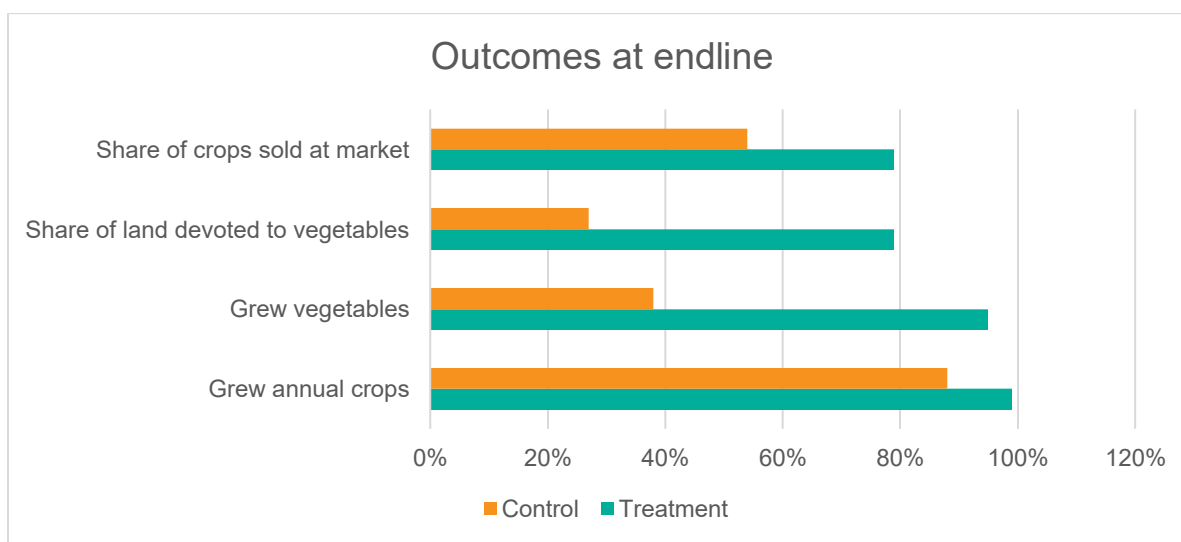


Solar Powered Drip Irrigation: Lessons Learned from an Impact Evaluation in Yemen

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This policy note summarizes findings from a clustered randomized controlled trial (RCT) conducted in eastern Yemen to assess the impacts of **subsidized solar powered drip irrigation systems** on smallholder farmers' production decisions and household food security. The study provides **causal evidence** on how subsidizing solar drip irrigation for smallholders affects crop choice, market engagement, and welfare outcomes in a fragile, water-scarce context.

The intervention led to a **significant shift in cropping patterns**, with treated farmers becoming less likely to cultivate cereals and more likely to grow higher-value horticultural crops. Treated households also sold a greater share of their harvest in markets during the first season following installation, suggesting increased commercialization. However, the study did not detect significant short-term impacts on household food security, indicating that production changes did not immediately translate into improved consumption outcomes.



Overall, the findings provide preliminary support for investments in solar powered drip irrigation in Yemen, however, further research is needed on long-term welfare impacts, environmental externalities, and cost-effectiveness relative to alternative agricultural interventions.

1. Context and Policy Relevance

Yemen faces intersecting challenges of **water scarcity, energy shortages, conflict, and food insecurity**. Smallholder agriculture remains a critical livelihood source, yet production is constrained by scarcity of surface water, declining groundwater resources, and high fuel costs for diesel-powered pumping of groundwater for irrigation. These constraints limit productivity and discourage diversification into higher-value crops.

Globally, adoption of solar irrigation has been very high in conflict-affected contexts such as Yemen where fuel costs are a key constraint. While addressing high fuel costs, solar irrigation also facilitates continued overexploitation of groundwater resources. Combining solar irrigation with drip irrigation offers a potential solution, however, the initial investment costs for solar panels, solar powered pumps, and drip irrigation tubing are high, limiting adoption by smallholder farmers.

This study evaluates the impacts of providing subsidized access to this technology bundle, specifically in a conflict-affected setting where rigorous quantitative research is scarce.

2. Study Design and Methodology

2.1 Intervention

The intervention consisted of **subsidized solar powered drip irrigation systems** provided to smallholder farmers in five districts in Hadhramaut governorate in eastern Yemen (Al Qatn, Tarim, Sah, Sayun, and Ghayl Bin Yamin). Solar powered pumps were installed on wells serving five to nine smallholder farmers and the farmers received grants subsidizing 80% of the purchase of a drip irrigation system covering 0.5 hectares. In addition, well operators and farmers received technical training and assistance on how to effectively use solar powered drip irrigation to improve agricultural income and diversify their production.

2.2 Evaluation Approach

The study employed a **clustered randomized controlled trial**, allowing for causal inference. Each well and the associated smallholder farmers using the well were randomly assigned to:

- **Treatment group (16 wells, 91 farmers):** received access to subsidized solar drip irrigation system and training.
- **Control group (20 wells, 99 farmers):** did not receive the intervention.

Impacts were estimated using an ANCOVA specification which compares outcomes at endline between control and treatment groups while controlling for baseline values of respective outcome variables and baseline household characteristics (household head age, household head education, household size, household size, and indicator variable for livestock ownership, and productive assets).

Outcomes were measured during the **first agricultural season post-intervention**, focusing on: crop choice and production decisions, market participation and sales behavior, and household food security indicators.

3. Key Findings

The most robust finding of the study is a **shift in cropping patterns** among treated farmers:

- Farmers with solar drip irrigation were **significantly less likely to cultivate cereals**.
- They were **more likely to cultivate horticultural crops**, which are typically higher value and more water sensitive.

This suggests that improved access to reliable and low marginal cost irrigation encourages farmers to move away from low-value staple crops toward more profitable production systems.

The intervention also affected how farmers used their output:

- Treated farmers sold a **higher share of their harvest in markets** compared to control farmers.

This indicates a move toward **greater commercialization**, consistent with the adoption of higher-value crops. Increased market engagement may have implications for income generation and rural economic activity, even if immediate welfare effects are not observed.

Despite changes in production and sales behavior, the study found **no statistically significant impacts on total agricultural production value or household food security** in the short term. Descriptive patterns in the data and anecdotal reports provide suggestive evidence that the full impact of the intervention could be realized beyond short-term, through future and additional cropping seasons. The delays in the distribution of inputs and the need for learning by doing with horticultural crops suggest that eventual impacts on the total value of production and household food security may be higher than seen in the first season post-intervention. The shift towards growing vegetables was due to smallholder farmers perceiving horticultural crops as benefitting more significantly from the new irrigation technology. However, farmers were generally planting these horticultural crops for the first time and therefore may have experienced challenges including incorrect location selection (anecdotal reports confirmed some farmers intended to shift horticultural production towards less shaded locations in the next season) and difficulties with marketing.

4. Policy Implications

Our study provides preliminary support for solar drip irrigation systems in conflict affected areas. Our analysis is limited by only looking at the first season after the intervention, during which farmers were still imperfectly benefiting from the new irrigation system. As such, our results likely underestimate the benefits of adopting improved irrigation technology. Another limitation of our study is that we did not yet estimate the effects of installing solar drip irrigation on groundwater depletion. Finally, our intervention was relatively costly, and the gains to smallholder farmers and wider community should be weighed against the investments and potential overextraction of groundwater resources. An accurate cost-effectiveness analysis would require measuring economic returns for smallholder farmers beyond the first season, as the long-term benefits of eliminating ongoing fuel costs could outweigh the upfront investment.

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