Are Rainwater Harvesting Techniques Profitable for Small-Scale Farmers? The Adoption and Impact of RWH Techniques in Niger

Researchers:

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Sector(s): Agriculture, Environment & Energy

Fieldwork: Sahel Consulting Group

Location: Niger

Sample: 2861 smallholder farmers in 180 villages

Initiative(s): Agricultural Technology Adoption Initiative (ATAI)

Target group: Farmers Rural population

Outcome of interest: Technology adoption Climate change adaptation Productivity

Intervention type: Cash transfers Information Natural resource management Sustainable farming Unconditional cash transfers

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Research Papers: Harvesting the Rain: The Adoption of Environmental Technologies in the Sahel

Partner organization(s): Niger Ministry of Environment, Sahel Consulting Group, Gates Foundation, UK International Development, Independent Science and Partnership Council's Standing Panel on Impact Assessment (ISPC-SPIA)

In low-income contexts, liquidity and credit constraints can hinder the adoption of improved agricultural and climate-resilient technologies. In Niger, researchers conducted a randomized evaluation to test the impact of providing training and conditional or unconditional cash transfers on farmers' adoption and use of an environmental technology, their resulting land use, agricultural production and profitability, and labor allocation. Providing farmers with training led to a substantially higher probability of adopting the technology, while the conditional or unconditional cash transfers had no additional effect on farmers' decision to adopt.

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Global agricultural yields have more than doubled since the 1960s, but productivity has stagnated in much of sub-Saharan Africa, causing many farmers to clear more land for agriculture to meet growing food demand. This expansion often pushes production onto increasingly rocky, sandy, or shallow soils with limited soil nutrients and water availability, leading to rapid depletion and degradation of farmland. Barriers to information on sustainable agricultural practices hinder the adoption of environmentally-friendly agricultural technologies. Demi-lunes, water collection pits, are one such technology that can help farmers restore their land by briefly capturing rainfall and runoff for soil nutrient replenishment. However, farmers do not often know how to construct them correctly and their construction is labor intensive, requiring a large upfront cost. Can providing households with information and cash transfers increase their construction of demi-lunes and, therefore, production, soil fertility, and profitability?

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Niger is one of the lowest-ranked economies on the UN's Human Development Index[1], with 85 percent of its people living on less than US$2 per day in 2017. Due to its semi-arid climate, rainfed agriculture is the primary source of livelihood. Niger has a single rainy season from June to September, with harvest between October and January. After harvest, there is less access to food, income, and labor, triggering seasonal migration, as many households send at least one member abroad for work. In addition, severe soil degradation is a common problem, with at least 60 percent of land under cultivation experiencing soil erosion.

Demi-lunes can be an appropriate rainwater harvesting technique for land restoration and climate change adaptation. When constructed correctly, they can capture rainwater for a short period of time (2-3 days), stymy soil runoff, and increase soil nutrient content. The Nigerien Ministry of Environment recommends building 250–300 demi-lunes per hectare of degraded land. Each demi-lune costs about US$80 to construct, primarily due to labor costs, but once constructed, they do not require maintenance until three years later at which time the land should show signs of restoration.

Eligible households were comprised of about eight people, with four adults, and owned or cultivated approximately 4 hectares of land, at least half of which was degraded. Households primarily grew millet, sorghum, cowpea, and peanuts. While only one-third of households had prior experience constructing demi-lunes, the majority of farmers had heard about demi-lunes prior to the start of the study.



Farmers in Niger struggle with soil erosion and degradation.

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Researchers conducted a randomized evaluation to test the effect of training and cash transfers on farmers' adoption of demi-lunes, agricultural production and profitability, land use, and household labor allocation to agriculture. Within each of the randomly selected 180 villages, researchers randomly selected sixteen individuals, eight men and eight women, ensuring gender balance. They then randomly assigned these 2,861 participants to one of five groups:

1. Training (40 villages): Farmers were offered an interactive training covering the purpose of demi-lunes as well as the steps for constructing and maintaining demi-lunes, including the technical aspects of construction, like the proper dimensions and orientation. The training differed from past trainings because it focused on construction on private not communal land and emphasized the use of readily available tools.
2. Unconditional Cash Transfer (UCT) Early (40 villages): Farmers were offered the same training and an unconditional cash transfer of US$20 that was paid one month after the training and was independent of whether farmers chose to construct demi-lunes.
3. Conditional Cash Transfer (CCT) (40 villages): Farmers were offered the same training and a conditional cash transfer of US$0.40 per quality demi-lune constructed. The CCTs were paid out after the initial training and before the rainy season and were dependent on verified demi-lunes constructed on the farmers' land.
4. Unconditional Cash Transfer (UCT) Late (30 villages): Farmers received the same training and an unconditional transfer of US$20 timed to coincide with the CCT payout plus US$0.50 to compensate for the delay in payment relative to the UCT-early group.
5. Comparison (30 villages): Farmers were not offered any training or cash transfer for the duration of the study.

Researchers also selected 670 individuals, two men and two women per village, who were not included in the rollout of the intervention to assess spillovers from the evaluation, namely whether neighboring farmers learned about and constructed their own demi-lunes.

Between 2018 and 2021, researchers conducted household surveys before the start of the intervention, during the intervention at various time points and two years after the intervention, collecting information on household demographics, assets, agricultural production, land and labor outcomes, and demi-lune construction.

In assessing the benefits and costs of the study, the researchers carefully weighed the risks. Overall, it was determined that, since the technology under consideration (the demi-lune) focused on severely degraded land that could not be cultivated, it was not substantially increasing households' risks. There was a small risk that households could have expended effort and adopted with little benefit, but this was not evident in the study results.

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Researchers found that providing farmers with training increased adoption, but conditional or unconditional cash transfers had no additional effect in the medium- or long-term. Adoption of demi-lunes led to an increase in agricultural output, a reduction in land turnover, and an increase in profits.

Demi-lune adoption: All four interventions resulted in increased adoption of demi-lunes. Beyond being offered the training, there were no meaningful differences in adoption between the intervention groups after the first year. Specifically, farmers in participating villages were 91 percentage points more likely to adopt demi-lunes compared to 4 percent of households in comparison villages. On average, farmers who participated in the interventions adopted between 28–40 additional demi-lunes relative to the comparison group. Researchers suggest that adoption was driven by training farmers on the correct specifications to construct demi-lunes, increasing farmers' technical knowledge and social interaction around the technology. The conditional or unconditional transfers did not meaningfully affect farmers' adoption, suggesting that they could come up with the financial

resources to cover agricultural investments when the primary constraint to adoption was alleviated.

Three years after the intervention was delivered, farmers were still actively using their demi-lunes. Farmers in intervention villages were 74 percentage points more likely to have operational demi-lunes for a total of 90% in treated villages.

Spillovers: Farmers in intervention villages were 50 percentage points more likely to have neighbors who adopted demi-lunes (an almost 300 percent increase relative to adoption of an additional 0.7 fields on neighboring fields in the comparison group). Researchers suggest spillovers did occur, but that directly participating in the training was more effective.

Heterogeneity by gender: Although women who were offered the training adopted five fewer demi-lunes than men in the first year, by the third-year, women's adoption caught up with men's. Given that Nigerien women cannot own private land and have limited access to financial services alone, researchers highlight the importance of this finding especially due to the physical labor required to build a single demi-lune.

Labor allocation: In the first year, households in all four intervention groups hired more outside labor, sent fewer household members to work off-farm, and reallocated family labor to construct demi-lunes. Specifically, intervention households used an additional fifteen days of one family member's labor to construct demi-lunes relative to two days among households in the comparison group and reduced family participation in seasonal migration for work. Households in the intervention groups also hired outside laborers for other agricultural tasks over multiple seasons.

Agricultural production: Farmers who were offered the training increased the quantity and value of their agricultural production by 0.12 to 0.15 standard deviations relative to comparison group households, with larger effects over time. Concretely, these farmers produced 80–90 kilograms more output, primarily of sesame and sorghum. Households in intervention villages had a 40 percent lower likelihood of crop failure than those in the comparison group in the first year and the likelihood of crop failure did not increase over time.

Land use: Intervention households were 33 percentage points more likely to self-report working on previously uncultivable land by the third year, planting an additional 0.3 hectares relative to comparison households. Specifically, participating households were 33 percent less likely to retire land from planting due to degradation, and farmers did not buy, sell, or rent more land as a result of the intervention.

Profitability: Households who received any of the interventions increased their agricultural revenues by US$34–37 in the first and third years, which translated to an increase of 10–13 percent more than farmers in the comparison group. However, intervention households also spent about US$20 on hired labor and materials and forewent approximately US$15 from income from family labor that was reallocated to work on the farm. This suggests an increase in profits of US$3 in the first year. Profit gains are expected to persist and continue to increase after the first year due to rising revenues and decreasing labor costs.

Researchers suggest that simple trainings could be effective in increasing adoption of rainwater harvesting to address land degradation and increase resilience to climate shocks in other contexts.

At the end of the evaluation, the researchers rolled out the training to all of the villages assigned to the comparison group and provided feedback to the Ministry, stakeholders, and the communities on the results. Informed by the results, the researchers are scaling up the intervention with the Ministry of Environment in Niger.

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1. UNDP (United Nations Development Programme). 2020. Human Development Report 2020: The Next Frontier: Human Development and the Anthropocene. New York.