153.21 using combined electric/kerosene systems, while solar-powered brooding costs only about USD 9.82 annually [1]. Similar cost advantages are observed at larger scales, where brooding 1,000 costs USD 883.97 using kerosene and USD 515.81 using kerosene/electricity, compared to USD 126.05 using solar technology [1]. Kerosene systems also present risks of fire outbreaks and emissions of harmful gases such as carbon monoxide and carbon dioxide. In Lebanon, the adoption of solar water heaters as alternative heating sources in poultry farms demonstrated fuel and electricity cost savings of up to 60%, while also improving chick health and performance during winter periods [2]. Additional experiments in Nigeria found that solar-powered brooders recorded only 3% mortality compared with 7% and 10% mortality for kerosene and electricity systems, respectively. Feed Conversion Ratios were also significantly better under solar systems [3]. A review in the United Kingdom further showed that renewable energy technologies could achieve energy savings of up to 85% in poultry operations, with payback periods between three and eight years [4]. Another Nigerian study reported that solar brooding systems were significantly cheaper per bird and improved growth and health indicators compared with kerosene stove systems [5]. In Ethiopia, small and medium-scale chick brooders predominantly rely on charcoal, which supplies about 75% of brooding energy needs. In contrast, the remaining energy is sourced from unreliable grid electricity and/or diesel generators. These practices are associated with high production costs, environmental and health risks, and chick mortality rates that can reach up to 5% at 45 days, often accompanied by poor body condition and growth performance. Given successful experiences elsewhere and the critical challenges in Ethiopia, testing solar-powered heat and lighting systems for chick brooding and lighting at micro-pilot scale is both timely and a necessity. Accordingly, this micro-pilot project was tested in strategic locations within WondoGenet Woreda, Ethiopia, with the following specific objectives.

Specific Objectives

A. Increase access to reliable and sustainable energy sources for smallholder farmers, thereby improving their income and livelihoods.
B. Demonstrate solar technologies and develop viable business cases for adoption.
C. Understand the effect of clean energy on the health of the chicks, attendants and their environment compared to the conventional heating and lighting systems.

Methodology

Description of the Study Area, Sample Size, and Demographics

The intervention sites are in WondoGenet District, Sidama Regional State, Ethiopia, approximately 270 km south of Addis Ababa. The altitude of the intervention areas ranges from 1,761 to 1,918 meters above sea level, providing favourable climatic conditions for poultry production. The maximum distance between the two most distant brooder sites was 5 km, allowing relatively easy coordination and monitoring of intervention activities.

Duration of the Intervention

The micro-pilot intervention was conducted over two years (2023–2024), including preparatory, implementation, and follow-up phases.

Experimental Units and Sample Size

Three Small and Medium Enterprises (SMEs) were selected for micro-pilot testing. Two SMEs each had a brooding capacity of 2,000-day-old chicks per batch, while the third SME had a capacity of 3,000 chicks per batch.

Ownership and Management Arrangements

- The first brooder unit is owned by three women members, with daily operations mainly managed by the members themselves.
- The second unit is owned by a woman entrepreneur, where daily activities are largely managed by hired labour.
- The third SME is owned by six members, of whom 50% are women, with daily operations managed mainly by members, supported by hired labour when necessary.

Brooding Energy Sources

Before the intervention, brooding and lighting relied mainly on charcoal (about 75%) and unreliable grid electricity, with occasional use of diesel generators. The cost of charcoal increased by approximately 300% over the previous two years, making brooding operations increasingly expensive and exacerbating environmental pollution. Following the intervention, on average, 80% of brooding heat and lighting demand was supplied by solar power, while the remaining 20% relied on grid electricity under a hybrid energy connectivity model. Chicks were in a brooding unit for 45 days and then distributed to the surrounding smallholder farmers. Depending on the season, the actual brooding time was on average 24 days.

Solar Power Setup and Shed Rehabilitation

Before solar installation, brooder sheds were rehabilitated to improve energy efficiency and operational performance. The intervention adopted a standard renewable energy installation of 4.11 kW solar capacity per 2,000 chicks per batch. System sizing was made based on the daily energy requirements of chicks, in which a 250-watt capacity infra-red lamp was recommended for 150-200 chicks for lighting and brooding. These infra-red lamps were positioned at a height of around 60cm from the floor. Solar equipment and accessories were procured from suppliers in Addis Ababa and installed as per the requirements. The solar systems included panels, inverters, and battery storage, with panels roof-mounted and maintained through routine cleaning and care. Following installation, SME members received hands-on practical training on solar system operation, cleaning procedures, troubleshooting, and data recording and reporting.

Data Recording Techniques

Data were collected using standardized recording formats. Records, including chick mortality, feed supply, energy source used daily (solar or grid), day-old chick prices, breed type, vaccines administered, disease occurrences and treatments were recorded daily and as it occurs. On top of these, pullets sold, unit prices, litter material used, quantities and selling prices, and other conditional costs were recorded. Both hard-copy and digital records were maintained and shared with the respective team members at the SNV office.

Data Analysis Methodology

Collected data were analyzed using simple descriptive statistics, and findings were compiled every quarter and shared with respective line organisations.

Social Mobilisation and Popularisation Activities

From the outset, relevant stakeholders, including the Bureau of Agriculture, Bureau of Water and Energy, their respective district offices, and technical teams were engaged in the selection of sites and SMEs through consultative processes using predefined selection criteria. Following project inception and solar installation, subsequent multi-stakeholder workshops were organized, involving representatives from agricultural and energy bureaus, financial institutions, microfinance institutions, and SME peers. Additionally, experience-sharing visits were organized among brooding SMEs and smallholder farmers, facilitating knowledge exchange and wider adoption of improved practices.

Results

A one-and-a-half-year solar-powered intervention in chick brooding units in WondoGenet District, Ethiopia, demonstrated significant benefits from the productive use of solar energy. Chick mortality declined from 5 to less than 1%, leading to a 42% increase in farmers' income per batch due mainly to minimizing chicks losses and significantly reduced charcoal use. The intervention reduced charcoal consumption for brooding by 90%, significantly lowering environmental pollution. Previously, poultry attendants were forced to care about the charcoal stoves throughout the night, by exposing themselves and the chicks to smoke, which contributed to respiratory illnesses. Following the intervention, respiratory disease incidence among poultry attendants and chicks decreased significantly. Encouraged by the improved performance and profitability, one of the SMEs expanded its operations from 2,000 to 5,000-day-old chicks per batch, which is 150% increase in scale. The other two SMEs are at different stages of the investment process. The success of the intervention also motivated chicks' brooders adjacent to the project areas to invest in solar-powered brooding and lighting systems. The lessons learned also influenced policymakers to think about the introduction of solar power technologies in the expansion of modern poultry farming in rural areas. By regularly being involved in the project implementation, the development agents and extension officers at WondoGenet district also acquire knowledge about the importance of solar power in chicks' brooding operations. The investment payback period for solar-powered brooding systems was less than three years, which also helped the Banks and microfinance institutions to think about loans to solar power facilities over time.

Conclusions and Recommendations

Day-old chick brooding in the poultry sector is an energy-intensive operation that requires a reliable energy supply to achieve high performance and profitability. Conventional energy sources used by farmers for poultry brooding have several limitations, including unreliability, limited access, high operating costs, greenhouse gas emissions, high labour demand, and increased chick mortality. This case study demonstrated that the intervention increased the income of smallholder farmers, reduced chick mortality and morbidity, lowered labour burdens on the attendants, reduced environmental pollution, and improved the health of both attendants and chicks. Overall, the comprehensive intervention using solar power provided a sustainable, long-term solution and viable business model. The lessons learned could be easily adopted by other smallholder farmers and SMEs, creating opportunities to expand artificial chick brooding in rural areas by linking to Banks and Microfinance institutions with different financial models. Policymakers and extension officers were also involved, starting from the selection of the localities and SMEs till implementation stage, which gave them confidence to expand modern poultry operations in rural areas using solar energy as an enabler. Further research is recommended on the application of solar energy in egg production, hatchery operations, and feed processing units. To promote wider adoption and dissemination of these technologies and reduce the higher upfront costs of solar power, solar technology suppliers should be linked with banks and microfinance institutions for reliable financial access and sustainability.

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