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A social and environmental evaluation of fuel-efficient cook-stoves and conservation in Uganda

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Summary

A significant factor contributing to deforestation is the expanding human populations' increasing demands on forests and forest products. In many areas, rural households rely solely on fuelwood collected from the forest for their domestic energy supply. Fuel-saving stoves, or improved cook-stoves, have been introduced to reduce fuelwood consumption and thus alleviate deforestation, but there is frequently little or no formal monitoring and evaluation of programmes; their success as both a development and a resource-conservation tool is therefore undetermined. A programme was implemented in communities surrounding two national parks in western Uganda to compare domestic fuelwood consumption of an improved cook-stove and the traditional cooking fire, and assess the attitudes of stove users and non-users towards the improved stove and resource conservation. A kitchen performance test conducted in 100 households in Kiziba, Kahangi and Matayisa/Bundinyama parishes showed that fuelwood consumption did not differ significantly between improved and traditional stoves under actual field conditions. Household surveys showed that respondents in all three parishes had positive perceptions of the improved cook-stove. Perceived advantages of the improved stove included the ability to cook more than one item at once, fuelwood savings, quick cooking, and smoke/accident reduction. Many problems cited with the stove were technical, such as chimney malfunctions and pot-holes being too large or small to accommodate cooking pots. Cost of the stove was the primary reason for non-adoption. Improved-stove users were more concerned with forest conservation than were non-users. The need for monitoring and evaluation of improved-stove programmes is strongly indicated if they are to continue to be implemented as tools for resource conservation.

Keywords: conservation, deforestation, evaluation, fuelwood, energy efficiency

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Introduction

Increasing demands for forest products from expanding populations, particularly in developing countries, are one significant factor contributing to deforestation. In sub-Saharan Africa, for example, the population has doubled in the past 25 years (Mabogunje 1995). The population is expected to double again in 24 years, and predicted to stabilize in the year 2050 with a population of 2.5 thousand million (Cleaver *et al*. 1992). Inevitable consequences of this growth include the increasing demand to convert forested areas into agricultural plots and the demand for forest products such as timber and fuelwood. Fuelwood consumption warrants special consideration, as the amount of wood consumed annually for fuel increased from 1500 to 3500 million m^3 between 1950 and 1990 (Durning 1991). Further, wood is the predominant source of energy in most parts of the developing world, and in many areas rural households rely solely on fuelwood for their domestic energy supply. Eckholm *et al*. (1984) found in a survey of 76 developing countries that about eight times as much wood is used for domestic cooking as for lumber and other industrial purposes. It is estimated that by the year 2000 one-half of the developing world's population will lack a sustainable supply of fuelwood if deforestation rates remain constant (Miller & Tangley 1991).

The predictions of world-wide deforestation and the repercussions which follow are magnified in countries like Uganda, where the impacts may be particularly severe. While less than 5% of Uganda's land surface remains covered in closed forest, deforestation is estimated at approximately 2% per year (C. Chapman & L. Chapman, personal communication 1994). The causes of deforestation in Uganda are numerous, though population growth is perhaps one of the most significant, as the country's annual population growth is 3.4%. Activities such as timber harvesting have affected approximately 35% of the forested land within Uganda's principal forest reserves; however, the demand for timber is only 1/60 of the demand for fuelwood (Howard 1991). Becker *et al*. (1995) estimate that about 94% of the human enterprises in Uganda are powered by wood. In 1986, the World Bank estimated the fuelwood demand to be 18.3 million m^3 yr^{-1} and increasing. In 1991, Uganda's annual production of woody biomass was estimated at only 15.6 million m^3 of fuelwood equivalent (Howard 1991), leaving a deficit of 2.7 million m^3. These figures clearly demonstrate the need for both reforestation and introducing methods to increase fuel efficiency. Struhsaker (1987) suggests that immediate attention should

Table 1 Elements of improved cook-stove programmes around the world. Data are from Bhattarai (1983), Estrada (1983), Navarathna (1983), Sudjarwo (1983), Hyman (1987), Caceres and Caceres (1990), Jagadish and Ravindranath (1990), Karekezi and Walubengo (1990, 1991), Mounkaila (1990), Sarin (1990), Sawadogo (1990), Dendukuri and Mittal (1993), Smith *et al*. (1994) and Campbell (1994).

Programme elements	*% of programmes with element*	*% of programmes without element*	*% of programmes where element not reported*
Stove construction and design			
Design includes input from potential users	26	13	61
Local construction by trained artisans	48	43	9
Construction by women	22	78	0
Self-construction	26	74	0
Mass fabrication	48	52	0
Construction with locally-available materials	48	17	35
Stove similar to traditional stove	52	13	35
Stove saves fuel	74	0	26
Stove saves time	43	4	53
Stove reduces smoke/accidents	26	26	48
Programme planning			
Programme targets region where fuel is scarce	70	0	30
Programme targets region where smoke causes health problems	13	0	87
Programme has goals and objectives	57	0	43
Programme has promotion and dissemination plan	74	17	9
Programme has monitoring and evaluation plan	35	4	61
Programme implementation			
Stove is promoted with help from community organizations	48	26	26
Stove is pilot tested	30	4	65
Programme monitoring and evaluation			
Stove is monitored by tests/surveys	22	4	74
Subsidies			
Stove price is subsidized	22	30	48

be given to increasing fuel efficiency, which could be 2–26 times more effective in dealing with Uganda's fuelwood problems than the reforestation programmes planned and in progress. One potential strategy aimed at improving fuel efficiency is the use of fuel-conserving stoves.

Fuel-saving stoves, or improved cook-stoves, have been introduced in developing countries as a method to reduce fuelwood consumption, and thus alleviate deforestation. In many rural areas where food is cooked over an open fire, efficiency of heat transfer (the heat transferred from the fire to cooking pots) ranges from 3 to 10%. However, improved cook-stoves, when used properly, can reach efficiencies of 20 to 30% (Islam *et al*. 1984). Given the fact that in many countries firewood and charcoal are estimated to be approximately 90% of total inanimate-energy consumed (Agarwal 1983), a stove that conserves fuel could play a major role in conservation efforts. Between 1977 and 1985, over 42 900 000 improved cook-stoves were distributed in developing countries (Caceres *et al*. 1989), at a minimum cost of US$ 40 million. Despite the large numbers of stoves disseminated, the experience with such programmes has been, for the most part, discouraging. As of 1984, 10-20% of stoves introduced had fallen into disuse, and 20–30% were used only intermittently (Manibog 1984). Manibog (1984) ascribed the beleaguered success of these programmes to technical factors (stoves not performing well under field conditions), economic factors (need for fuelwood conservation not perceived by stove users and high cost of stove) and socio/cultural factors (people not willing to adopt stove). Further, after introduction into a given area, there is a frequent lack of monitoring of programmes because of a lack of resources, time, and personnel in the implementing agency. As a result, information concerning stove use, stove performance, fuel savings, and perceived benefits and constraints of both the new and traditional stoves, is not collected. This information is often crucial to the success of current and future improved cook-stove projects, and certainly critical to evaluate the conservation potential of improved cook-stoves.

Monitoring improved cook-stove programmes

The complex process of developing and disseminating improved cook-stoves requires careful planning, monitoring and evaluation. A wide variety of methods for monitoring stove programmes exists, yet they are often time-consuming and difficult to conduct under field conditions. Generally, monitoring activities can be conducted by technical tests and surveys. For example, technical tests may be designed to compare fuelwood consumption of improved and traditional stoves under laboratory and field conditions. Technical tests may be accompanied by surveys which examine people's reactions to a new stove and the perceived benefits and disadvantages of adopting it. These activities allow the implementing organization to make specific modifications on stove design to help meet the objectives of the programme and the needs of stove users.

An analysis of 23 programmes revealed that stove construction and design, programme planning, implementation, and monitoring are undertaken by variably incorporating a variety of elements (Table 1). Less than a quarter of the programmes reported any formal monitoring or evaluation, and fewer than half indicated whether or not the programme involved was successful. These data demonstrate the need for organizations implementing projects to establish criteria for monitoring and evaluation which provide feedback about programme success and required modifications. Further, technical monitoring of stove performance that quantifies fuelwood consumption under realistic cooking conditions must be undertaken if improved cook-stoves are to be promoted as a resource-conservation tool.

Monitoring activities which have been conducted on previous programmes involving improved cook-stoves have revealed information concerning people's perceptions of new and traditional stoves. For example, monitoring and evaluation of the Nada 'Chula' programme in India determined that the primary benefits of the improved stove were smoke removal, fuel savings, time savings, and personal comfort (Joseph *et al*. 1990). Evaluations in China found that stove benefits included the attractiveness of the stove and the health benefits associated with the use of improved stoves (Smith *et al*. 1994). A survey of improved cook-stoves which were distributed in Guatemala found that residents rejected the stoves because fuelwood consumption increased, durability was less than projected, smoke was not eliminated, and cooking times were longer (Joseph *et al*. 1990). Disadvantages of an improved stove in Ghana included the need for larger pieces of fuelwood, the unsuitability of the stove for local cooking, the large size, which required women to stand while cooking, and the small pot-holes, which could not accommodate all cooking pots (Foley & Moss 1983).

Guidelines for monitoring and evaluation of improved cook-stove programmes have been designed; however, they are rarely followed or reported on, and it is crucial that both adoption of the new stove and subsequent stove performance are fully understood if programmes are to succeed. Moreover, the large sums of money and human resources dedicated to the programmes implemented in developing countries make appropriate evaluation a critical need if real forest conservation is to be achieved. This study provides a model for the type of evaluation and feedback that should be incorporated into the programmes. The study focuses on a programme which was implemented in villages directly adjacent to Kibale and Semuliki National Parks in western Uganda (Fig. 1). The programme was initiated by the Kibale

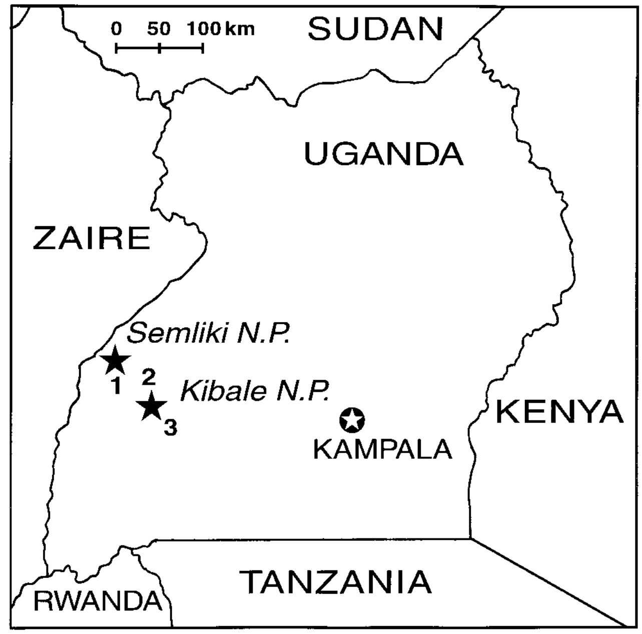

Figure 1 Diagrammatic map of Uganda indicating locations of Kibale National Park and Semliki National Park. (1 = Matayisa and Bundinyama Parishes; 2 = Kahangi Parish; 3 = Kiziba Parish)

and Semliki Conservation and Development Project (KSCDP), and was intended to reduce consumption of domestic fuelwood and alleviate the need to collect fuelwood from within Park boundaries. The objectives of this study were to: (1) compare fuelwood consumption between the improved cook-stove and a traditional three-stone fire under field conditions; (2) determine both the perceived advantages and disadvantages of the improved stove and the three-stone fire, and the specific factors influencing adoption and non-adoption; (3) assess the attitudes of residents of each of the parishes towards natural resource conservation; and (4) provide recommendations for the future direction of the KSCDP stove programme and an evaluative framework for other stove programmes implemented in developing countries.

Methods

Study sites

In late 1993, KSCDP introduced a three-pot Lorena mud stove (Stewart 1992) into three pilot parishes in western Uganda. As of December 1995, the programme involved had spread to 10 parishes and 683 stoves had been constructed. Stoves are constructed by community members from each parish who have been trained by KSCDP staff. After training, community members with a demonstrated ability in stove construction become stove promoters for KSCDP, and construct stoves in households within their parish. Materials for construction consist of 35 bricks, mud, water, sand or cow-dung, a chimney pipe, a machete, and a hoe. Each household requesting a stove must supply bricks, mud, sand and a chimney pipe. Initially, to promote the Lorena stove, KSCDP paid stove promoters for each stove constructed. Limited monitoring of the programme occurred throughout development and pilot testing, and feedback from early adopters was used to modify the initial stove design before widespread dissemination.

The study was conducted from January to June 1996 in four parishes surrounding Kibale and Semuliki National Parks: Kahangi and Kiziba parishes, located at the northern and southern tips of Kibale National Park, respectively, and Matayisa and Bundinyama parishes, located at the southern tip of Semliki National Park. The climate is tropical with two rainfall peaks from March to May and September to November (Howard 1991). Annual precipitation ranges from 1.1–1.6 m; temperatures range from 14–30 °C (Howard 1991). The primary economic activities include commercial tea, coffee, and cocoa cultivation; however, most families who participated in the study farm at the subsistence level and sell surplus crops at local markets. Predominant crops include bananas, maize, beans, groundnuts, sweet potatoes and rice. Rapid Rural Appraisals found that frequently-cited problems included fuelwood scarcity, lack of potable water, drought, termites and other pests, lack of seedlings for tree planting, shortage of land (primarily agricultural), crop damage by wildlife, low soil fertility, lack of extension services, lack of capital to finance income-generating activities, and lack of access to forest (Kibale and Semliki Conservation and Development Project, unpublished data 1993, 1994).

Data collection

Two types of monitoring activities were conducted in each parish, namely an adoption and impact survey (AS) and kitchen performance test (KPT). Both activities were conducted in cooperation with Ugandan parish extension officers working with KSCDP. Participants in both activities were randomly selected from a list of stove users and non-users provided by the extension officers as part of the experimental design. Eighty-one users and 84 non-users participated in the AS ($n = 165$), and 50 users and 50 non-users participated in the KPT ($n = 100$).

Adoption and impact survey

The AS was divided into eight sections, each concerned with ascertaining specific information on a different aspect of the improved cook-stove programme. Data were collected on cooking practices, stove promotion and perceptions, stove condition, fuelwood collection, attitudes towards conservation, non-adoption of stove, non-use of stove after adoption, and socio-demographic data. Survey data were collected through informal interviews and discussions with household members. Direct observation also was used to substantiate and supplement interviews and discussions. Households were visited once or twice per day for a period of four days. In most instances, the researcher was accompanied by a field assistant and the stove promoter, who acted as an interpreter. Visits ranged from 15-45 minutes, depending on the number of people present. Most visits occurred in the kitchen while women were preparing dinner or lunch so that cooking practices could be observed. This also created an informal setting in which respondents might have felt less inhibited during discussions. The survey target-group consisted of women from each household who were responsible for preparing meals. However, there were often other family members present, which generally prompted group discussions revealing information might not otherwise have been revealed.

Kitchen performance test

The KPT was conducted in each parish to compare the performances of the Lorena stove and the three-stone fire under field conditions. The test is recommended by the Food and Agricultural Organization of the United Nations (FAO 1985) and was conducted with the cooperation of individual families using improved and traditional stoves. Prior to the KPT, participating households were visited to discuss the rationale and procedure for the test; the ages, sexes, and number, of people being catered for per household were also determined. The number of people per household was converted to standard adult equivalents (SAE) according to FAO (1985) guidelines: children 0–14 years = 0.5 standard adult; females over 14 years = 0.8 standard adult; males 15–59 years = 1.0 standard adult; males over 59 years = 0.8 standard adult. This conversion allowed fuelwood consumption per household to be calculated on a standardized basis.

The procedures for the actual KPT were as follows. (1) A wood inventory area located in the kitchen or in a covered area outside was designated in each household on the morning of the first testing day. Fuelwood in the inventory area was weighed to the nearest 0.1 kg. Participants were asked to keep any incoming fuelwood separate until it was weighed. All fuelwood was weighed by species for the duration of the test. (2) Fuelwood remaining in the inventory area was weighed the following day. Any added fuelwood was also weighed and combined by species with the remaining fuelwood. (3) The number of times the stove was used and all types of food prepared from the morning of the first day until returning to weigh on the second day were recorded. For the purposes of this test, stove use (SU) during the testing period was standardized according to the relative amounts of time taken to prepare each meal. This standardization was based on discussions with women from each parish and observing cooking practices, and it was determined that cooking a supper equals 1.0 stove use, lunch equals 0.33 stove use, and breakfast equals 0.15 stove use. In certain cases, lunch was prepared as the main meal of the day, and under these circumstances it was counted as 1.0 stove use. Steps (2) and (3) were repeated on the third day. (4) The remaining fuelwood was weighed on the fourth day, and the total amount of fuelwood consumed per household was calculated.

Data analysis

AS data were analysed using a χ^2 test of independence ($\alpha < 0.05$). KPT data were analysed using regression analysis to determine trends in fuelwood consumption as a function of SAE / household and a general linear model to determine any significant differences in fuelwood consumption between the two stove types. For regression analysis, fuelwood consumed for a three-day period was the dependent variable in all parishes. Independent variables included SAE per household and SU during the testing period. For all general linear models, SAE per household and SU during the test were incorporated as covariates. These covariates were included to ensure that any differences in fuelwood consumption between users and non-users were not an artefact of SAE or SU, thus reducing the possibility of committing a type I error.

Results

Adoption and impact survey

Stove promotion and perception

When asked about sources of information, 51% of the respondents ($n = 165$) stated that they heard of the stove through the stove promoter in their parish. Other sources of information included the parish extension officer (30%), KSCDP workshops (20%), other community members (5%) and KSCDP drama performances promoting the stove (1%). After learning about the stove, respondents stated that they adopted the stove for one or more of the following reasons: three pot-holes allowed pots to cook simultaneously; neighbours or stove promoters encouraged adoption; fuelwood savings; attractive appearance; reduced smoke production; food cooked quickly when using pot-hole directly above fire-box; status of women enhanced and promoted; less tending required than for a three-stone fire; reduced accidents; and improved cleanliness because ashes contained in fire-box. Reasons for non-adoption frequently cited by non-users included: lack of bricks or money to buy them; lack of kitchen or permanent house; stove was not the traditional stove and / or adversity to change; stove benefits were not perceived; stove did not accept all fuelwood types; stove could not cook all foods properly; stove did not provide warmth; other family members preferred to cook on three-stone fire and refused to construct a stove; stove could not accommodate all pan sizes.

Table 2 Stove benefits perceived by Ugandan villagers. Percentages may total over 100 due to multiple responses.

Stove benefits	*% of users stating response (n = 81)*	*% of non-users stating response (n = 84)*
Cooks quickly	63.0	28.6
Saves fuelwood	60.5	28.6
Cooks several items at once	58.0	58.3
Reduces accidents and burns	38.3	4.8
Reduces smoke	35.8	9.5
Does not require constant tending	13.6	8.3
Cleanliness	7.4	2.4
More comfortable while cooking	6.2	0.0
Attractive	3.7	15.5
Keeps fire going overnight	1.2	0.0
Accepts all types of fuelwood	1.2	0.0
New innovation / technology	0.0	2.4
None	0.0	8.3

Stove users and non-users were asked to describe the benefits and disadvantages of the Lorena stove (Tables 2–3). Although non-users were not cooking on the Lorena stove, 100% of the non-users who participated in the survey had seen the stove and were able to describe what they perceived as stove benefits (Table 2). Problems of the stoves frequently cited among non-users were dissimilar to those of the users, primarily because they did not have first-hand experience with the stove (Table 3). Although stove users generally stated that they were satisfied with the Lorena stove, 48% had not completely abandoned the traditional three-stone fire for one or more of the following reasons: pans were too large to fit on stove; other family members preferred cooking on the three-stone fire because of the difficulty in lighting the fire in the Lorena stove; three-stone fire provided warmth

Table 3 Stove problems perceived by Ugandan villagers. Percentages may total over 100 due to multiple responses.

Stove problems	*% of users stating response (n = 81)*	*% of non-users stating response (n = 84)*
All pot-holes cannot cook food	49.4	0.0
Cannot accommodate all sizes of pots	33.3	19.0
Chimney does not function properly	18.5	0.0
Stove does not provide heat to warm yourself	16.0	28.6
Does not prepare all foods properly	11.1	13.1
None	9.9	23.8
Difficult to get fire started in fire-box	6.2	7.1
Does not accommodate all types of fuelwood	6.2	6.0
Uses more fuelwood than three-stone fire	3.7	1.2
Mud cracks easily / needs repairing	5.0	0.0
Does not ripen food (bananas)	2.5	3.6
Attracts ants on outside walls	1.2	0.0

(Table 3); stove was constructed outside and could not be used in bad weather; stove could not roast/grill foods properly (improper food preparation, because the fire-box is enclosed); available fuelwood, especially reeds, did not burn well in the stove; both the stove and the three-stone fire were needed to prepare a large quantity of food for visitors; insubstantial amount of heat/smoke radiated to ripen or smoke food, mostly bananas, placed on a rack above stove.

Perception of National Parks and conservation

All of the users and non-users were aware of Kibale and/or Semuliki National Parks, and were able to discuss reasons for maintaining parks in Uganda. These reasons included revenue for the government, local income from tourism, importance for future generations, provision of medicinal plants, home for wildlife, reduction of wildlife crop raiding by providing suitable habitat for animals, responsibility for rain (people believed that forests helped to maintain a normal hydrological cycle), and role as a wind-breaker. Because the conservation of national parks and their resources was the primary reason behind stove promotion by KSCDP, it is possible that those who adopt the stove do so in part because they are more concerned about forest conservation. For example, 80% of users and only 58% of non-users felt that it is generally important to have national parks in Uganda. On specific questions, Lorena stove users were significantly more supportive of parks and conservation than non-users. For example, stove users stated that parks provided local income from tourism (users = 17, non-users = 8; $\chi^2 = 4.22$, $p = 0.04$) and parks generated revenue for the government (users = 29, non-users = 19; $\chi^2 = 3.47$, $p = 0.06$). In addition, more non-users than users were unaware of any benefits of parks (users = 9, non-users = 18; $\chi^2 = 3.21$, $p = 0.07$).

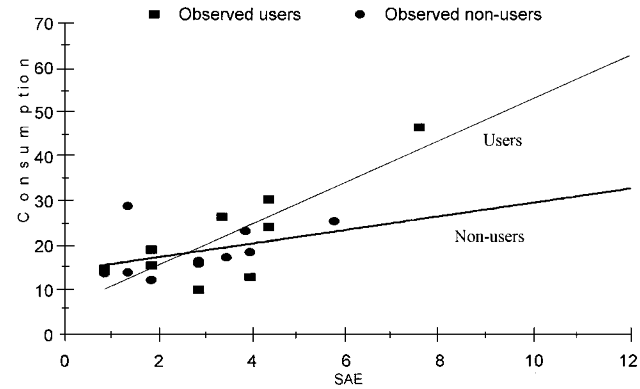

Figure 2 Plot of fuelwood consumption (kg per household per 3 days) against standard adult equivalents (SAE) per household for Lorena stove users ($r^2 = 0.69$; stove use = 3.8) and non-users ($r^2 = 0.18$; stove use = 3.8) in Kiziba parish.

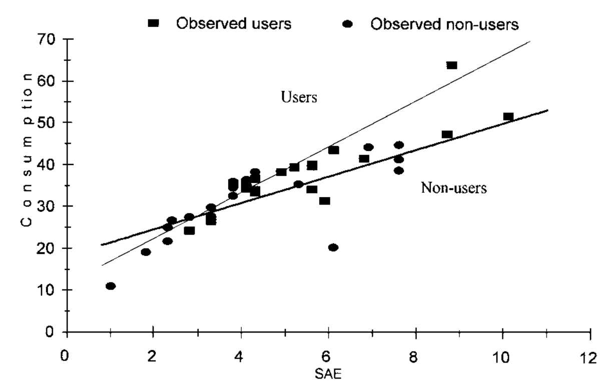

Figure 3 Plot of fuelwood consumption (kg per household per 3 days) against standard adult equivalents (SAE) per household for Lorena stove users ($r^2 = 0.86$; stove use = 4.1) and non-users ($r^2 = 0.81$; stove use = 4.1) in Kahangi parish.

Table 4 Results of kitchen performance test. SAE = Standard Adult Equivalents; SU = Stove use; U = Lorena stove user; N = non-user. Statistical signifiance: NS = not significant; * = $p < 0.05$; ** = $p < 0.01$.

	Kiziba	*Kahangi*	*Matayisa/ Bundinyama*
Total fuelwood consumed (kg/3 days)	U 217.5 N 188.1	U 759.9 N 630.0	U 684.3 N 691.2
Mean fuelwood consumed per household (kg/3 days)	U 21.75 N 18.81	U 38.00 N 31.50	U 34.72 N 34.56
Mean SAE/household	U 3.23 N 2.76	U 5.38 N 4.19	U 5.72 N 6.34
Mean SU (/3 days)	U 4.16 N 3.52	U 4.19 N 4.10	U 4.06 N 4.28
General linear model			
Treatment (user/non-user)	F=2.56 NS	F= 1.07 NS	F= 0.43 NS
Covariate SAE	F=6.17 NS	F=90.90**	F=23.14**
Covariate SU	F=5.09*	F=11.42**	F= 0.08 NS

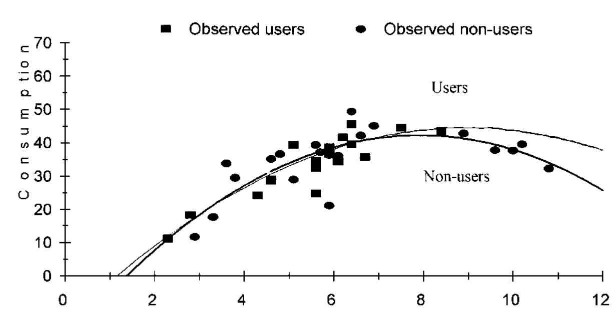

Figure 4 Plot of fuelwood consumption (kg per household per 3 days) against standard adult equivalents (SAE) per household for Lorena stove users ($r^2 = 0.89$; stove use = 4.1) and non-users ($r^2 = 0.58$; stove use = 4.1) in Matayisa/Bundinyama parishes.

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Kitchen performance test

Based on the results of the general linear model, there were no significant differences between fuelwood consumption of the Lorena stove and the three-stone fire in any of the parishes, even after adjusting for covariates (Table 4). Fuelwood species was not accounted for in the analysis of covariance or in the regression models because 60% of the total fuelwood consumption for users and non-users in each parish was derived from the same genus. There was minimal difference in the food types prepared between the users and non-users in each parish, although there were considerable differences among the three parishes. Thus we assumed that food type would not significantly affect the fuelwood consumption of the two groups within each parish.

Data from the three parishes were not analysed as a combined data set because of differences in predominant ethnic groups, types of food prepared, and type and availability of fuelwood among parishes. In Kiziba and Kahangi parishes, fuelwood consumption for both stove types increased as the number of SAE per household increased (Figs 2–3). In Matayisa and Bundinyama parishes, fuelwood consumption for both stove types increased until approximately seven SAE per household, after which consumption levelled off for users and began to decrease for non-users (Fig. 4). For all three parishes, regression trends demonstrate that, as the number of SAE per household increased, the efficiency of the Lorena stove decreased in comparison to the three-stone fire.

Discussion

The AS provided insights into people's perceptions of the Lorena stoves and three-stone fires. As with all survey data, it is possible that a response bias occurred in this study; however, the consistency of the data suggests that this effect was limited. The AS results indicated that the most frequently-cited benefits were the ability to cook more than one item at a time, the ability to cook quickly and perceived fuelwood savings. Smoke and accident reduction were cited to a lesser extent. Fuelwood savings were a frequently-cited stove benefit, yet results from the KTP suggested otherwise. It is possible that Lorena stove users are realizing time savings and equating those with fuelwood savings. A laboratory test indicated that the stove cooks faster than the three-stone fire, yet consumes approximately the same amount of fuelwood due to the heat which it generates.

The time and fuel savings, and smoke and accident reduction, which were cited by Lorena stove users as benefits are relatively common elements of construction and design (Table 1), and the Lorena stove disseminated by KSCDP has several other elements that are common to improved cook-stove programmes. For example, KSCDP's stove is constructed from locally-available materials by trained stove promoters from each village. Both of these elements were present in 48% of the programmes reviewed (Table 1). It is interesting that the Lorena stove promoted by KSCDP did not incorporate local input on the stove design from potential users, and only 26% of the programmes reviewed stated that local input contributed to stove design. It would seem that such input would be crucial for programme success; however, due to the lack of reporting success or failure in many programmes, conclusions can scarcely be drawn about the impact of such input.

Like many programmes, KSCDP targeted an area where fuel is scarce. However, this scarcity does not result exclusively from over-use, but results also from the incorporation of land into a national park, where human interference is prohibited. Several AS respondents discussed the fact that, while fuelwood was becoming more difficult to collect due to the establishment of national parks, at the present time there was still enough fuelwood available for domestic consumption. KSCDP may have perceived a more severe situation than the residents did at that time, which demonstrates the importance of ensuring that fuelwood scarcity is recognized both by programme planners and potential stove users.

KSCDP outlined goals and objectives and developed a promotion and dissemination plan based on a pilot study. Further, KSCDP developed and undertook monitoring and evaluation activities and are thus able to report some measure of success, unlike the majority of programmes reviewed. If monitoring and evaluation were undertaken on a widespread basis by improved cook-stove programmes, it should be possible to correlate various programme elements with successful or unsuccessful status, thereby increasing the potential for improved cook-stoves to serve as a tool for forest conservation.

Frequently-cited stove problems included the inability to provide warmth, pot-hole size, and improper food preparation. The majority of stove users who still cooked on the traditional three-stone fire did so because large pots could not fit on the Lorena stove. This source of failure has been acknowledged in other stove programmes; for example, in Nepal, approximately 70% of the UNICEF New Nepali Insert stove users cooked beverages, snacks, and livestock feed on the traditional stove and prepared meals on the new stove (Stewart 1992). Stove users also recognized as problems the inability of the stove to heat all three pot-holes sufficiently and chimney malfunctions. Resolving these problems may be difficult for various reasons. Because improved stoves are designed to contain and not radiate heat to the surrounding atmosphere, no stove type will provide as much warmth as a three-stone fire. Pot-hole size presents a problem because generally the pots which the stove cannot accommodate are those used for making large quantities of alcoholic beverages and palm oil, and need a large institutional-size stove. Improper food preparation (roasting) may also pose a problem, as the stove is not designed for roasting foods. To reduce complaints of chimney malfunctions it should be stressed during the promotion of the stove that regular chimney cleaning is important for smoke reduction and for increasing th efficiency of the cooking process.

Generally, the perceptions of the Lorena stove were positive among the majority of both users and non-users.

Technical problems with the stove may be addressed by experimenting with stove dimensions and design and introducing an institutional stove designed for cooking large quantities. Despite the stove problems, research results demonstrate that a desire for an improved stove exists among women in all three parishes, in part as a result of the promotion methods used by KSCDP.

These promotion methods may also influence attitudes towards conservation. For example, results of the χ^2 analysis indicate that stove users have a stronger interest in conservation, particularly since they were less inclined to state that they did not know the benefits of parks. It is difficult to determine if this correlation is the result of KSCDP's promotional strategies or simply as a result of a strong conservation ethic amongst stove users, and thus a greater desire to adopt the stove in the first place. However, the fact that Lorena stove users demonstrated support for park resources emphasizes the need to ensure that the new stoves do indeed conserve fuelwood.

The primary reason for KSCDP's implementation of an improved cook-stove programme was to reduce domestic fuelwood consumption and thus alleviate the need to collect fuelwood from the National Parks. Based on the analysis of the KTP, there is no statistically significant difference in fuelwood consumption between cooking on a Lorena stove and the three-stone fire. The regression analysis showed that the efficiency of the Lorena is greatest when used in smaller households, and the stove may actually be less efficient than the three-stone fire when used in larger households. One explanation for this may be that larger families tended to use larger cooking pots, which did not fit correctly on the stove and allowed heat to escape.

Several mediating factors should be considered when examining KPT results. For example, households could not be monitored during the preparation of every meal, and practices such as covering pot-holes when not used, covering pots when cooking, and adding unnecessary fuelwood to the fire, could not be directly observed during every cooking period. Also, the majority of users stated that any unused pot-holes were covered when cooking. Direct observations confirmed this; however, even a small number of users who stated that they covered unused pot-holes, and in practice did not, could affect fuelwood consumption considerably. Further, some pot-holes were covered with pots of water when extra pots were available; however, many pot-holes were covered with pieces of scrap metal that did not cover the entire opening and allowed heat to escape. This practice can also significantly increase fuelwood consumption. Although the aforementioned factors may affect fuelwood consumption, the significance of the KPT results lies in the fact that the test was conducted under realistic cooking conditions, which may not incorporate fuel-efficient cooking practices, and results reflect domestic fuelwood consumption under actual field conditions.

Both users and non-users stated that cooking pots were generally left uncovered, especially when preparing a full meal, due to lack of lids or other material for covering. This is unfavourable, as covering cooking pots can reduce heat loss and increase efficiency by up to 40% (Stewart 1992). Also, when tending the stove, many users inadvertently increased the fuelwood consumption by continually adding fuelwood to the fire-box, although the remaining coals were sufficient to cook food. This would have decreased the efficiency of the stove, as it is designed to cook with coals to save fuelwood. Consumption was also increased by cooking with large pieces of fuelwood rather than pieces cut to fit into the fire-box. Both practices were common amongst stove users in all parishes. Finally, although fuelwood was weighed daily and test participants were asked to keep any new fuelwood separate until it could be weighed, the possibility always exists that some participants used fuelwood which was not accounted for during the weighing. Efforts were made to minimize the chances of this occurring by ensuring that at the time of weighing participants had enough fuelwood to last until the next day. If this was not the case, the household was visited later the same day to weigh any new fuelwood that was collected. Participants understood the basis and procedure for the test and agreed to participate according to the procedure; thus it is improbable that a significant amount of fuelwood was not accounted for during the test period.

Conclusions

This study provides several general conclusions about the introduction of the Lorena stove in Western Uganda. While it is difficult to generalize these findings to other improved cook-stove programmes, it is certainly worthwhile for conservation and development organizations to consider this research before embarking on improved cook-stove development and dissemination. Further, the research highlights the need for any organization considering improved stove dissemination to monitor and evaluate the stove's performance and the perceptions of the new technology.

Generally, KSCDP's promotional activities were successful in influencing adoption of the stove, and people's perceptions of the stove are positive, even among most non-users. Problems with the technical performance of the stove can feasibly be corrected through stove modifications, proper stove usage, maintenance, and improved user education. Some stove problems, such as the inability to provide warmth, cannot be corrected. In these instances, stove benefits must be stressed during promotion, so that the perceived benefits outweigh the problems of the stove. Monitoring of the KSCDP stove programme demonstrates that future research should be directed at maximizing fuel efficiency of the Lorena stove: modifications of stove design are needed, and the necessity of efficient cooking practices should be emphasized to stove users. Several measures that may increase fuel efficiency and enhance the stove programme are given below.

- Regular stove maintenance and fuel-saving cooking practices such as covering unused pot-holes tightly, covering cooking pots, using pieces of fuelwood that do not extend from the fire-box, and cooking on coals remaining in the fire-box, should be stressed during promotion.

- Multi-pot chimney-less stoves should be constructed, as many of the chimneys were not cleaned regularly or functioning properly, thus decreasing fuel efficiency.
- Stoves should be constructed according to the size of the pots used in the household. Generally, larger families have larger pots, and require stoves which accommodate large pots to ensure efficient heat transfer.
- Doors or coverings for the fire-box entrance will produce more efficient burning and greater fuelwood savings.

Few reports of extensive improved cook-stove monitoring are available to conservation and development organizations. Given the wide variety of programme elements employed in developing and implementing improved cook-stoves, reports of monitoring activities may help establish guidelines for organizations embarking on improved cook-stove programmes. Perhaps one of the most significant aspects of monitoring the KSCDP programme was the results of the KTP, which quantified and compared the fuelwood consumption of the Lorena stove and traditional three-stone fire. Results indicate that the Lorena stove did not save a significant amount of fuelwood under realistic cooking conditions. This study suggests that the resources expended by KSCDP have not facilitated the conservation of fuelwood, and therefore forests, in communities surrounding Uganda's national parks. Moreover, the study demonstrates the importance of monitoring any stove programme to determine if conservation objectives are being met. Given the amount of money, time and resources that are devoted to improved cook-stove programmes worldwide, it is imperative that monitoring and evaluation activities occur if organizations continue to promote improved cook-stoves as a tool for fuelwood, and thus forest, conservation.

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