Darfur Fuel-Efficient-Stoves (FES)

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Outline

1. Problem Statement: Environment, hardship, and hunger -- findings from our survey in Nov-Dec. 2005
2. Proposed solution: Metal FES

    Observed problems with the mud ITDG FES stoves
3. Relative fuelwood savings of metal FES "Berkeley Tara"
4. Economics of Firewood and "Berkeley Tara"
5. Lessons from dissemination experience of others -- mistakes to avoid

Systematic household survey in North and South Darfur, Nov-Dec 2005

Obtained relevant data on household size, kind and amount of fuel, fuel collection effort, fuel prices, cooking methods, amount of food cooked, and access to fuel.

Survey forms were vetted by double translation, tested with a pilot survey, and then data collected and analyzed. Report available electronically from LBNL or us.

The Problem:
Environmental degradation, hardship and danger, and hunger

Owing to fuelwood collection by IDPs, there is increasing zone of total denudation around the camps

The rate of extraction far exceeds the regeneration rate of vegetation

There is no such thing as "agricultural waste."

The Problem: Environmental degradation, hardship and danger, and hunger

The average fuel collection trip lasts for 7-10 hours.
Average time spent collecting fuel is 25 hours a week.
Each trip takes the women far from the safety of the camp

High exposure to threat of physical violence during the fuel collection trips

The Problem: Environmental degradation, hardship and danger, and hunger

IDPs sell food for purchasing fuel ~ 40% in South Darfur, and 80% in North Darfur reported doing so. Even then they miss meals for want of fuel to cook with

50% households in South Darfur, and 80% in North Darfur reported missing a meal in the previous week for lack of fuel, even when they had raw food on hand

More survey results: fuel use and fuel cost

80% IDPs in North, and 50% in South, *buy* wood for cooking, spending SD 200 - 300 per day, on average.

More than 90% of households use a three-stone fire for cooking meals

One meal needs avg. 2 kg wood; average daily household use is 5 kg, average daily spending was SD 250

Current situation is unsustainable

We believe the shortage of firewood has essentially become a food security issue.

Collecting any kind of wood-like fuel is not practicable for most IDPs

Purchasing wood is expensive

Most families sell food to buy wood

Missing meals for lack of wood is commonplace

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Proposed solution: Fuel Efficient Stoves that actually work in the field

Several dozen well-designed efficient biomass cookstoves exist. Research on this has been ongoing for decades in many countries.

We need to find/modify one that is right for the conditions in Darfur and the needs of the IDPs.

Stove’s fuel efficiency: definition

Efficiency is the fraction of the chemical energy in the fuelwood that ends up in the cooking pot as heat.

This equals the product of the stove’s combustion efficiency and the heat transfer efficiency.

Rocket Stove

Fuel Efficient Cookstoves Basics

Five factors determine fuel efficiency:

1. Skill / training of the cook tending the stove
2. Fuel (diameter, moisture content, density, wood species, etc.)
3. Stove design
4. Fit of the pot to the stove
5. Type of food and type of cooking performed

Tara

Testing Stoves in IDP Camps

Four stoves were tested against a three-stone fire in IDP camps: the ITDG (mud), the Priyagni (metal, India), the Tara (metal, India), and the Rocket stove (metal, U.S.A.).

Tests used IDP cooks, local fuel, local pots, and local food (*assida* and *mulah* are the staple foods of IDPs).

Testing Stoves in IDP Camps: Outcome

Among the four stoves, the Tara tested the best, and was recommended for further work

The Tara was demonstrated to save 50% fuel over a three-stone fire, in side-by-side tests in IDP camps in Nov-Dec 2005.

Tara Stove

The Tara is a multi-fuel, metal FES developed in India by Development Alternatives (www.devalt.org) in 1980s

Tara strengths

- Can be hand-built or mass-produced from sheet metal for US$ 10 locally in Sudan
- Critical stove dimensions can be easily ensured
- Tested to have very low smoke emissions and high efficiency under field conditions in India
- Multi-pot design

Tara

Why not the ITDG mud FES?

The mud FES design uses locally available clayish-mud, donkey dung, and water.

Initially looks good because of low cost, and local IDP production.

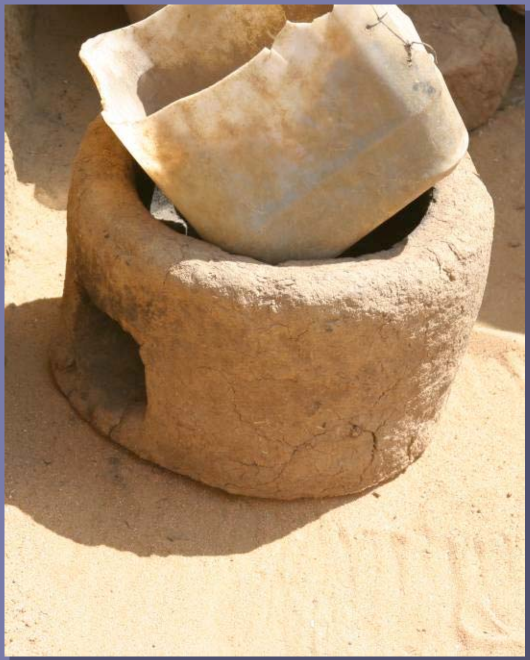
Practical Action claims a 50-60% reduction in wood use and a large reduction in harmful smoke exposure.

Neither claim is supported by data.

Mud FES not actually used in the field

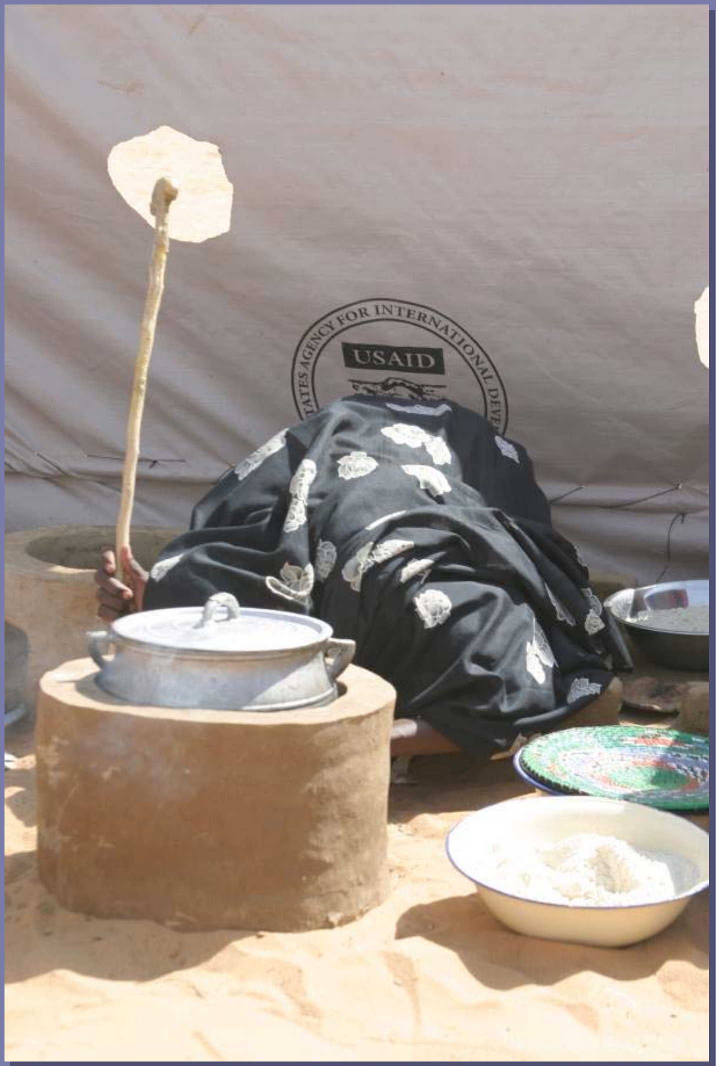
Only a small percentage of IDP families have the mud FES.

We observed only three Mud FES in IDP huts in North Darfur: (1) used in addition to a three-stone fire, even though it fit no pot in the household, (2) never used since it “did not work”, and (3) used as a *bambur* (cooking stool).



Mud FES design flaws

- The combustion chamber is poorly designed
  - no primary air supply
  - inadequate space for flue gas exhaust
- Difficult to monitor the fire and to tend it properly
- It is a one-stove, one-pot solution
- Mud FES takes one person-day to build. Too slow for large scale rapid dissemination while maintaining quality control



Mud FES dissemination flaws

Implementation has inadequate quality control and user training, resulting in poor performing stoves and poorly skilled fire-builders.

Critical dimensions are neglected: (a) the gap between pot and stove or (b) the height of the combustion chamber.

We observed few, if any, FES that fit its pot acceptably.

"We met no IDPs or NGO trainers who appeared to understand the basic techniques for building efficient fires." -MBJ & YML

Mud FES retrofit

Could fix most design flaws, but not dissemination barriers

Add grate for SD 100, cut flue gas channels in the inside surface of stove walls, add bumps to top rim

-- This improves performance, and reduces smoke generation

However, still takes 1 person-day to build, and doesn't work as well as the Tara

Quality control in the field remains an insurmountable challenge

Conclusion of testing in Dec. 2005

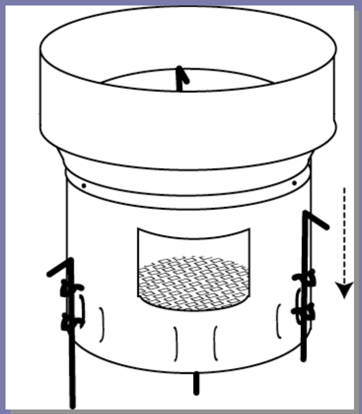
Tara was best of the lot, but needed more work to rectify two shortcomings:

- Performance degraded under windy conditions
- Stove tended to tip while making *assida* (vigorous stirring)

The Berkeley Tara

The Tara was modified during Spring Semester 2006 to address shortcomings

Original Tara



Modified Design

- Wind shields maintain the stove performance under windy conditions

- Pegs provide stability while making *assida*

Berkeley Tara Prototype

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Testing the Berkeley Tara

- The three-stone geometry was not accurately measured; hard to reproduce reliably in Berkeley

- Comparisons were made instead with Tara, which had been compared against three-stone fire in the field

- This allows us to predict the performance of the Berkeley Tara against a three-stone fire

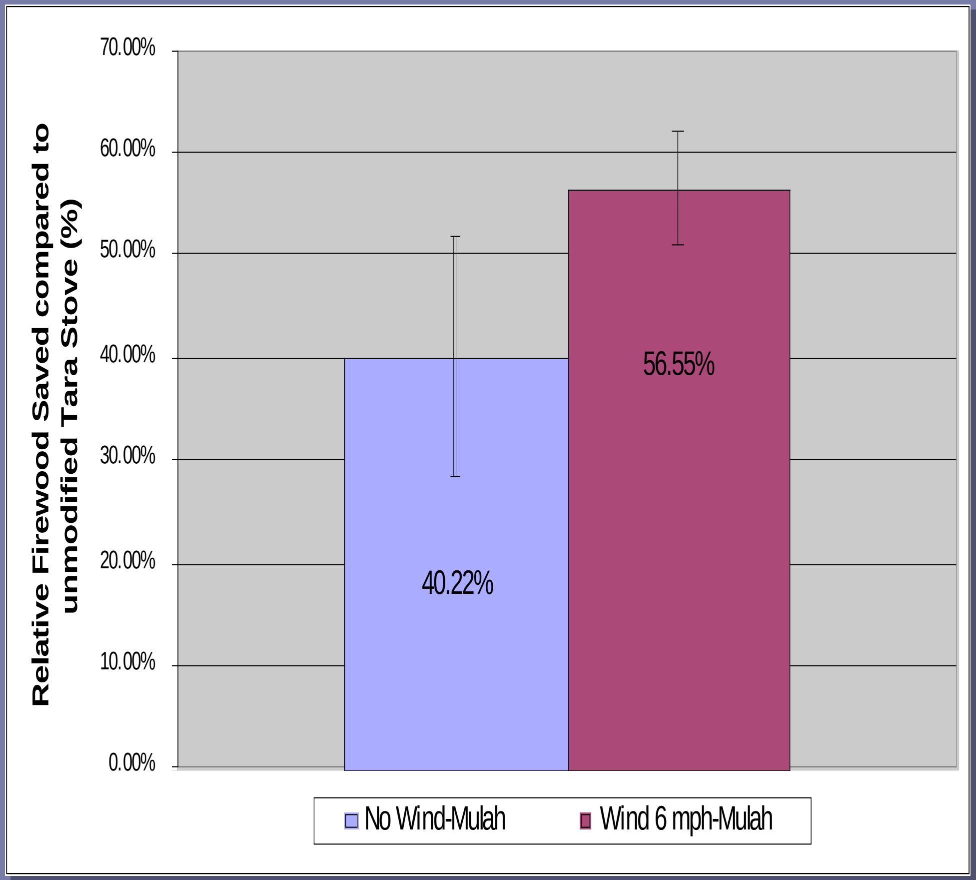
Testing the Berkeley Tara against the Tara

- Protocols were developed to simulate the cooking of *mulah* and *assida*

- The stoves were compared side by side with the same cook, fuel, and pots from Darfur

- A fan was used to simulate wind of 5-6 mph

Relative Fuelwood savings of Berkeley Tara over Tara -- (1) for making *mulah*



Calculation method

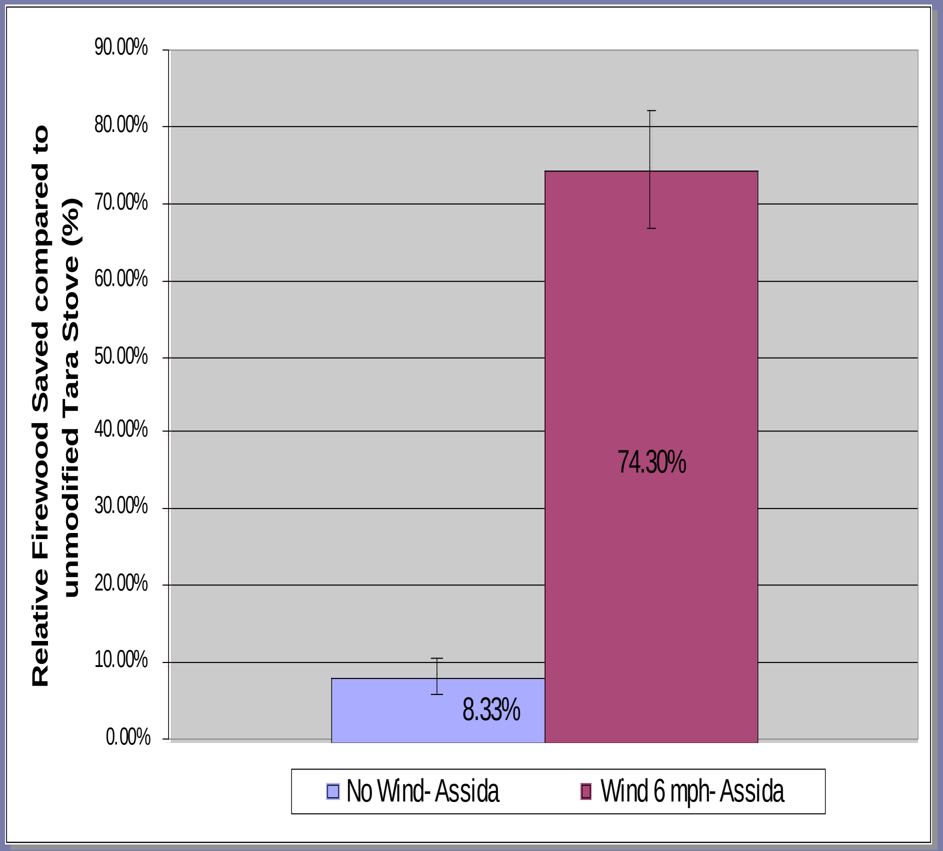
Percent relative fuel savings =

[Fuel used (original) – Fuel used (Berkeley)] / Fuel used (original)

Conclusions:

- 40% relative fuelwood savings for *mulah* in still air.
- 57% relative fuelwood savings under 6 mph wind!

Relative Fuelwood savings of Berkeley Tara over Tara -- (2) for making *assida*



Conclusions:

- 8% relative fuelwood savings for *assida* in still air.
- 75% relative fuelwood savings under 6 mph wind!

Berkeley Tara over three-stone fire

Combining the relative savings from making *mulah* and *assida* under windy and non-windy conditions, we estimate the Berkeley Tara will save about **70-75%** of the fuelwood used by a three-stone fire.

Measurements under field conditions are needed to make a more accurate prediction.

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The Economics of Firewood and Stoves for one IDP household

Households eating three meals per day currently spend SD 300 on wood

At least 70% (SD 210 per day) of this can be saved with the Berkeley Tara

Berkeley Tara estimated price, made in Sudan, is US$ 15 = SD 3000

The Economics of Firewood and Stoves for 2.2 million IDPs

300,000 households consuming 1.5 million kg firewood daily (if demand is met)

Potential annual fuelwood savings = 345 million kg, worth US$ 86 million (at SD 200 per dollar)

Cost of 300,000 stoves = US$ 4.5 million (excluding program costs)

Essential Evaluation Costs

To maintain quality and correct design errors, if any, continuous and independent field evaluation is necessary

This raises the cost by 10% when the program is small, and by 5% when the program is large

Incorporating these costs, each stove costs SD 3300 (US$ 16.50) ⇣ ⇣ ⇣ ⇣

Simple payback time, if IDPs pay the full cost of the stove and field evaluation, is (3300/210 =) 16 days

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Key to successful implementation

Training IDPs about the efficient tending of the fire to save fuel with the stoves is critical

In our estimation, this takes an hour or so

Additionally, periodic social reinforcement of efficient fire tending technique (e.g. through competitions in women's centers for least fuel use) is essential until it becomes internalized

Dissemination: mistakes to avoid and actions to ensure success

1) Do not give the stoves away free

2) Avoid giving production to a single manufacturer

3) Operate and maintain a certification program for quality control of stoves. This should include a testing program for stove performance

4) Conduct third party field evaluations of the program throughout its life

Recommended Next Steps

1) Fifty stove technical rollout. Fifty IDP households given Berkeley Tara for one month -- technical feedback and evaluation at end of the month

2) Establish fee-based FES performance-testing program (open to all designs)

3) Five-hundred stove social rollout. Test different methods for IDP ownership (e.g. micro lending)

4) Establish fee-based certification program (open to all designs and manufacturers)

5) Manufacturing rollout. Invite multiple bids, downselect based on production samples and cost. Require periodic certification of participating manufacturers

Acknowledgements

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Questions?