CHAPTER 4

Technical Solutions, MVP Infrastructure Program

The Millennium Village Project aimed to improve the lives and livelihoods of rural populations by undertaking a range of infrastructure interventions. Electricity services (grid connections, solar power), roads, water (irrigation, pumping and piping), improved cookstove programs and solar LED lantern programs were implemented across sites. The nature and scale of the projects depended on the needs of the site, as identified by the site team, and the available budget. The following details the strategy, process and progress of each of the energy and infrastructure sector technical solutions.

This chapter frequently makes references to data obtained from various sources, one of the most important being the MVP household surveying program. Summarized briefly, the MVP survey effort included a baseline and two follow-up surveys of households in each MV cluster, using several structured household questionnaires covering several sectors (health, agriculture, energy and transport, etc.) More information about the MVP surveying efforts can be found at: http://millenniumvillages.org/progress/monitoring-evaluation/ .

Electricity in the MVP

Reliable, modern energy services, particularly dependable, affordable electricity, are key to improving the health and welfare of the world's poor. Electricity in homes enables lighting for children's studies and home-based income generation. Power for markets and communities supports various income-generating activities and provide a lower-cost alternative for high power demands such as pumping for irrigation or drinking water and motive power for grinding, milling, and other agro-processing2.

However, the poorest, especially in rural areas, typically have access only to costly and unreliable energy. Essential household needs, such as lighting or mobile phone charging, are usually met by technologies that are dirty and expensive, such as kerosene wick lamps and torches powered by dry cell batteries. Compounding these issues, access to these energy sources may also be available only at substantial distances. Off-grid electricity systems—such as diesel gensets or solar photovoltaic systems in health facilities, schools, and markets—often suffer from a range of problems related to improper sizing, unmet operating and maintenance costs and poor management.

Figure 4.1: Grid Extension Mbola Cluster

The MVP has defined the following targets:

- Community-level electricity service to all markets and 50 percent of cluster households (defined as grid access to the home or within two kilometers).
- Social infrastructure (health facilities, schools, community centers and other public buildings) outfitted with electricity as deemed necessary by those sectors, in coordination with government ministries.

To achieve these objectives, the MVP has employed three primary electricity strategies targeting homes, marketplaces and social infrastructure:

1. EXTENSION OF THE ELECTRICITY GRID

The cost of grid extension, and thus the viability of electricity access programs, varies greatly, depending upon factors such as population density and settlement patterns, household electricity demand, efficiency and the effectiveness of utilities in construction and cost-recovery, the availability of key materials and equipment within the country. Table 4.1 shows the cost range for medium voltage (MV) and low voltage (LV) line per km in the projects where MVP contributed substantially to funding, or solicited cost estimates to do so.

Table 4.1 Cost of Grid Extension for Medium (MV) and Low voltage (LV) line, $ per Kilometer

Site		MV (Avg: 33/11 kV)	LV (220 V)
Country	Cluster	US$ / km	US$ / km
KEN	Sauri	$25,600	$8,500
MWI	Mwandama	$ 29,000	$ 16,000
RWA	Mayange	$ 48,046	$ 18,000
TZA	Mbola	$ 33,520	$ 19,633
UGA	Ruhiira	$ 40,000	$ 20,000
GHA	Bonsaaso	$ 13,000	$ 10,000
MLI	Tiby	$ 28,500	N/A
NIG	Pampaida	N/A	$ 9,868
SEN	Potou	$ 17,688	$ 15,477
AVERAGE		$ 29,419	$ 14,685
MAX		$ 48,046	$ 20,000
MIN		$ 13,000	$ 8,500

Table 4.2: Estimated Percent of Population with Grid Access at the Community Level (within 2 km): Baseline and Year 5.

Site	Percentage of population with grid access at community level (within 2 km of household)		
	Baseline	Year 5	Notes
1. Koraro	30 %	> 80 %	
2. Dertu	0 %	0 %	Grid deemed infeasible for this site
3. Sauri	60 %	80 %	
4. Gumulira	0 %	0 %	Budget limits prevented grid extension
5. Mwandama	< 10 %	50-60 %	
6. Mbola	30 %	35 %	(SharedSolar being implemented)
7. Ruhiira	0 %	13 %	(SharedSolar being implemented)
8. Mayange	20-30	60 %	
9. Tiby	0 %**	0 %	(SharedSolar being implemented)
10. Bonsaaso	0 %	70-80 %	
11. Potou	0 / 30%	50–60 %	
12. Toya	0 %	0 %	Grid deemed infeasible for this site
13. Pampaida	20 %	50 %	
14. Ikaram***	> 90 %	> 90 %	

*A gridline existed in Potou, but was not yet electrified at the start of the project

*A diesel mini-grid system provided inconsistent service to roughly 20% of the cluster at baseline.

**Grid coverage was nearly universal in Ikaram at the start of the project.

These data are insufficient for a detailed examination of all the factors influencing grid extension costs in various countries. Nonetheless, it is important to note that—particularly if planning covers a long (10-20 year) timeframe and a sufficiently large scale and population (roughly the district level or above)—unit costs for widespread electrification can be reduced substantially through what is sometimes referred to as a "mission-oriented" approach. This approach emphasizes features such as bulk procurement to reduce equipment costs, lower connection fees to raise penetration rates and better metering and management to improve the recovery of operating costs for dramatic overall cost reduction. Important examples in Tunisia and South Africa (among other countries) have carried out national electrification programs at remarkable rates, in a cost-effective manner.

In rural areas, population densities and consumption levels are such that the initial costs of grid electrification can be as high as $1000 per household. In such settings, while connections to households and businesses should be achieved where possible, it may be most cost-effective overall to target grid connectivity in key markets and trading centers, and social infrastructure such clinics, schools and government offices.

In much of Sub-Saharan Africa, if the distance to extend the grid is on average less than two kilometers per community, and each community averages 2,000 people, and extension costs are below $25,000 per kilometer of MV line, then an initial investment of $50,000 per community represents a $25/capita initial investment. This is a reasonable investment for the benefits of a low cost, load-following, scalable electricity supply, even if reasonably reliable grid power is available. With tariffs typically between $0.10 - 0.25 per kWh, the recurrent costs in terms of actual electricity supply costs for such an investment are affordable.

Unfortunately, in much of Sub-Saharan Africa, access

Figure 4.2: Solar Electrified Clinic Mbola

to modern energy services remains limited. This trend has been reflected at all the Millennium Villages except Ikaram, Nigeria. Thus, a central part of the MVP energy strategy has been to support the extension of the electricity grid to communities, households and key demand points such as social infrastructure in three ways:

First, MVP encourages grid extension indirectly, through non-grid related investments in communities, such as in the construction of clinics and schools and a range of interventions that promote higher incomes. Such investments in public facilities and programs raise the benefits of grid extension by enabling government ministries to improve the quantity and quality of related services. Meanwhile, investing in household income-generation raises the benefits of grid extension for utilities by strengthening and expanding their client base of household ratepayers.

Second, the MVP supports grid extension directly, by funding in full or in part the extension of both low and medium voltage grid lines. This strategy can be particularly important in extending the grid to key demand points, such as water pumping or agro-processing sites, or to small population centers, which may not be part of government or utility grid extension plans. The strategy targets larger and/or more aggregated population centers where grid extension will have the most impact. Crucially, MVP strategy holds that grid extension should be complemented by other technologies, such as off-grid power systems and portable lanterns, particularly for household electricity needs in areas where grid extension is not cost-effective.

Third, where the grid is extended, a related aim is to promote electricity connections to households and businesses by reducing fees and administrative barriers. This may mean financial support for communities or individual customers (households, businesses) or assistance in community organizing and sensitization efforts. Whatever the specific strategy, a key goal toward increasing penetration rates has been to reduce connection costs for the consumer to about $50.

Furthermore, energy projects were designed to reduce the time and effort spent on grinding grain and other agro-processing activities, as well as lifting water for drinking or irrigation. These MVP energy interventions reduced the time-labor burden on women and encouraged economic growth through increased agricultural yields.

Table 4.3. Cost of Institutional Solar Photovoltaic Systems (US$ per peak Watt installed)

Country	MVP Cluster	Year	Number of Systems	Average Cost (US$/Wp)
Senegal	Potou	2007	6 systems	$ 17.85
Ghana	Bonsaaso	2007	6 systems	$ 9.59
Ethiopia	Koraro	2008	15 systems	$ 26.78
Mali	Tiby	2007	7+ systems	$ 15.72
Tanzania	Mbola	2008	7 systems	$ 22.54
			ALL SITES HIGH	$ 26.78
			ALL SITES AVERAGE	$ 18.50
			ALL SITES LOW	$ 9.59

2. OFF-GRID STANDALONE SYSTEMS FOR KEY SOCIAL INFRASTRUCTURE

While modern energy services provided by grid electricity should ideally be available to all communities and households, in many locations a grid connection is simply not cost effective in the next 5-10 years. Under these circumstances, off-grid approaches can provide reliable energy for essential services—particularly for urgent health needs—without delays.

For initial demands of less than 4 kWh per day, which is likely at small clinics and schools, the most likely choice is a solar PV system with battery storage. For every kWh of daily use, an approximate upper limit for a small clinic, the expense is about $5,000 in initial system costs (see Table 4.3 for costs in practice).

Off-grid approaches that rely on high initial cost per unit capacity (e.g., solar systems) will need to ensure that operations, maintenance and reinvestment (particularly in batteries) are planned and budgeted. Related concerns include ensuring the proper training of site personnel, choosing the type and number of electric appliances to ensure demand is manageable and ensuring a thorough understanding of cold chain requirements.

At consumption levels above 4 kWh per day, or in locations with poor solar insulation (such as coastal areas of West Africa), other options, such as hybrid solar-diesel options, or relying on gensets during peak load times, should be considered.

3. MICRO-GRID (SHAREDSOLAR) FOR HOUSEHOLDS, MARKETS, AND OTHER OFF-GRID SITES

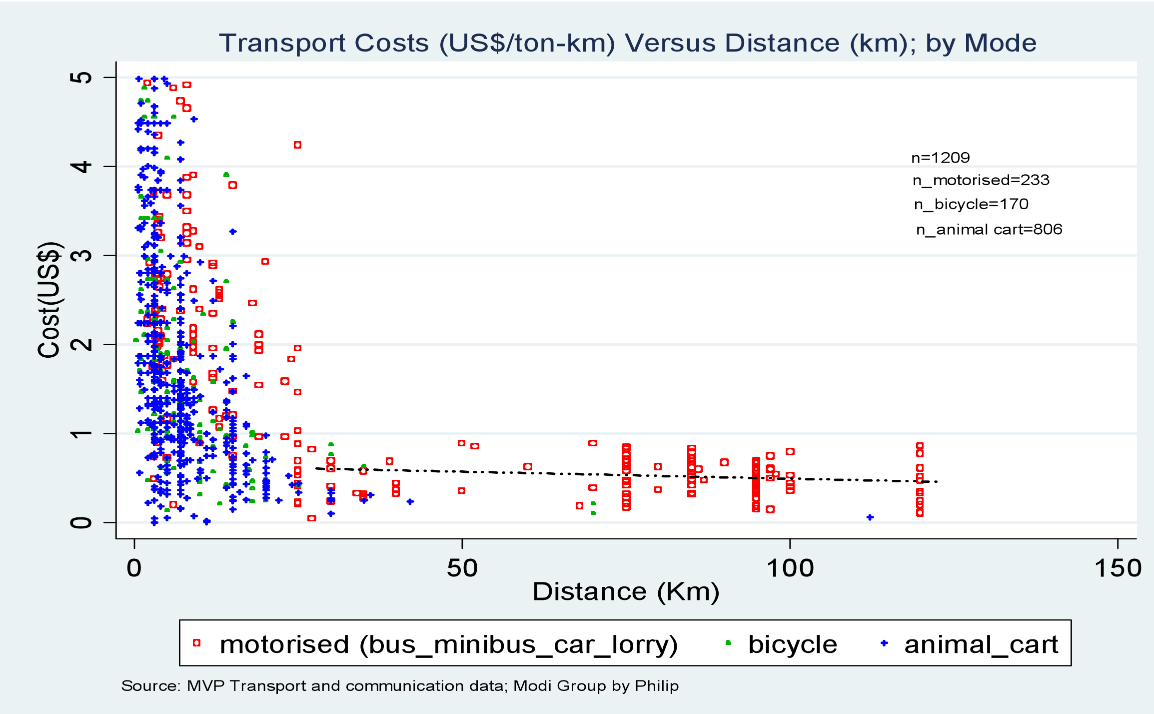
Solar home systems have typically been unaffordable for most households in the MVP locations and typically provide too little power for business needs. Generators, while popular in shops, are typically used only for limited applications, due to high fuel costs and the short operating life of very small petrol engines.

In response, MVP has taken two complementary approaches. For very small power needs in households (room lighting and mobile phone charging), MVP has developed distribution programs for portable, solar, rechargeable LED lanterns, generally with bulbs and panels of roughly one watt. For higher wattage needs in homes and businesses, MVP has introduced a novel electricity technology, SharedSolar, employing solar photovoltaic electricity generation coupled with an automated metering and payment system in which users purchase scratch cards and receive prepaid, metered power in their homes on a pay-as-you-go basis. (see Chapter 5.) Diesel mini-grids, particularly when implemented with careful metering and attention to the efficiency of end-use devices, is another option, as are portable batteries, recharged centrally and carried to the home.

These technologies are considered transitional in that they provide rural areas with an increased range of electricity options, at various costs, for immediate scale-up until access to the power grid becomes locally viable, as is likely with economic and population growth, or gradual grid expansion nearby. The low up-front costs of such solutions are key in that they allow them to be easily replaced. The higher recurrent costs of such technologies are less of an issue since consumption levels are likely to be low during this transition. For example, the generation and fuel costs of diesel-based electricity do not exceed $0.40/kWh if diesel costs are below $1/liter. Even at this relatively high generation cost, the recurrent electricity expense is still lower than the recurrent cost of kerosene for lighting currently being shouldered by many rural poor.

It is important to note that as population, incomes, costs and technologies change, other technologies may become more cost effective. Renewable energy technologies, particularly solar photovoltaic with battery storage, may be the cheapest option in conditions where power demands are small and fuel is hard to obtain reliably. Decentralized energy systems may also permit the use of local biomass to produce electricity (e.g., via biomass gasification). If such systems can be scaled down to one or several households and made low-maintenance, they could potentially become the preferred electricity source for rural areas

Figure 4.3: Transport Costs (US$/ton-km) Versus Distance (km) by Mode



Roads

TRANSPORTATION SERVICES

Transport in most poor, rural areas means walking long distances carrying heavy loads. Some modern transport services that are widely recognized include motorized ambulance services for medical emergencies; faster means of getting to school and less burdensome means of carrying goods to market, or just to the roadside. These interventions often rely upon motorized vehicles, but may, be intermediate transport technologies, such as carts or bicycles. Road improvements themselves are crucial.

An analysis of the MVP transportation data and patterns shows, the costs of transport are high and highly variable for distances up to 10 kilometers and reduce gradually for longer distance across all modes. Non-motorized transport is mainly used for distances up to 20 kilometers, while motorized transport is mostly used for longer trips, at a much lower and stable price of around $0.65 per ton-kilometer. The cost of moving commodities is high—above $2 per ton-km for distances up to 5 km but below $2 for distances above 5 km. The implication of these findings is that the market/trade for non-grain goods is localized while that of grains is diverse.

ROAD ACCESS

Road improvements can both enhance transportation and build local capacity. Villagers' participation in planning, constructing and maintaining road works can build local knowledge and capacity while establishing links and influence with local government.

The MVP has defined the following targets:

- Community-level road access to all market centers and (50-80%) of households (an all-weather road within 2 kilometers of the home)

Table 4.5: Costs of Moving Grains and Non-Grain Commodities

	Average costs in in US$ per ton-km with standard deviation (in parentheses); and n, number of observations									
Goods Transported	0-5 km		5-10 km		10-15 km		15-20 km		>20 km	
	Costs	n	Costs	n	Costs	n	Costs	n	Costs	n
Grains/Cereals	2.79 (1.15)	99	1.58 (0.77)	89	1.29 (0.81)	37	0.66 (0.25)	17	0.65 (0.61)	65
Fruits/Veg/Nuts	2.56 (1.13)	218	1.69 (0.88)	77	1.48 (0.51)	13	1.35 (0.47)	4	0.71 (0.71)	42
All goods	2.63 (1.14)	317	1.63 (0.82)	166	1.34 (0.74)	50	0.79 (0.40)	21	0.70 (0.63)	197

- All-weather road access for social infrastructure (health facilities, schools, community centers and other public buildings) as deemed necessary by those sectors, in coordination with government ministries.

Main interventions for this sector:

- Construction of new facilities: This reduces the distances that villagers need to travel for essential services. Also, the investment by MVP increases the likelihood of government maintenance.

- Provision of transport services: This may include a cargo truck that functions as a “village vehicle” to improve market access, or a program to introduce “intermediate” technologies (carts, bicycles, etc.) for local transport.

- Construction and rehabilitation of roads: While this typically includes some new construction, the majority of the Project’s work follows a “spot improvement” approach.

Data on MVP roads rehabilitation projects provide the following information on costs per kilometer. Generally, these refer to gravel roads six to seven meters wide, including culverts and small structures and side drainage. Key factors affecting costs include local topography, thickness of gravel layer and quality of materials.

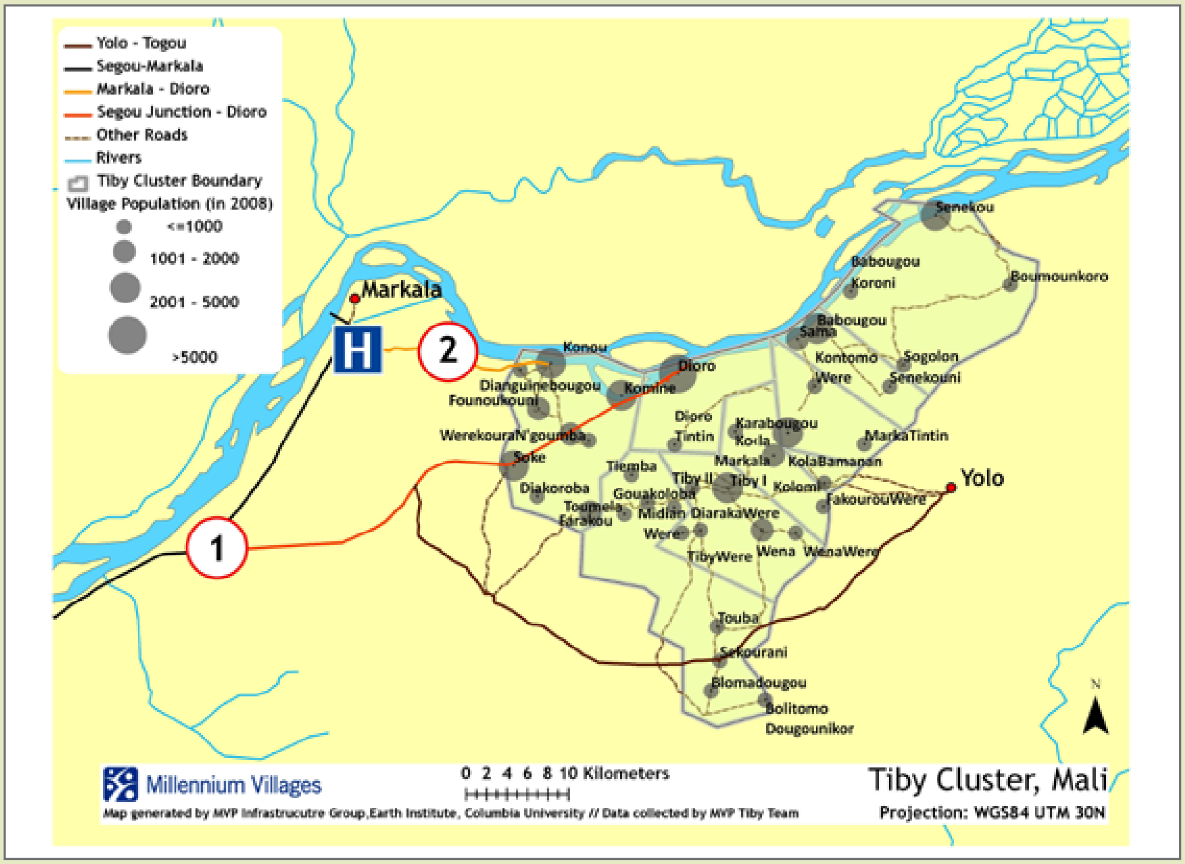
Table 4.6: Road Rehabilitation—average cost per km

Country	MVP Cluster	Year	Kilometers of road rehabilitated	Average Cost ($/km)
Senegal	Potou	2009	18 Km	$ 17,590
Ghana	Bonsaaso	2011	17 Km	$ 18,775
Ethiopia	Koraro	2010	23 Km	$ 30,435
Mali	Tiby	2010	65 Km	$ 13,500
Tanzania	Mbola	2010	13 Km	$ 21,154
			ALL SITES HIGH	$ 30,435
			ALL SITES AVERAGE	**$ 20,291**
			ALL SITES LOW	$ 13,500

Village Vehicles in Koraro and Dertu

At baseline, the lack of available transportation to nearby towns was one of the main problems for villagers of Koraro, Ethiopia, and Dertu, Kenya. Transport of farm produce, animals, materials such as building supplies, and people were all severely limited, and, when it was available, it was expensive. To improve this problem in Koraro, in early 2006, MVP helped obtain a community-run NPR ISUZU truck. The truck is managed by a Track Managing Committee, a driver and permanent assistant. In year five, the truck continues to run between Koraro and local towns, provides free services to emergency patients and is available to all residents on a fee-for-service basis, depending on the distance traveled. For villagers in Dertu, the combination of the community vehicle and the road rehabilitation has reduced costs per ton of cargo transport by 50 percent. The fee-for-service model allows the community-managed transport to generate revenue that covers the recurring costs of the service. The communities benefit from increased access and have been able to save money toward major repairs. ■

Village Vehicles in Koraro, Ethiopia (bottom), and Dertwu, Kenya (top).



New Road Connects Tiby to Markets

In April 2009, the Millennium Villages Project completed construction of a new road connecting the Tiby, Mali, cluster to the major nearby town of Markala. By connecting the villages of the Tiby cluster to health services and a major market center, the new road is helping to achieve the income and health Millennium Development Goals.

Top: Map of situation of the Tiby cluster area
Bottom: New Road to Markala

Before construction of the new road there was no direct route from the Tiby cluster to Markala. Patients with medical emergencies had to travel 70 km—more than an hour's drive (map point 1)—to reach the referral hospital in Markala. Now, the new road along the Niger River provides a shortcut to the hospital (see map point 2), reducing the travel distance to 30km—less than a half hour drive.

With one of the only bridges in the region, Markala also attracts people from either side of the Niger River to create a bustling market center with internet cafes, fish markets and much more. The new road connects these services to people in the Tiby cluster, creating a broader market for their products. ■

Figure 4.4: Water Pump for School Facility (left); Public Tap (right), Tiby, Mali

Water and Sanitation

Access to safe drinking water and adequate sanitation, in conjunction with good hygiene, are key factors in the health and development of rural communities and for agricultural production. As of 2004, 322 million people in sub-Saharan Africa lacked access to an improved drinking water source.

Governments have several alternatives when drafting water supply development plans to meet the MDG for drinking water access, which will require building infrastructure and providing access to an additional 28.8 million people annually until 2015.[4] Appropriate solutions vary tremendously from place to place depending on water resource availability, setting, socioeconomic standing of the users, existing infrastructure, availability of energy, topography and other factors. There is no single accepted system based solely on demographic data to estimate costs or the best type of water infrastructure to provide. In most cases, local expert knowledge is key to evaluating the multiple variables that inform the choice of technology.

For improved water supply, the options employed by the MVP include protecting water sources such as springs, boreholes and piped water systems. A generous donation of piping from JM Eagle has been essential for providing improved water access for more than 120,000 people in MV sites in Senegal, Mali, Ghana, Uganda, Tanzania, Malawi, Kenya and Rwanda. The first, in Potou, Senegal, provides an example of the overall approach.

The site team in Potou drew up technical plans to construct a system throughout the cluster. Potou was chosen to be the first recipient of the piping donated by JM Eagle, as the local government and national water agency there were concurrently completing a complementary system in the project zone. The site team received and installed approximately 67 miles of PVC piping and public taps in 2008. Since October of that year, some 13,000 people in more than 80 villages have used the system. It is managed and operated by the community with technical support from the public water agency.

Following the success of this system, similar projects were initiated at seven other sites. Table 4.8 provides an overview. Fifty-five containers with more than 260 miles of PVC piping) are currently in the process of being installed in the MVs.

While the piping for these projects was donated, an estimation of its value is presented in Table 4.9 along with the costs of installing drinking water systems, other infrastructure and the total cost per capita of the systems. Note the costs do not include irrigation.

4. WHO (World Health Orgaziation), UNICEF. Meeting the MDG Water and Sanitation Target: The Urban and Rural Challenge of the Decade. Geneva, Switzerland: World Health Organziation, 2006.

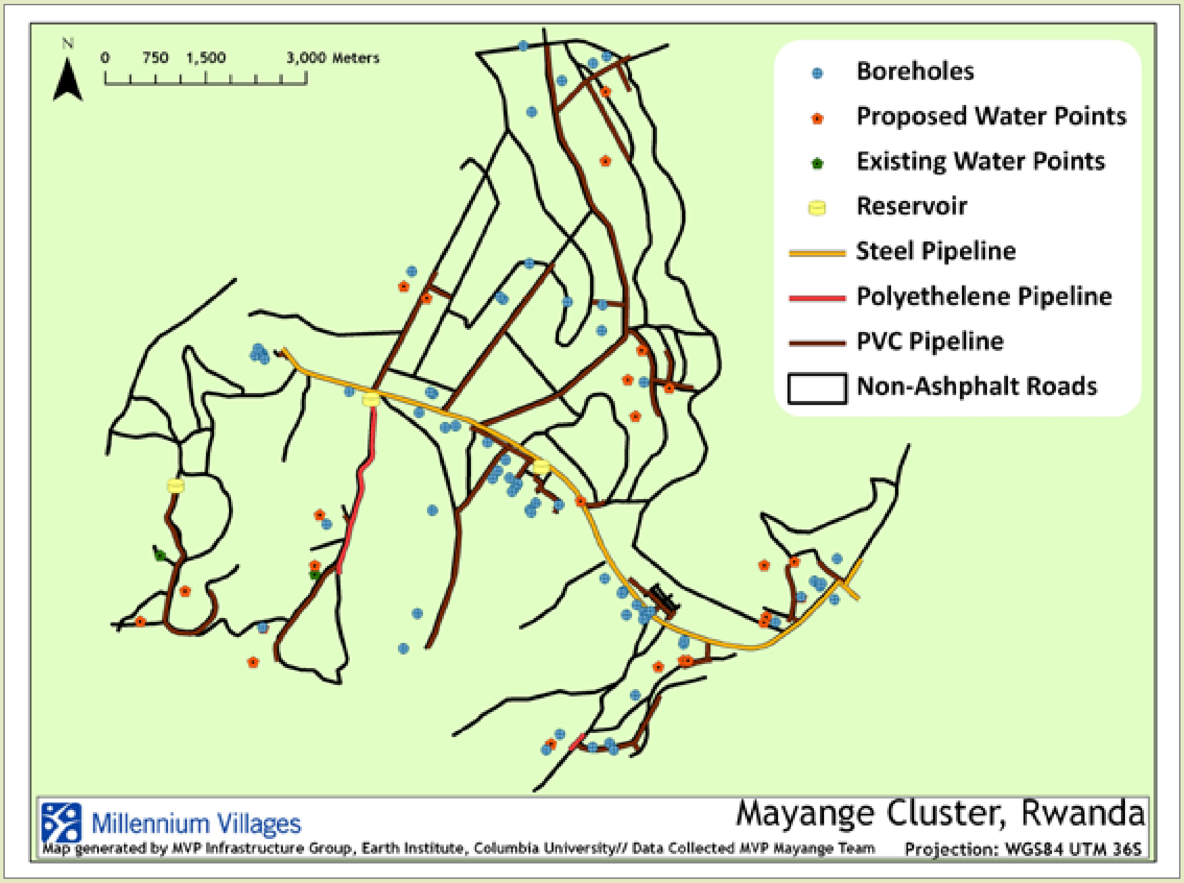
Figure 4.5: Health Clinic Water Storage Tanks; Potou, Senegal

Table 4.8. Piping Projects: Technical Overview and Project Timeline

Site	No. of Taps	Drinking water length (miles)	Irrigation length (miles)	Total length of piping (miles)	Start Date	Completion Date
Bonsaaso	66	58	0	58	Early 2011	End of 2011
Mayange	70	37	4	41	Early 2011	End of 2011
Mbola	26	22	3	3	July 2010	Mid 2011
Mwandama	27	9	0	9	Mid 2010	Mid 2011
Potou	85	67	0	67	Early 2007	End of 2008
Ruhiira	311	71	5	75	Early 2011	End of 2011
Sauri	15	20	3	23	Early 2011	Mid 2011
Tiby	91	62	0	62	Early 2011	End of 2011
Totals	**691**	**345**	**15**	**360**		

Table 4.9. Water Piping System Initial Costs: Total and per capita, for all MVP Sites (Estimated)

		Piping Costs (Value of JM Eagle Donation)		Non-piping Costs		All Costs (piping and non-)	
Site	Population to be served	Pipe Value	per capita	Tower, Gensets, etc.	per capita	Total	per capita
Potou	13,500	498,780	37	340,000	25	838,780	62
Bonsaaso	16,633	379,790	23	902,000	54	1,281,790	77
Tiby	38,921	526,490	14	1,296,000	33	1,822,490	47
Mayange	18,900	117,360	6	236,000	12	353,360	19
Ruhiira	21,922	291,770	13	2,506,000	114	2,797,770	128
Mbola	5,660	146,700	26	200,000	35	346,700	61
Mwandama	2,666	88,020	33	95,000	36	183,020	69
Sauri	3,500	58,680	17	128,000	37	186,680	53
Totals	**121,702**	**2,107,590**	**21**	**5,703,000**	**43**	**7,810,590**	**64**

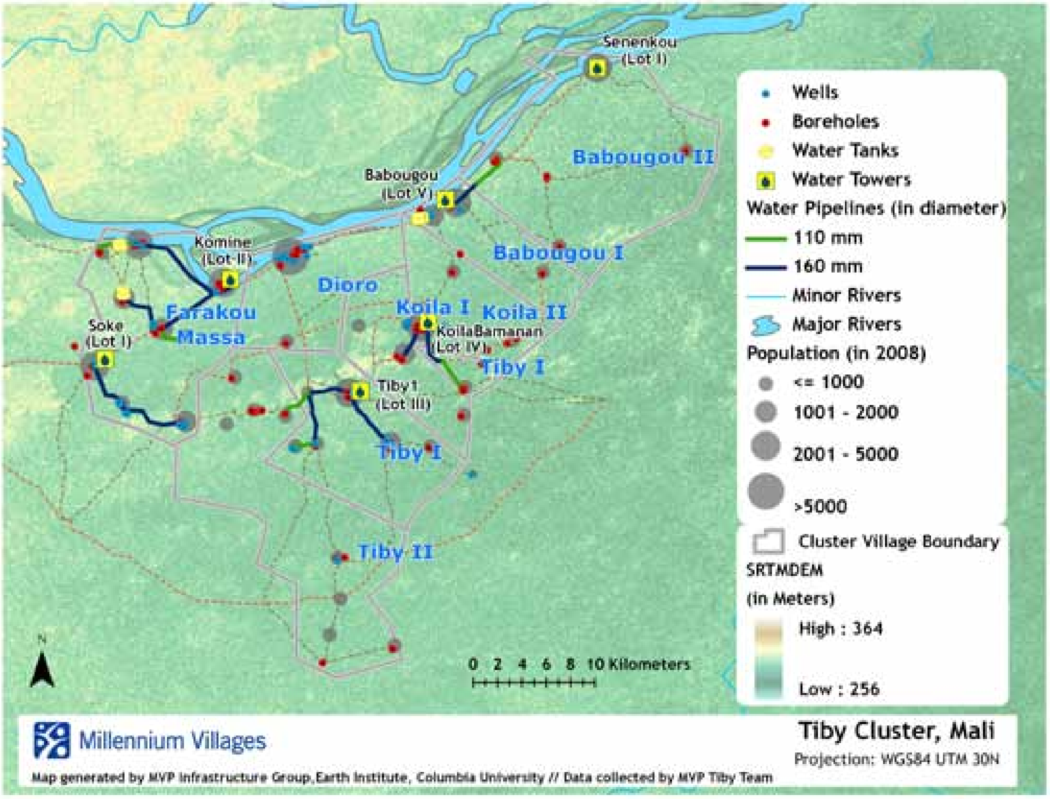


Lessons in Shared Infrastructure—Water in Mayange

Village Vaehicles in Koraro, Ethiopia (top), and Dertu, Kenya (bottom).

The MVP site of Mayange, Rwanda is an example of local government and the Millennium Villages Project collaborating to provide benefit to both the local water district by creating more infrastructure and service points for increased revenue but also to MVP in helping to reach the Millennium Development Goal of improved access to safe, clean water. Prior to the Millennium Villages Project, the Mayange sector had few public water points available through the existing piped water system that were located on the main road running through the sector. Villagers would have to travel as far as 4km over steep gradients to reach the few public taps.Since the implementation of MVP in Mayange, several new boreholes with hand pumps have been developed, creating more access to groundwater.

Now, an extension of the piped and treated water system is taking place. Nearly 60 of piping will be installed when the project is complete and a total of 70 new water points will be constructed where water will be sold. The expanded system will provide 20 to 40 liters per capita per day of clean water to the 18,900 villagers of Mayange. The population coverage of the new system is expected to be greater than 90%. ■



Piped Water in Tiby

Before the Millennium Villages Project, the prospect of a centralized, multi-village piped water delivery system was unheard of in rural Mali. Most Tiby cluster residents relied on local wells, many of which dried up during Mali's long dry season, forcing women and children to walk miles for water. The lucky few with access to an improved water source—who at baseline comprised just 16 percent of its 64,000 residents—drew it from local boreholes, many of which had broken pumps, or delivered contaminated water. To meet the MDG of improved access to safe, clean water, the MVP team initially considered adding handpumps to the boreholes but determined instead that it would be cheaper and faster to link many villages to one water source. When completed, the new, piped water system will connect six existing boreholes that access—each outfitted with a solar or diesel powered pump serving a 15-meter water tower -- which in turn connect to a 65 mile long piped water distribution system that reaches all residents, who can draw from a water kiosk for a small fee. ■

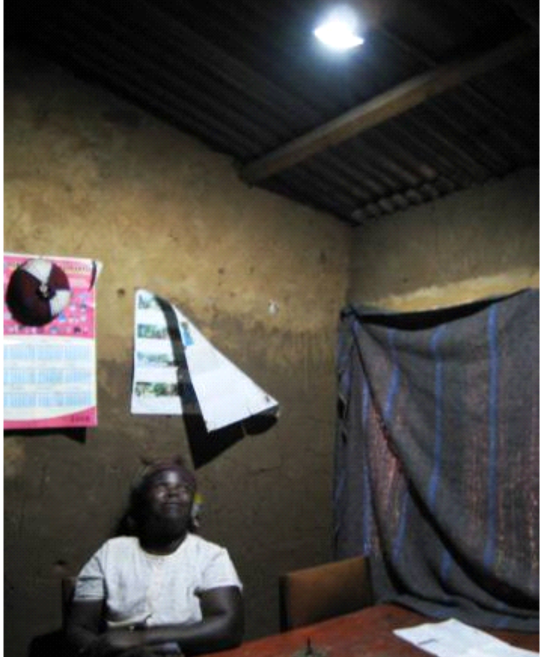


Figure 4.6: Solar Lanterns in the MVs

Lanterns

Rural populations in the poorest parts of the world typically rely on inefficient, expensive lighting options such as kerosene, candles, and low-quality electric lanterns powered by disposable, dry cell batteries. While cell phone penetration even in rural parts of the developing world has risen rapidly in recent years, these communities often lack grid electricity, making phone charging difficult and expensive.

According to the MVP baseline survey, the most common energy source for lighting is kerosene, which was reported as the primary or secondary energy source by an average 85 percent of households across the sites, followed by dry cell batteries, at 39 percent, and candles, at 21 percent. The exceptions were Dertu (KEN), where households also relied heavily on dry cell batteries—perhaps reflecting a reliance on flashlights consistent with the pastoralist population—and Ikaram (NGA), which had significant grid coverage.

Across all MV sites, households spent an average $58 per year on fuels and $17 per year on batteries. Of these energy expenses, $21 was for cooking and $41 was for lighting and electricity. Kerosene accounted for the bulk of fuel expenses across the villages, followed by fuelwood and charcoal.

Table 4.10: Total Fuel Expenses Per Household Per Year (USD)

	Kerosene	Fuelwood	Charcoal	Candles	All other fuels	Sum
Bonsaaso (GHA)	51.37	5.69	2.93	18.53	1.52	80.04
Ikaram (NGA)	48.81	15.35	6.98	1.90	0.00	73.04
Mayange (RWA)	11.66	24.22	0.00	1.69	0.59	38.16
Mbola (TZA)	33.10	5.45	4.47	0.35	0.59	43.97
Mwandama (MWI)	12.08	3.97	1.88	7.31	0.40	25.64
Pampaida (NGA)	48.62	16.44	0.25	0.48	2.17	67.95
Ruhiira (UGA)	15.10	4.83	2.09	2.44	0.70	25.16
Tiby (MLI)	55.80	41.66	9.39	1.16	4.10	112.11
Average (all sites)	**35.72**	**35.86**	**8.81**	**8.33**	**9.90**	**58.26**

Table 4.11. Lantern Programs in the MVs

Site	Program Start Date	Total Sales (Units)	Price to end user	Vendor Margin
Mwandama, Malawi	May, 2009	1000	$38	$3
Bonsaaso, Ghana	April 2010	402	$38	$3
Ikaram, Nigeria	October 2010	256	$36	$2
Pampaida, Nigeria	April 2011	56	$36.80	$3
Potou, Senegal	November 2010	168	Novas: $39 Kirans: $15	$3
Tiby, Mali	January 2011	139	Novas: $35 Kirans: 17.5	Novas: $3.5 Kirans: $1.70

Cutting Household Kerosene Expenditure: Solar LED Lantern Program in Malawi

In 2009 an improved LED lantern program was launched in the MV cluster of Mwandama, Malawi. Prior to purchasing lanterns, most households in the cluster were spending between US$2-4 monthly on kerosene to light their homes. Surveys conducted in 97 households who bought the lanterns -- first one week after purchase, and then again three to five weeks after—showed large decreases in expenditures on less efficient lighting options. Among lantern buyers, the average annualized drop in household lighting expenditures was $47 per household with a median of $37. Taking into account these avoided recurring expenditures, the majority of customers paying $29 for the LED lantern on cash basis had an average "payback period" of less than one year. Each lantern is expected to last several years, and return visits to households 12-14 months later showed that not only were lanterns generally still working well, but many households had purchased additional units. The cluster site team is still working to establish a system to allow for battery replacement after 1.5 years , extending the devices useable lives by years at low cost (<US$5 per battery). ■

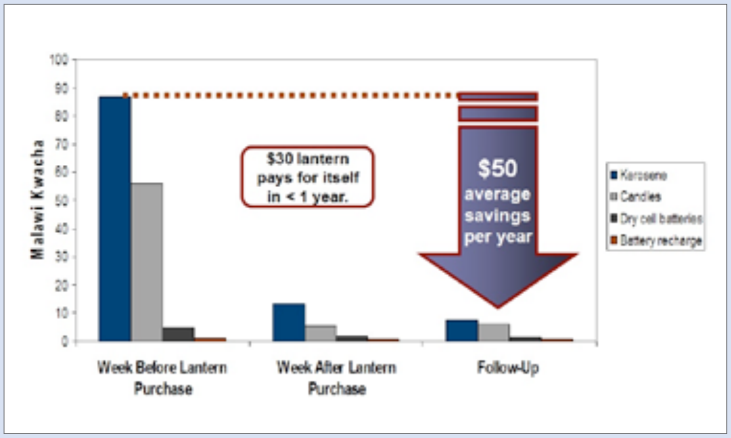


Photo 4.7: Lanterns Charging; Bonsaaso, Ghana

Figure 4.8: Controlled Cooking Tests in the MVs

In this context, portable, solar rechargeable lanterns with efficient LED bulbs offer rural households a cost-effective technology that delivers more light at lower or equal cost to kerosene. The MVP approach of introducing rechargeable LED lanterns is market-based, in which village-level vendors sell lanterns at full-cost (no-subsidies), spurring entrepreneurship at the local level. The first trial lantern program implemented in the Mwandama, Malawi, MV site showed significant benefits to households, who decreased purchases on kerosene and batteries by 90 percent, and vendors, who increased their income.

Based on the Mwandama pilot, the MVP has launched six lantern programs in five countries. A seventh program will launch in Tanzania in 2011. The programs employ the same basic approach, with adaptations for local conditions. Lanterns were tested by EI in New York to identify those with high technical performance, then imported from international suppliers and tested to identify preferred models. These were shipped to the MV sites and sold via a private sector led effort, in which margins were added at each step in the supply chain and lanterns were sold to villagers at full-cost (no subsidy). The ultimate goal of the MVP lantern program is to spur a self-sustaining commercial supply chain via a phased approach in which the initial technical support and oversight can be replaced by strong commercial supply chain. Village businesses should have a stake in continuing the program, with the wholesalers and retailers profiting from each sale.

The cost of each MVP lantern program varied, based on the length of the consultant's stay and the amount of original investment. The general costing: three months of consultant salary and expenses, and an initial investment of $20,000 in lanterns to be used as a rotating fund. Additionally, several sites hired local household energy program managers for one year and also budgeted for promotional activities. These additional expenditures proved crucial to the programs'

Table 4.12: Lantern Program Cost

Expense	Per-month	3 Month Launch
Consultant Salary	$5,000.00	$15,000.00
Consultant Expenses (including travel)	$2,000.00	$6,000.00
Initial lantern investment (rotating fund)	$20,000.00	$20,000.00
Suggested Expenditures		
Marketing	$600.00	$1,800.00
Household Energy Program Manager	—	$12,000.00
Total		$54,800.00

sustained success. The budget in Table 4.12 provides a rotating fund with the capacity to provide 100 percent lantern coverage to the cluster.

KEY LESSONS:

- **High demand for lanterns at a low price:** Data demonstrates that rural villagers are willing to pay market price for a lantern. Studies of lantern pricing at MVP sites show that 70%–80% of respondents are interested in purchasing the lanterns for \$40–\$50, while demand drops to 10%–20% at \$70–\$80. Projects must therefore keep prices low to maintain demand.

- **A Range of Benefits:** these appliances can save households money and time, allowing owners to forego travel of 5–10 kilometers for phone charging or purchase of kerosene or dry-cell batteries, and lanterns increase the quality of lighting. A decrease of 85–90 percent in kerosene expenditures among households who purchase the lanterns (this equates to a 6–9 month "payback" period) .

- **International Supply Chains Remain the Most Important Challenge:** Results suggest that a private sector led approach can be sustainable and scalable. However, this requires national and international supply chains, which in most countries are weak or absent. Efforts are underway to strengthen these chains. Lantern manufacturers are meanwhile working to establish regional distributors, and the availability of lanterns to rural populations will ultimately depend on their success.

Improved Cookstoves

Roughly half of the world's population burns solid biomass fuels—predominantly collected fuelwood and charcoal—for cooking and heating. Throughout poor, rural areas of the developing world, biomass is the dominant fuel, and cooking is usually performed using a simple three-stone fire (or "open fire"), often in poorly ventilated structures. The inefficient and incomplete combustion of these fuels without good ventilation produces indoor concentrations of health damaging pollutants. Moreover, women and children, who are primarily responsible for gathering fuelwood for cooking, may spend many hours searching for it each week.

An analysis of MVP baseline data revealed that the two most commonly used cooking fuels were wood and farm residue, at 74 percent and 12 percent respectively. Fuelwood was primarily used and mostly collected by women.

The majority of fuelwood used in households across all MVP sites (79 percent) was acquired via collec-

The MVP Stove Program:

The MVP Improved Cookstove Program model recognizes that cooking practices, biomass composition and locally cooked foods vary by country and region and that all of these can impact a stove's efficiency. In order to select the stove best suited to local conditions, the MVP conducts Controlled Cooking Tests (CCTs) and surveys to determine stove fuel efficiency and user preference. Using these results, the MVP launches demand-driven stove programs that spur entrepreneurship and encourage the adoption of efficient cookstoves in the MVs.

- Conducted CCTs at eight sites across seven countries to test locally made stoves, Envirofit stoves, and StoveTec stoves against the three-stone fire.

- Launched results-based household stove programs in five sites across four countries: Uganda (Ruhiira), Ethiopia (Koraro), Mali (Tiby), and Nigeria (Ikaram and Pampaida).

- Sold over 7,000 household stoves at a 0%-50% subsidy.

Figure 4.9: CCTs: Simultaneous Cooking Tests on Multiple Stoves (left); Weighing Fuelwood Consumed (right)

tion, whereas 18 percent was purchased. The highest reported percentages of fuelwood purchase were seen at the MVP sites with the lowest annual precipitation: the two Sahelian sites, Potou (SEN) and Tiby (MLI), as well as Dertu (KEN), all of which have rainfall below approximately 700 mm/year.

Fuelwood gathering requires, on average, six hours per gatherer per week, (ranging from 2.9 hours per week in Mwandama (MWI) to 10.8 hours per week in Potou (SEN)).

The Controlled Cooking Test (CCT) is designed to assess the performance of the improved stove relative to stove type generally in use (typically the three-stone fire). Stoves are compared as they perform a standard local cooking task. In parallel, a qualitative survey of local cooks was conducted to determine which stove each preferred, and which factors influenced that choice. The MVP CCT protocol can be found online at: modi.mech.columbia.edu. As of May, 2011, the MVP stove program has performed CCTs at seven sites across six countries using eight different stoves.

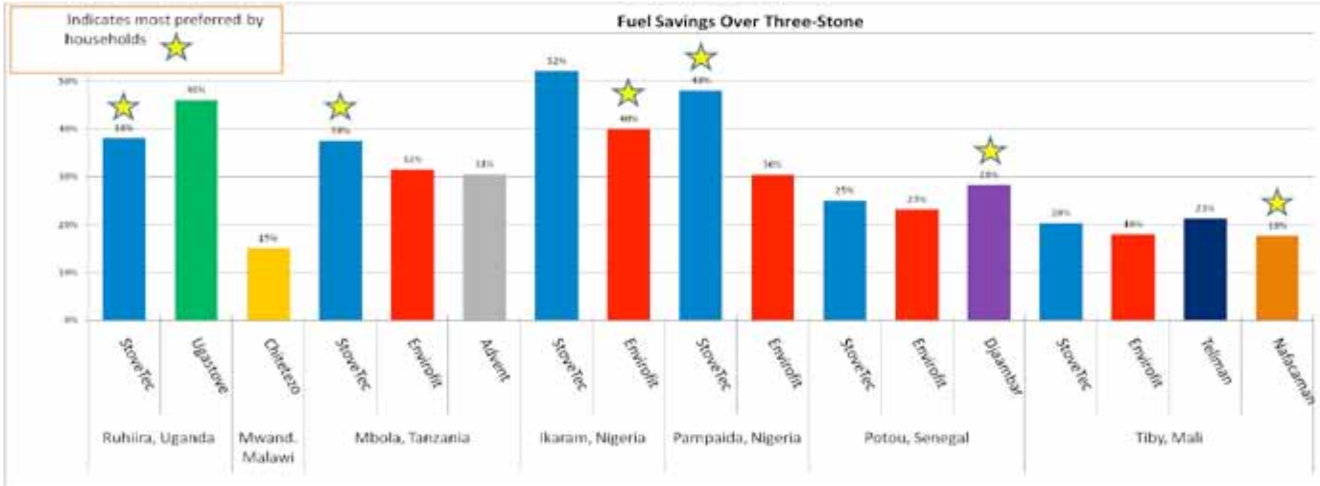
The cost of the MV stove programs varied based on the length of the consultant's stay for program launch and the amount of original investment of stove stock. ■

Table 4.13: Fraction of Cooking Done With Various Fuels (Average Across Seasons and Households)

	Fuelwood	Farm residue	Kerosene
Bonsaaso (GHA)	0.76	0.09	0.12
Ikaram (NGA)	0.74	0.00	0.19
Mayange (RWA)	0.92	0.04	0.01
Mbola (TZA)	0.64	0.19	0.11
Mwandama (MWI)	0.66	0.30	0.03
Pampaida (NGA)	0.61	0.20	0.15
Potou (SEN)	0.71	0.04	0.03
Ruhiira (UGA)	0.84	0.13	0.01
Tiby (MLI)	0.77	0.08	0.10
Average (all sites)*	0.74	0.12	0.08

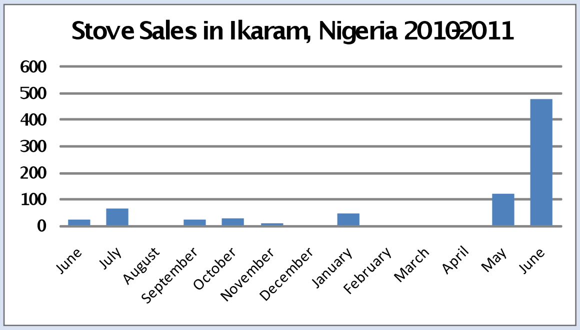
* In this table and all subsequent tables the phrase "average (all sites)" indicates a simple average of the numbers in the column above, and is not weighted in any way to reflect the populations, household sizes, or other factors particular to each site.

Figure 4.10. Results of CCTs and Surveys for Stove Preference from 7 MVP Sites.



Infra-fuelwood consumption tests for preparation in Ruhiira

Environment Week in Ikaram, Nigeria



In the Ikaram MVP, there was initial reluctance to buy cookstoves because of the plentiful wood supply in the cluster. In response, the site team introduced Environmental Week to educate the community on the importance of conservation. The week started by meeting community leaders, after which a stove rally reinforced these points and highlighted the role of stoves in conservation. By the end of the first three days, 121 stoves had been sold. ■

Selling Stoves on Credit: Improved Biomass Cookstoves in Pampaida, Nigeria

Despite surveys indicating high demand for improved stoves in Pampaida, sales began slowly, with only 43 stoves sold in the first two months, primarily because households lacked money pre-harvest. Adopting a successful fertilizer finance model from the MVP in Malawi, the Pampaida site team offered the stoves on credit: Customers put N300 ($2) down and take a stove home, an account was created, and the stove had to be repaid in full, N2500 ($16.70), over the next three months. Sales accelerated rapidly: over 500 were dispersed in under ten days. The cooperative-based system of sales continues, wherein each Co-op vendor gets N150 ($1) per stove, and only those vendors who have collected 100% of their outstanding balances receive commissions. Nearly one year later 744 stoves have been sold, 80% fully paid and the remaining 20% being repaid in increments. The Pampaida program is the only MVP stove program operating on credit and serves as an example for household's wiliness to pay when costs are distributed over time. ■