Water Supply Technology Selection in Senegal

Experiences and Analysis from the USAID / PEPAM Project

December 31, 2014

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Contents

Foreward

- This report was prepared by the Senegal Millennium Water and Sanitation Program (USAID / PEPAM), under Cooperative Agreement No 685-A-00-09-00006-00, being implemented by RTI International.
- This publication was produced for review by the United States Agency for International Development (USAID). It was prepared by RTI International, Relief International/EW-VITA, TetraTech/ARD, Inc., and with input provided by numerous Senegalese NGOs and businesses, and communities. Special credit goes to the staff of Relief International/EW-VITA, who led the field work on lower cost well drilling technologies and hand pumps.
- The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.
- The highlights of this document are summarized in a poster and a tri-fold brochure in both English and French, for dissemination among stakeholders across Senegal.

1. Technology Choice in Rural Water Supply

Technical Options involve choices in three areas:

- Well: technical design and cost depends on local geology, and ease of site access by drilling rigs
- Pump: various designs with power from humans, diesel engines, solar panels, etc
- Storage and Distribution: related to population density and desired level of service – standposts or house connections

1. Technical Drivers of Technology Choice

- Well Depth to Water:
  - If safe water is very deep, only large drilling rigs can reach it, but often producing good yield. Large cost of these wells suggest full use of well yield and extensive water distribution piping.
  - If safe water is not very deep, lower cost drilling methods can be used, leading to more, dispersed, wells (at lower yield) but less need for distribution and storage

- Level of Service:
  - Water delivered inside house, or
  - Water at public water point at a reasonable walk

  The choice of level of service has a large influence on storage and distribution system cost as well as some influence on pump and well design. Water inside house can help hygiene, but at a major cost

1. Criteria for Technology Choice

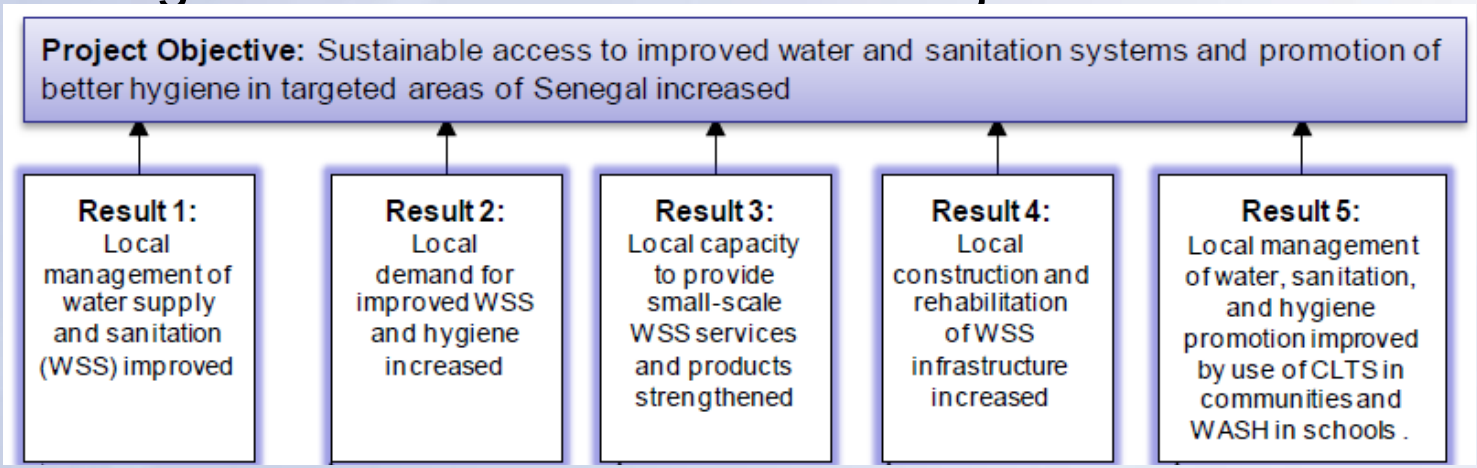
- Common criteria include:
  - Cost (initial, O&M and life-cycle),
  - Familiarity and availability,
  - O&M requirements,
  - Useful life,
  - Warranties
- Initial cost is often over-prioritized, given the Millennium Development Goals which utilize number of people with “access to improved supply” for a given investment. Governance, O&M, monitoring and technical support often not tabulated, or planned for, which decreases sustainability

2. Life Cycle Cost Analysis

- Life-cycle cost analysis (LCCA), is a best practice tool to select most cost-efficient option among alternatives
- For an infrastructure project, LCCA "balances" the ***initial*** construction cost, and all costs related to ***future*** activities:
  - Labor
  - Energy, chemicals, supplies
  - Regular maintenance and small repairs
  - Major component replacements e.g. diesel generators
  - Capacity-building activities such as community mobilization, water management training, and behavior change-related training
- LCCA computes a "present value" of all costs, including initial costs and present value of future costs (over 30 years), using a real discount rate of 5%. From the PV, we compute a Life Cycle Cost per person per year, in CFA

3. Water Supply Technology in Senegal

Senegal Water and Sanitation Project – USAID / PEPAM



- Over 340 small rural water supply points built, with 10-35% cost share
- Water management committees (CGs/ASUFORs) functioning at all sites
- Over 120,000 people with improved access to potable water supply
- Over 45 private businesses and hundreds of technicians engaged and trained
- 7 large water supply systems constructed and O&M training ongoing
- 8 medium sized water supply systems designed

These experiences helped us prepare these guidelines for USAID and the GOS

3. Well Drilling Options in Senegal

1. Hand Drilled Wells

Rig Cost: About $3,000

Maximum depth 30 - 35 m

Suitable in sedimentary rock, not consolidated bedrock

Well Cost 30m: about $2,500

3. Well Drilling Options in Senegal

2. Small Well Rig

Rig Cost about $45,000

Maximum depth: 70 m

Well Cost: 30m $7,000

50m $7,500

70m $8,000

3. Well Drilling Options in Senegal

3. Large Well Rig

Rig Cost: About $400,000

Can drill through consolidated rock formations

Cannot reach all isolated locations

Well Cost: 30m about $16,000
70m about $20,000
200m about $45,000

3. Summary: Well Drilling Options in Senegal

Type	Hand-drilled	Small rig	Large rig
Rig cost	$US 3,000	$US 45,000	$US 400,000
Max depth (m)	35	70	200+
Suitability	Not for consolidated bedrock – not applicable in some parts of Senegal	Not for consolidated bedrock – not applicable in some parts of Senegal	Usable with consolidated bedrock – applicable anywhere rig can access

3. Groundwater Resources in Senegal

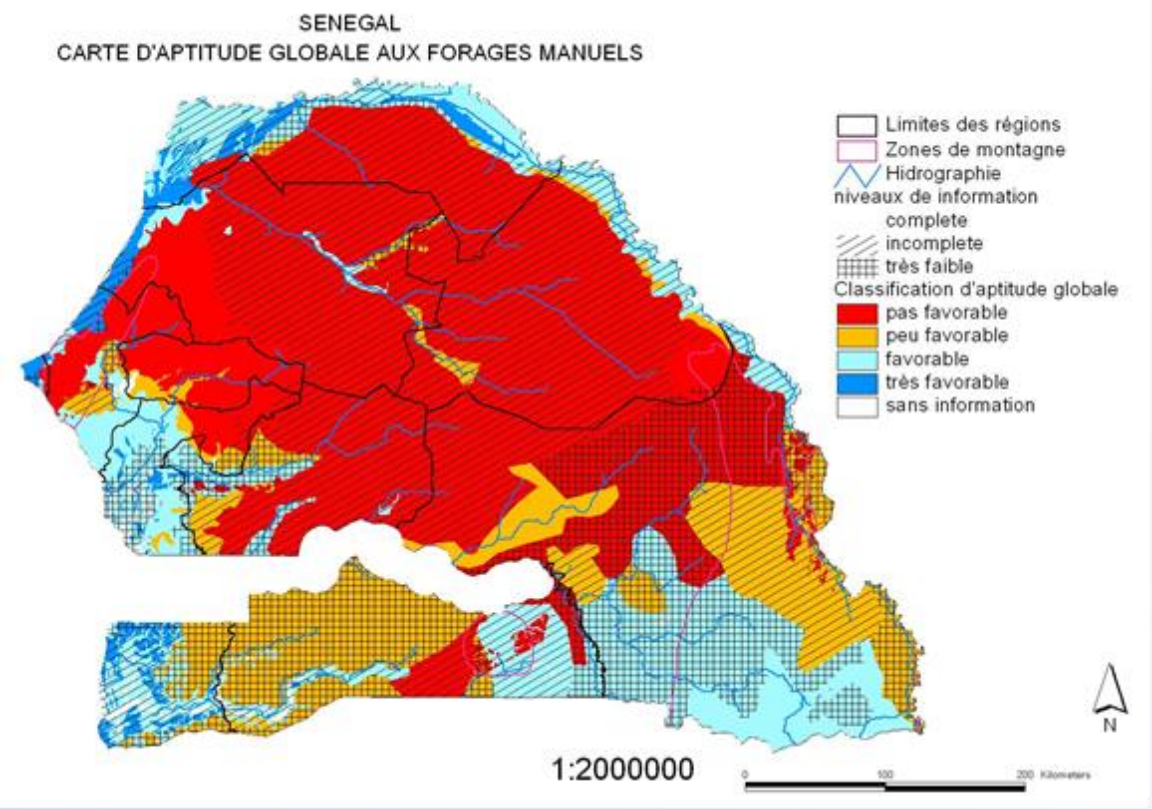
Early map of potential for hand drilled wells in Senegal

Not Favorable

Possible

Favorable

Very Favorable



However, USAID / PEPAM found that hand drilled wells or small rig wells were suitable to supply small to medium water demands in the Casamance and Tambacounda.

3. Water Supply Technology Options - Senegal

Candidate Water Supply Technologies		**Depth to water table,** *Well Drilling Technology*		
		<30m	**30 - 70m**	**>70m**
		Hand Drilled Well	*Small Well Rig*	*Large Well Rig*
Water Demand	Water Uses			
Small 100-1,200 people 3.5-42 m^3/day	Potable Water, Small Livestock	1. Line Extension 2. Hand Pump 3. Solar Pumps	1. Line Extension 2. Hand Pumps 3. Solar Pumps	1. Line Extension 2. Hand Pumps 3. Solar Pumps
Medium 1,000-3,000 people 35 - 105 m^3/day	Potable Water, Small Livestock and Productive Uses	Solar or Diesel Pump, Small Storage, Limited Distribution	Solar or Diesel Pump, Small Storage, Limited Distribution	Solar or Diesel Pump, Small Storage, Limited Distribution
Large 3,000-15,000 people 150-750 m^3/day	Potable Water, House Connections Larger Livestock and Larger Productive Uses	*Large Rig Well*, Diesel or Electric Pump, Large Storage, Longer Distribution	*Large Rig Well*, Diesel or Electric Pump, Large Storage, Longer Distribution	*Large Rig Well*, Diesel or Electric Pump, Large Storage, Longer Distribution

In the past, the main GOS focus has been on large rural water supply systems, using large well rigs, submersible pumps, diesel generators, elevated storage tanks and piped distribution, with line extensions to satellite villages within 5 km. USAID / PEPAM explored alternatives for small and medium demands

4. Technology Options for Small Water Demands

One or More Wells and Handpumps	Well and Solar Pump	Line Extension from nearby town
		

Traditional wells – “unimproved” sources of water

4. Hand Pumps: Erobon – Fabricated and serviced locally

- Maximum Depth: 30 m
- Maximum Users: 175
- Initial Cost: 100,000 FCFA

4. Hand pumps: India Mark II – Imported but Common

- Maximum Depth: 70 m
- Very durable, parts available in country
- Initial Cost: Galvanized: 350,000 FCFA
  Stainless: 740,000 FCFA

4: Hand Pumps: Vergnet – #1 and Model 60 - Imported

- Vergnet #1
- Maximum Depth: 80 m
- Cost: 1,450,000 FCFA
- Very durable
- Higher parts costs

- Vergnet HP 60
- Maximum Depth: 60 m
- Cost: 1,200,000 FCFA
- Very durable
- Higher parts costs

4. Hand Pumps: Vergnet –Model 100 - Imported

- Vergnet HP 100
- Maximum Depth: 100m
- Foot Pedal action appeals to users
- Cost: 2,000,000 FCFA
- Durable, but high parts costs

4. Summary: Hand Pump Choices

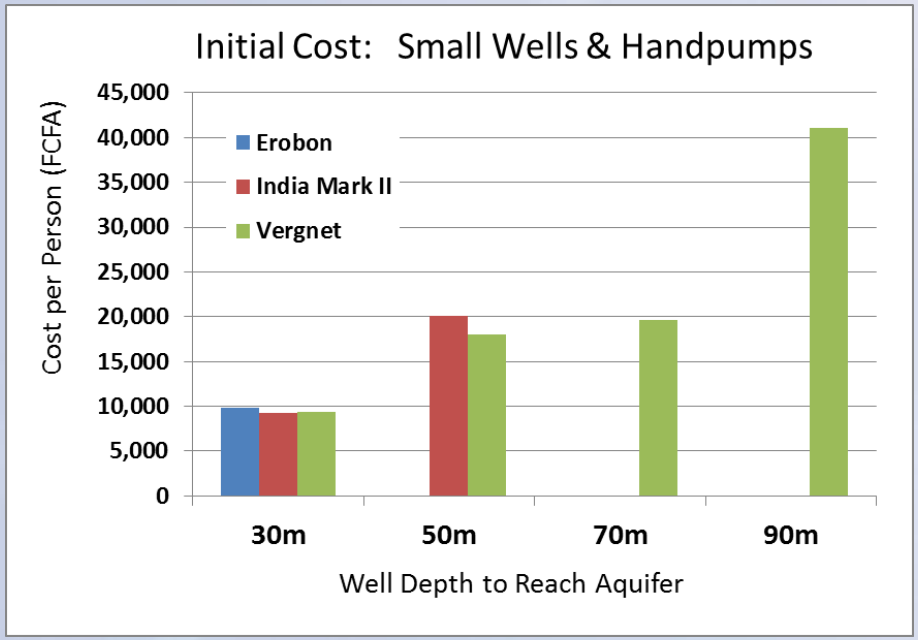
Type	Erobon	India Mark II	Vergnet #1/60/100
Source	Locally constructed	Imported	Imported
O&M requirement	Moderate but simple	Low, but more expensive	Low but more expensive
Maintenance	Local shops that built pumps can maintain	Skills and parts widely available locally	Skills and parts available locally but expensive
Maximum depth	30 m	70 m	60-100 m
Recommended maximum users, based on field experience	175	225	300
Initial Cost	100,000 FCFA	Galvanized: 350,000 FCFA Stainless: 740,000 FCFA	#1: 1,450,000 FCFA HP 60: 1,200,000 FCFA HP100: 2,000,000 FCFA

4. Field Application Experience by USAID / PEPAM

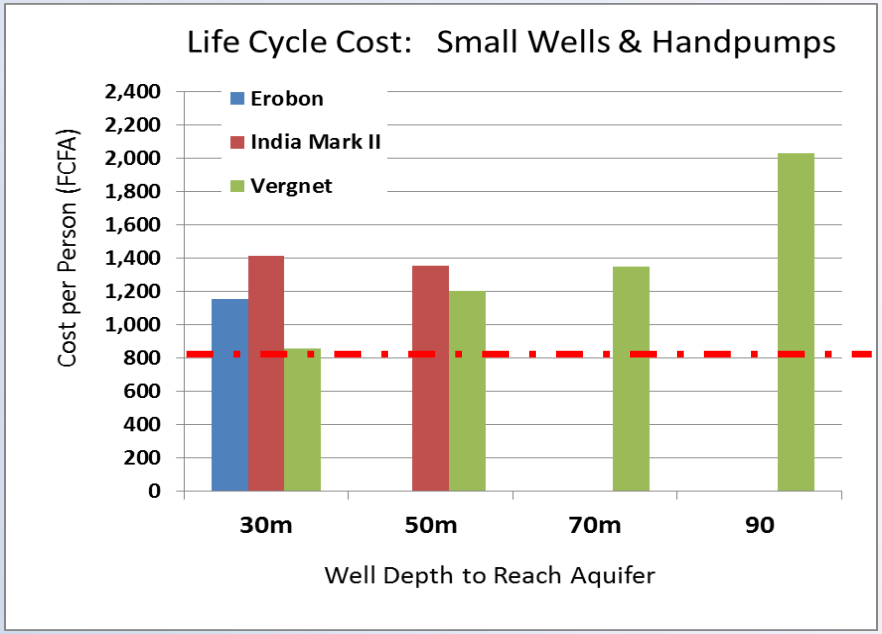
Type of New Water Point Installed by USAID / PEPAM	Erobon	India Mark II	Vergnet #1/60/100	Total
Hand Drilled Wells and Hand Pumps	51	151	2	204
Small Rig Wells and Hand Pumps	3	37	47	88
Total Wells and Hand Pumps installed	55	188	49	292
Average installed well depth (m)	20	26	54	30
Average well static water level (m)	9	13	35	17

- The project used 2 types of India Mark II – with galvanized or stainless steel piping. The galvanized models corroded, and were replaced with costlier stainless steel.
- The project also tried a different hand pump (Pompe Universelle – SOVEMA) similar, but less costly than the India Mk II – but they suffered frequent breakdowns, were hard to pump by woman and children, and thus were replaced.

4. Single Well and Hand Pump: Costs



For wells and hand pumps at 30 m, initial costs are almost identical, but there are some differences in life cycle costs. Nonetheless the range of life cycle costs for wells under 70 m, is not very large.

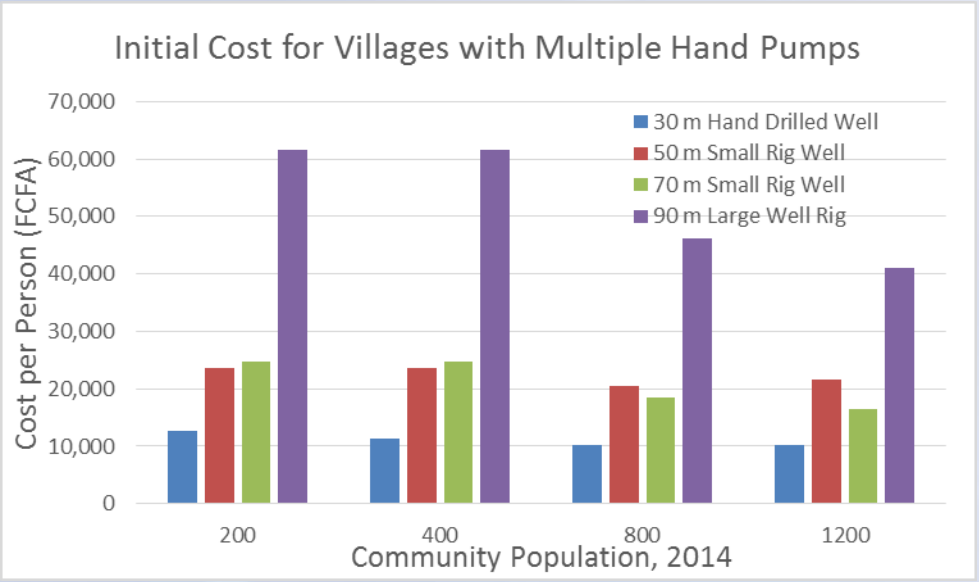


Life cycle costs for most pump types at the common depths of 30-70 m fall around the dashed red line at right, signifying 1,300 FCFA per person per year

4. Villages with Multiple Hand Pumps: Costs

Population	Well Depth / Well Type / Cost (FCFA)	30 m Hand Drilled Well	50 m Small Rig Well	70 m Small Rig Well	90 m Large Rig Well
200	Total initial cost	2.5 M	4.7 M	4.9 M	12.3 M
	Initial cost/person	*12,600*	*23,600*	*24,700*	*61,500*
	Life cycle cost/person/year	1,300	1,600	2,000	3,000
400	Total initial cost	4.6 M	9.5 M	9.9 M	24.6 M
	Initial cost/person	*11,400*	*23,600*	*24,700*	*61,500*
	Life cycle cost/person/year	1,200	1,600	2,000	3,000
800	Total initial cost	8.3 M	16.4 M	14.8M	36.9 M
	Initial cost/person	*10,300*	*20,600*	*18,500*	*46,200*
	Life cycle cost/person/year	1,100	1,500	1,500	2,300
1,200	Total initial cost	12.3 M	25.9 M	19.8 M	49.2 M
	Initial cost/person	*10,300*	*21,600*	*16,500*	*41,000*
	Life cycle cost/person/year	1,100	1,500	1,300	2,000

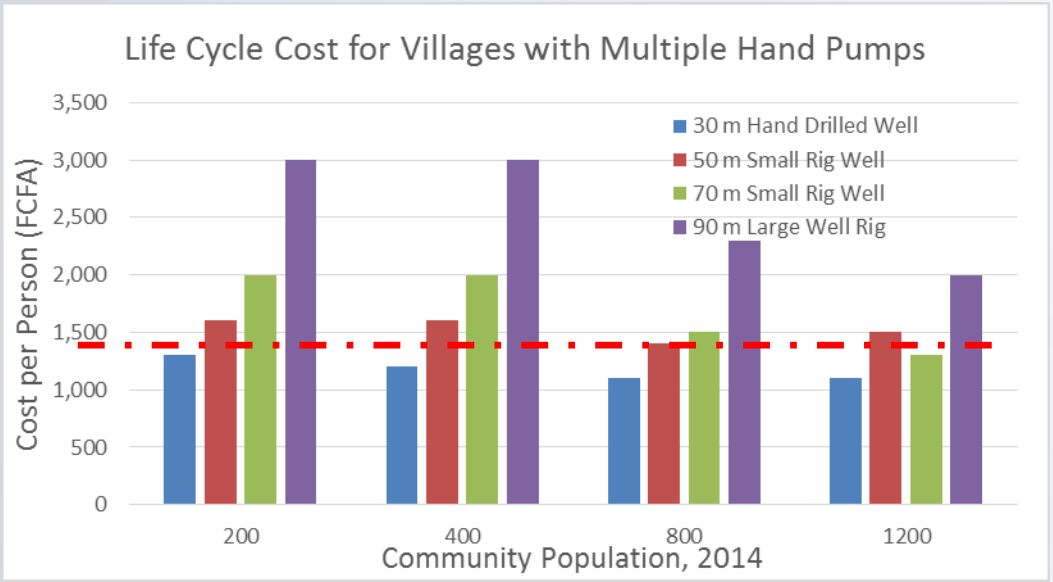
4. Villages with Multiple Hand Pumps: Costs



Initial costs are about 10,000 to 25,000 FCFA per person if well depths of 30 – 70 m are possible.

But the use of hand pumps in situations requiring large rig wells (> 70 m) become quite expensive.

Life cycle costs for depths of 30-70 m remain at the rough level of 1,300 FCFA per person per year



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4. Line Extensions from Existing Water Systems

It is a common practice in Senegal to extend networks from a town's large water system to outlying small villages. Life cycle cost depends on:

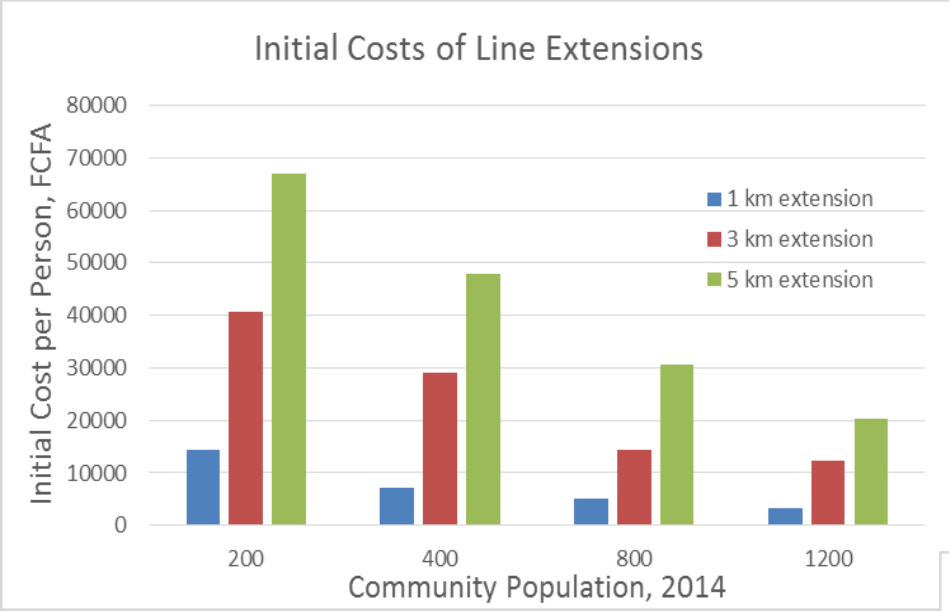
- distance to outlying village
- people to be served (related to pipe diameter necessary to allow gravity flow)
- cost to provide water at central town

USAID / PEPAM rehabilitated larger town water supplies and added line extensions in three locations. The increased number of users has made these sites more viable financially

4. Line Extensions: Costs

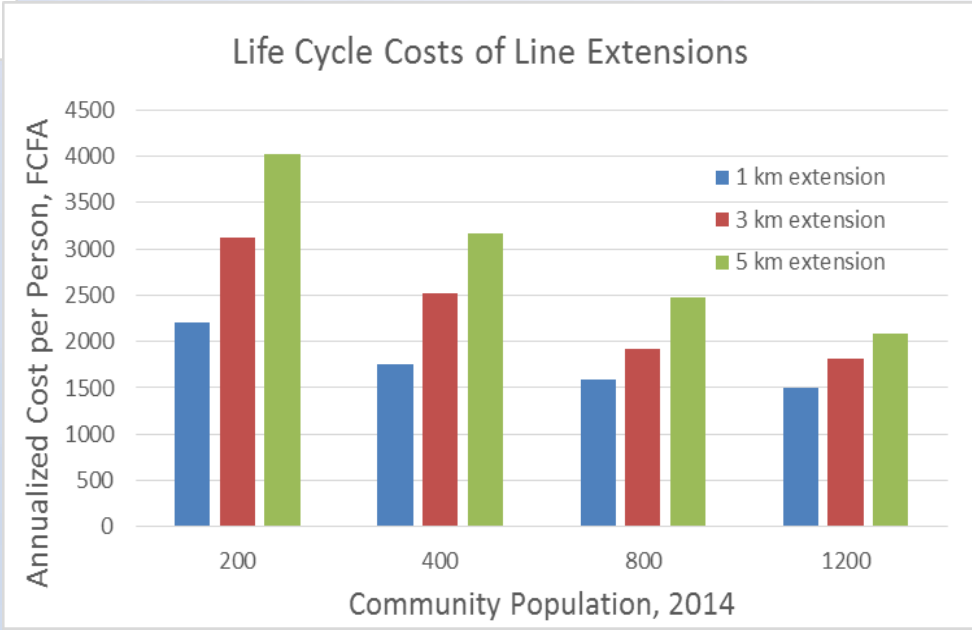
Population	Line Length (km) / Cost (FCFA)	0.5	1	2	3	4	5
200	Total initial cost	1.6 M	2.9 M	5.5 M	8.2 M	10.8 M	13.4 M
	Initial cost/person	*7,800*	*14,400*	*27,600*	*40,800*	*53,900*	*67,100*
	Life cycle cost/person/year	2,000	2,200	2,700	3,100	3,600	4,000
400	Total initial cost	1.6 M	2.9 M	5.5 M	11.6 M	15.4 M	19.2 M
	Initial cost/person	*3,900*	*7,200*	*13,800*	*29,000*	*38,500*	*47,900*
	Life cycle cost/person/year	1,600	1,800	2,000	2,500	2,800	3,200
800	Total initial cost	1.6 M	4.0 M	7.8 M	11.6 M	15.4 M	24.5 M
	Initial cost/person	*2,000*	*5,000*	*9,800*	*14,500*	*19,200*	*30,600*
	Life cycle cost/person/year	1,500	1,600	1,800	1,900	2,100	2,500
1,200	Total initial cost	1.6 M	4.0 M	7.8 M	14.8 M	19.6 M	24.5 M
	Initial cost/person	*1,300*	*3,400*	*6,500*	*12,300*	*16,300*	*20,400*
	Life cycle cost/person/year	1,400	1,500	1,600	1,800	2,000	2,100

4. Line Extensions: Costs



Initial costs are influenced greatly by distance and population.

Life cycle costs for extensions generally exceed the hand pump benchmark of 1,300 FCFA per person per year



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4. Small Solar Pumps

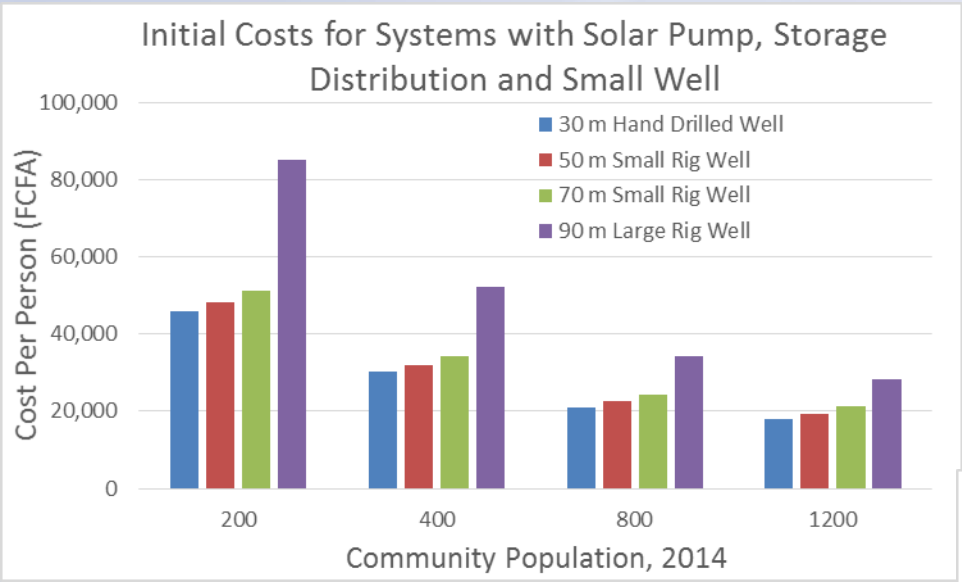
Small Solar Pump Systems:

- PV panels, controller and submersible pump
- Small plastic storage tanks – at ground level or elevated
- Several distributors, dozens of installations in Senegal
- Initial cost related to energy requirement in m^4, head (m) and daily water flow m^3 /day
- O&M is small except for periodic pump replacements

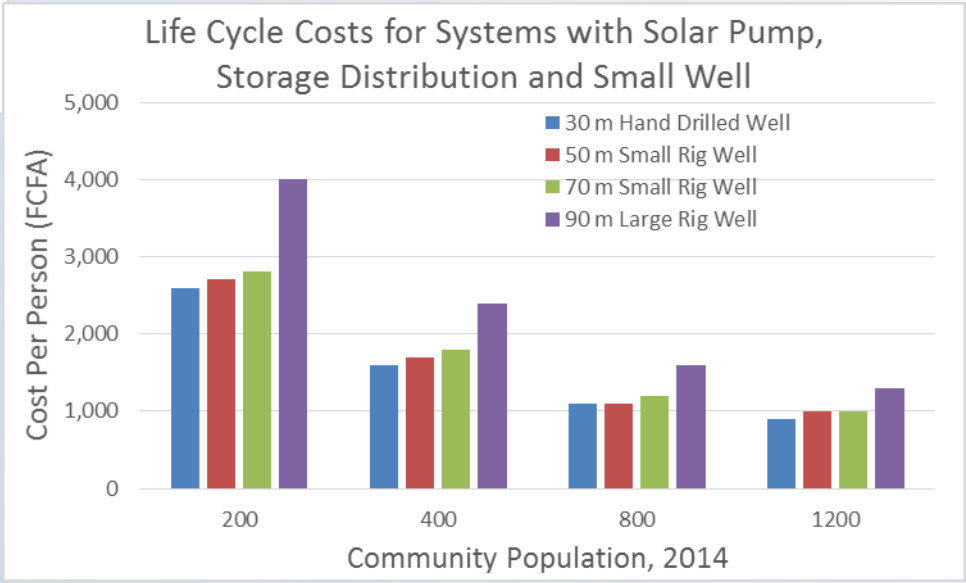
4. Small Solar Pumps: Costs

Population	Well Depth / Well Type / Cost (FCFA)	30 m Hand Drilled Well	50 m Small Rig Well	70 m Small Rig Well	90 m Large Rig Well
200	Total initial cost	9.1 M	9.6 M	10.2 M	17.0 M
	Initial cost/person	*45,700*	*48,200*	*51,100*	*85,100*
	Life cycle cost/person/year	2,600	2,700	2,800	4,000
400	Total initial cost	12.0 M	12.8 M	13.7 M	20.8 M
	Initial cost/person	*30,100*	*32,000*	*34,100*	*52,100*
	Life cycle cost/person/year	1,600	1,700	1,800	2,400
800	Total initial cost	16.8 M	18.0 M	19.5 M	27.5 M
	Initial cost/person	*21,000*	*22,500*	*24,400*	*34,300*
	Life cycle cost/person/year	1,100	1,100	1,200	1,600
1,200	Total initial cost	21.5 M	23.3 M	25.4 M	34.1 M
	Initial cost/person	*17,900*	*19,400*	*21,200*	*28,400*
	Life cycle cost/person/year	900	1,000	1,000	1,300

4. Small Solar Pump: Costs



Initial costs are influenced greatly by well depth, especially at small locations.



At the larger locations the life cycle cost of solar pumps reaches that of multiple hand pumps – about 1,300 FCFA per person per year.

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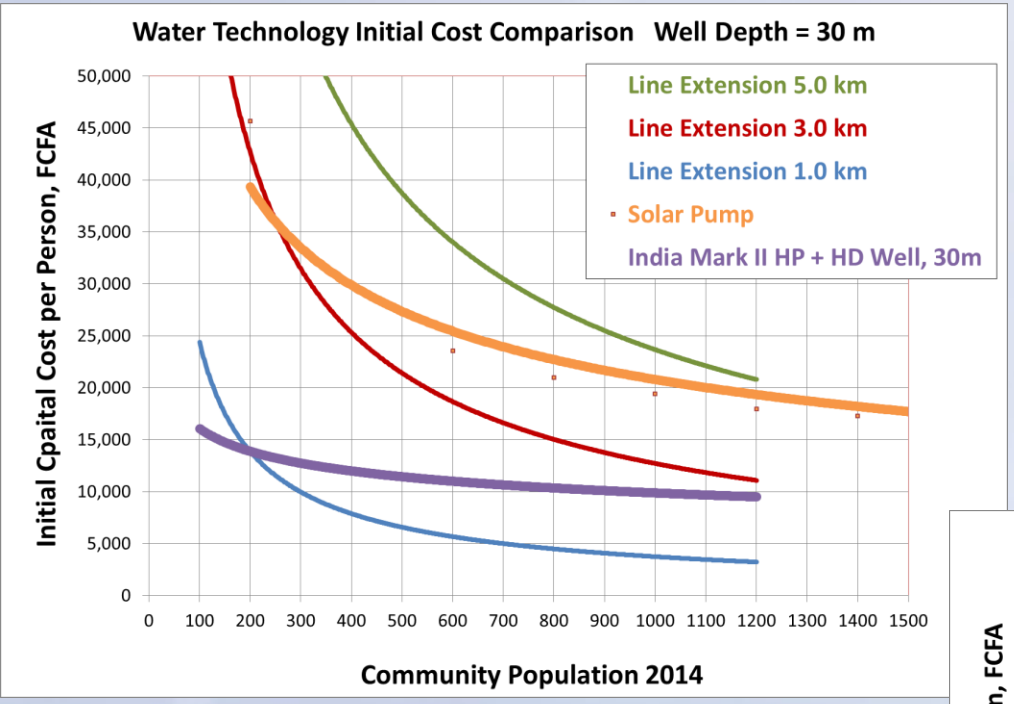
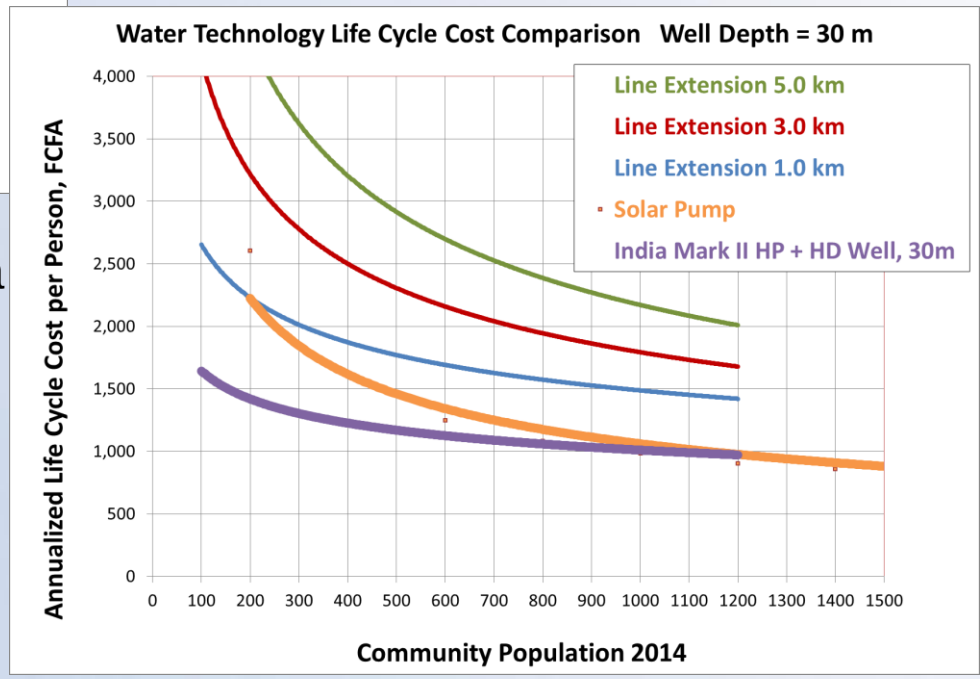
4. Synthesis: Small Water Demands at 30m



If short line extensions are possible, they look attractive from an initial cost point of view. Hand pumps are also relatively low in initial cost



Hand pumps look very economical from a life cycle point of view. Solar pumps are economical at larger demands. Line extensions are comparatively expensive in these shallow well situations

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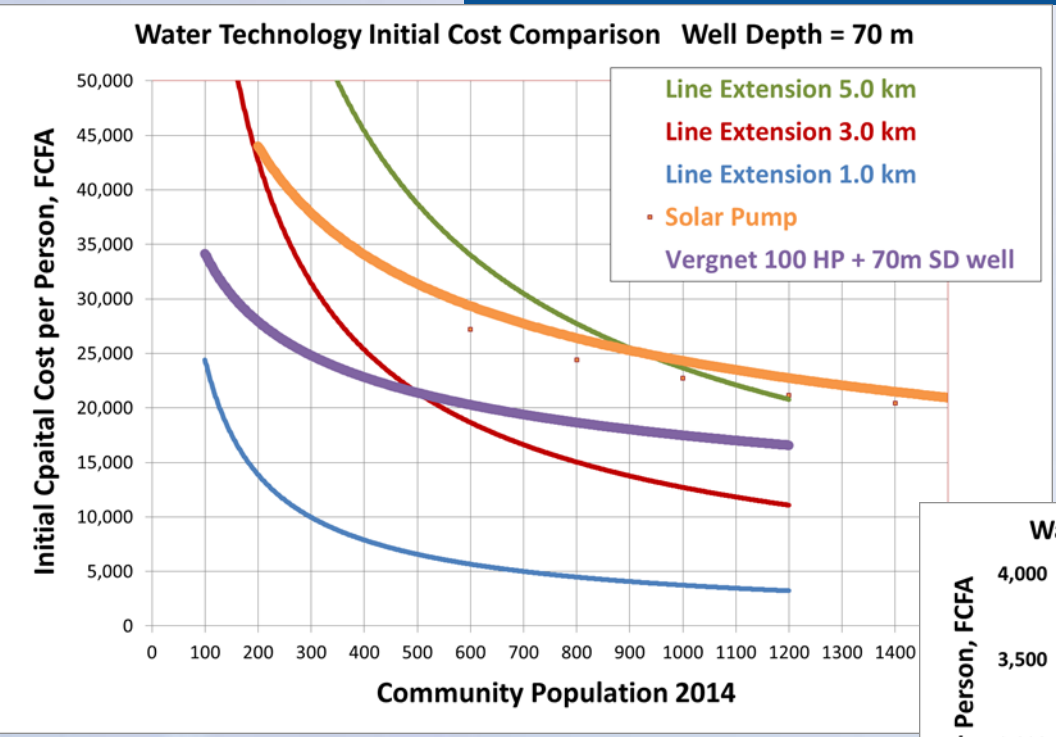
4. Synthesis: Small Water Demands at 70m



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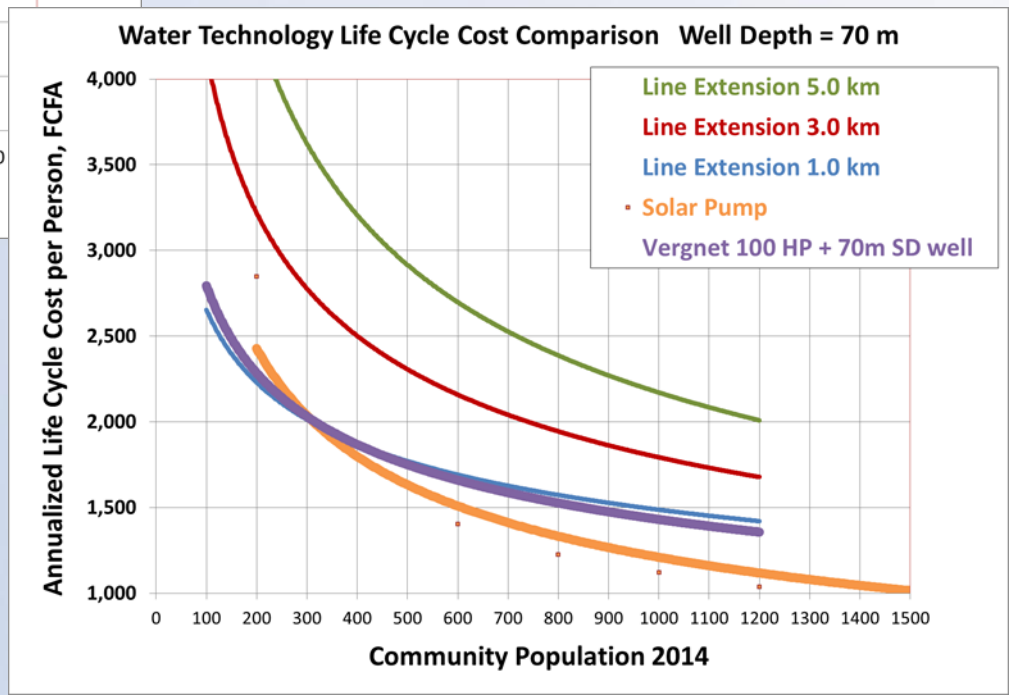

For deeper wells, line extensions costs have not changed, but hand pumps and solar have risen in cost. Nonetheless, small solar pumps look attractive in situations over 400 people

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5. Technology Options for Medium Water Demands

Solar Pump Systems:

- PV panels, controller and submersible pump
- Moderate size storage and stand-post distribution
- Several distributors, many installations in Senegal
- Initial cost related to energy requirement in m^4, head (m) and daily water flow m^3 /day
- O&M is small except for periodic pump replacements

Diesel Pump Systems:

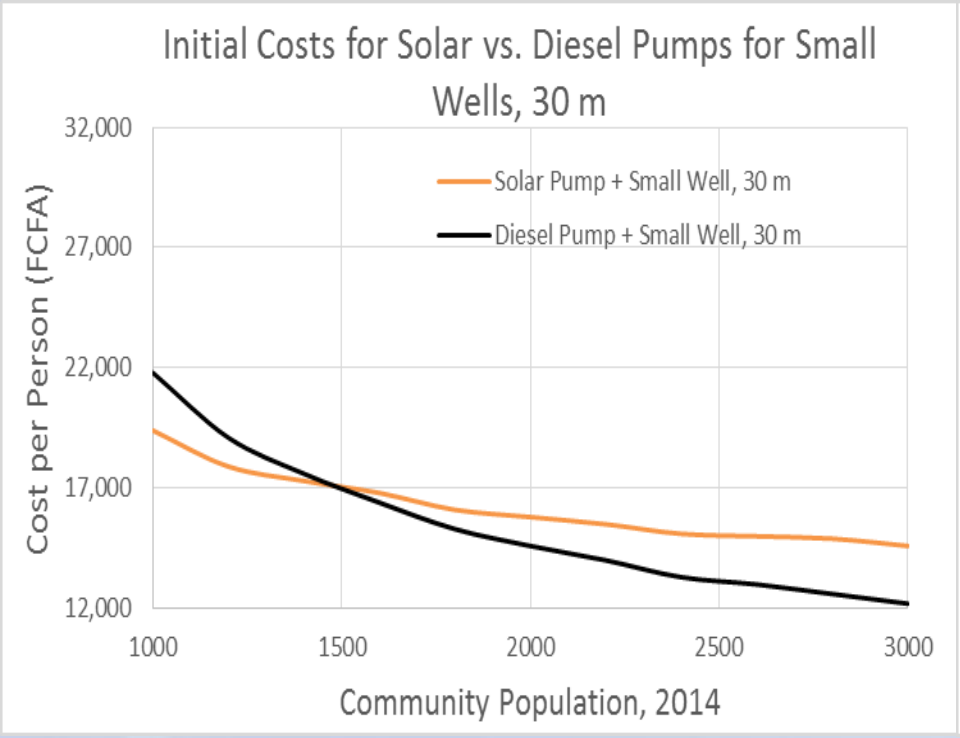
- Initial cost directly related to:
  - head (m) and hourly water flow m^3/hr
- O&M is significant including:
  - labor, fuel, fuel transport, oil changes, other regular maintenance, engine overhauls and pump replacements

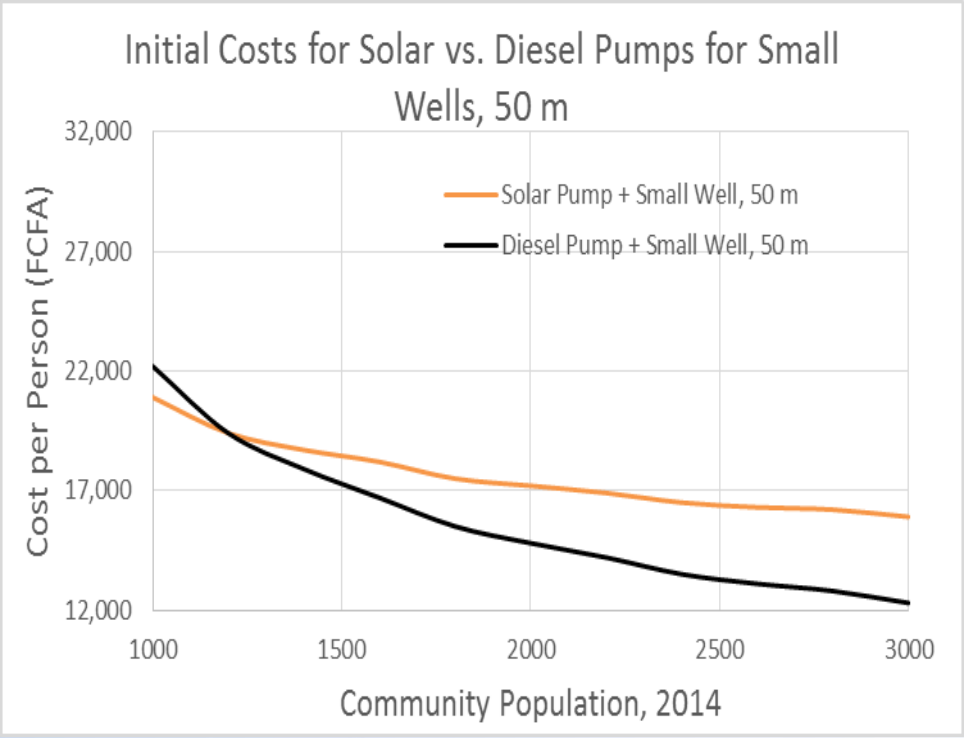
5. Experiences with Medium Water Supply Systems

- Solar Pumps: USAID / PEPAM: Badiana Middle School
- Solar Pumps: Twelve installed in Tambacounda by the Wulaa Nafaa Project. Project included an O&M contract to keep the systems running.
- Several suppliers in Senegal are installing and servicing solar pumps units from Germany and France. At least 20 in the Casamance area alone.
- Database of O&M costs of water systems diesel powered pumps assembled by Caritas
- USAID PEPAM also rehabilitated 6 small diesel powered water supply systems in Tambacounda for a very low cost per person.

5. Initial Costs for Medium Water Demands: 30/50 m

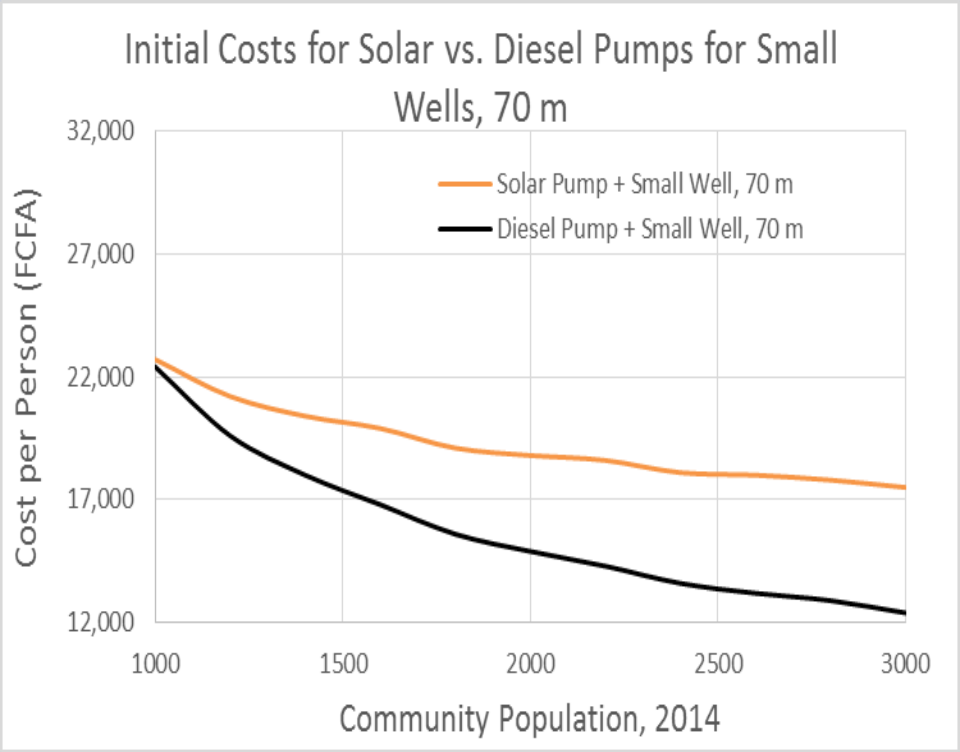
- Initial cost of diesel pump systems only changes slightly with well depth
- But, initial cost of solar pump systems does increase with well depth
- Diesel pumps systems have a lower initial cost at sites greater than1,500 people, at 30 m, and at sites greater than 1,200 people at 50 m.

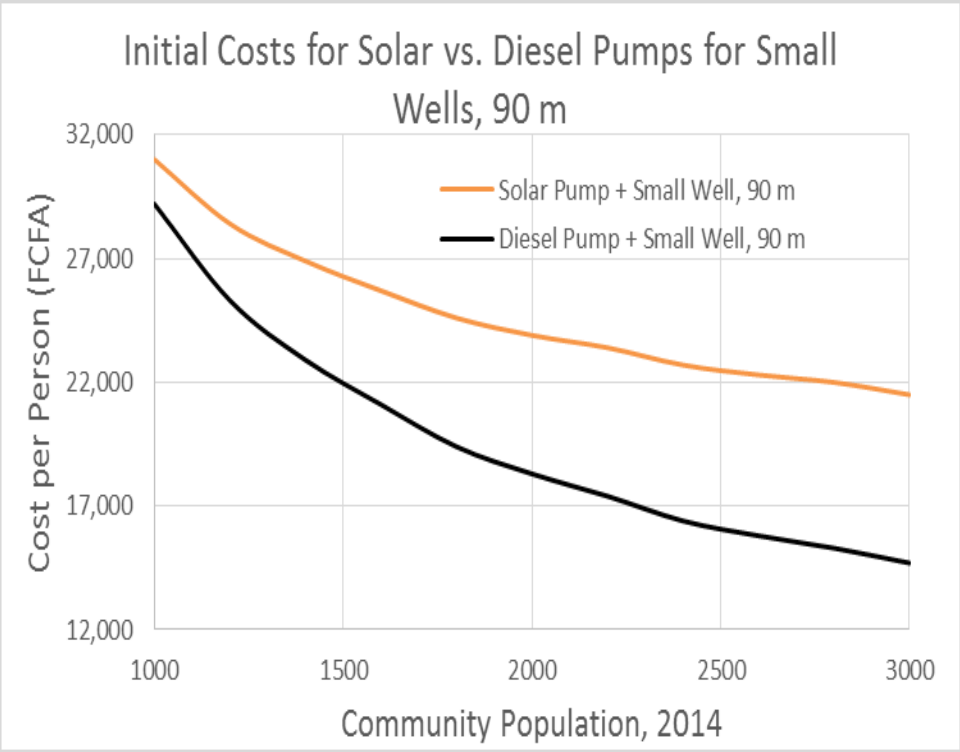




5. Initial Costs for Medium Water Demands: 70/90 m

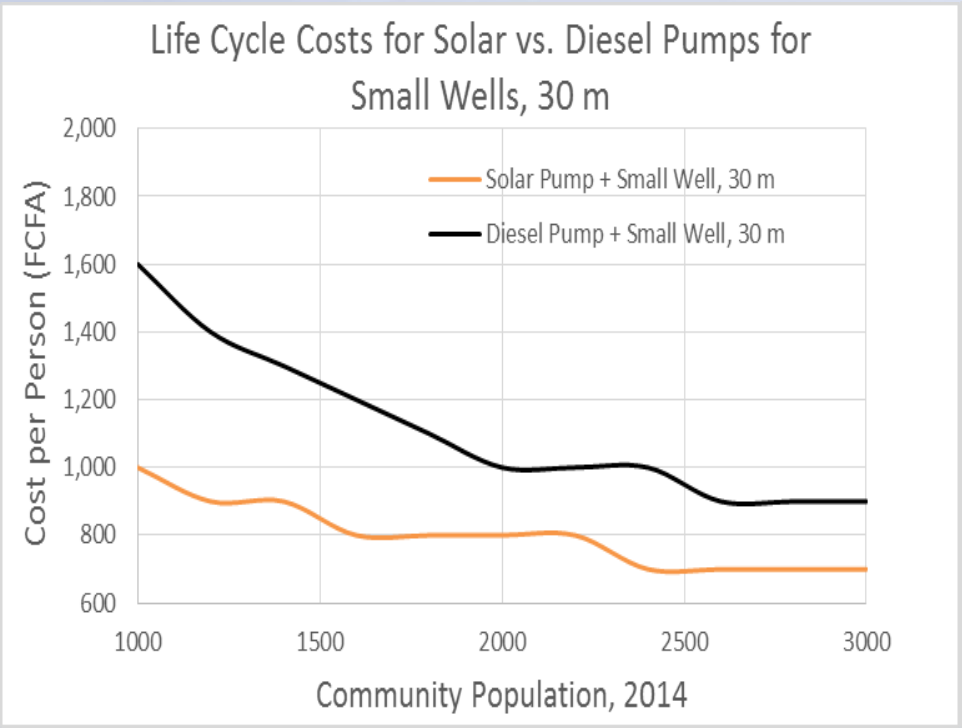
- Initial cost of diesel pump systems and solar pumps systems jump significantly at 90 m depth, due to the need for a large rig well.
- Diesel pumps always have a lower initial cost than solar pump systems for these deep wells

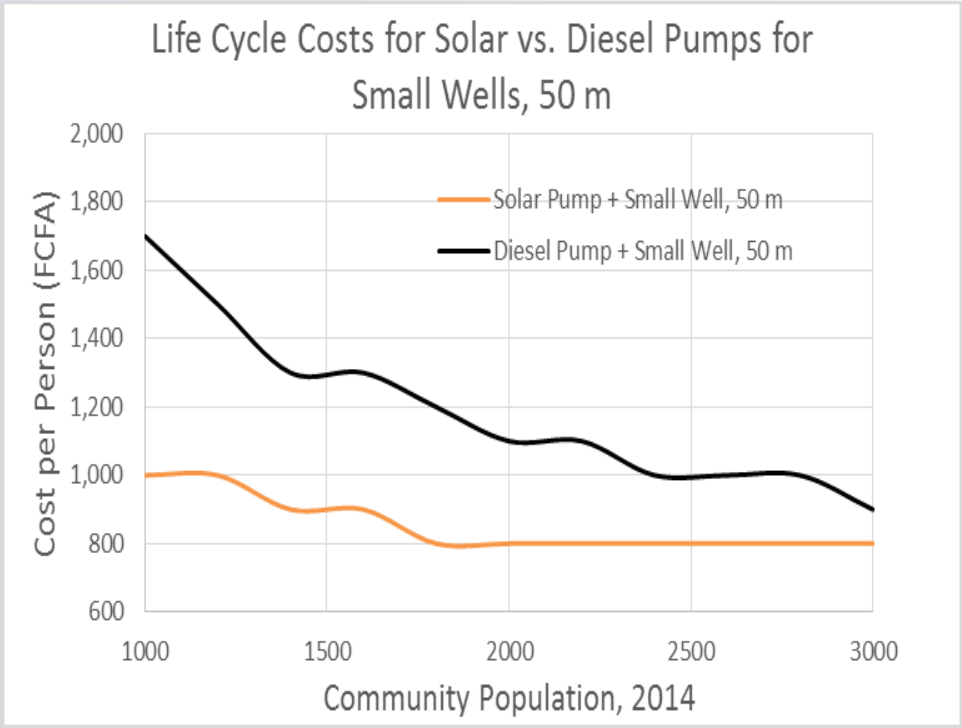




5. Life Cycle Costs for Medium Water Demands: 30/50 m

- Solar pumps systems are more attractive at all demands (populations)
- Life cycle cost of diesel pump systems begins to approximate that of solar pump systems only at high demands (>2,800 people) at 50 m depth





5. Life Cycle Costs for Medium Water Demands: 70/90 m

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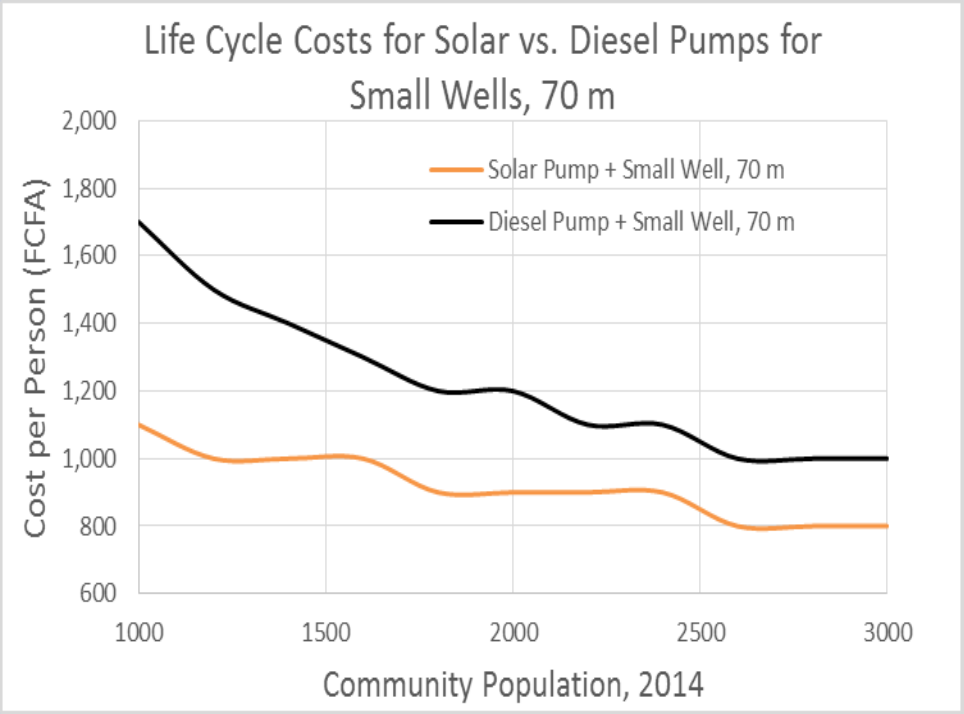

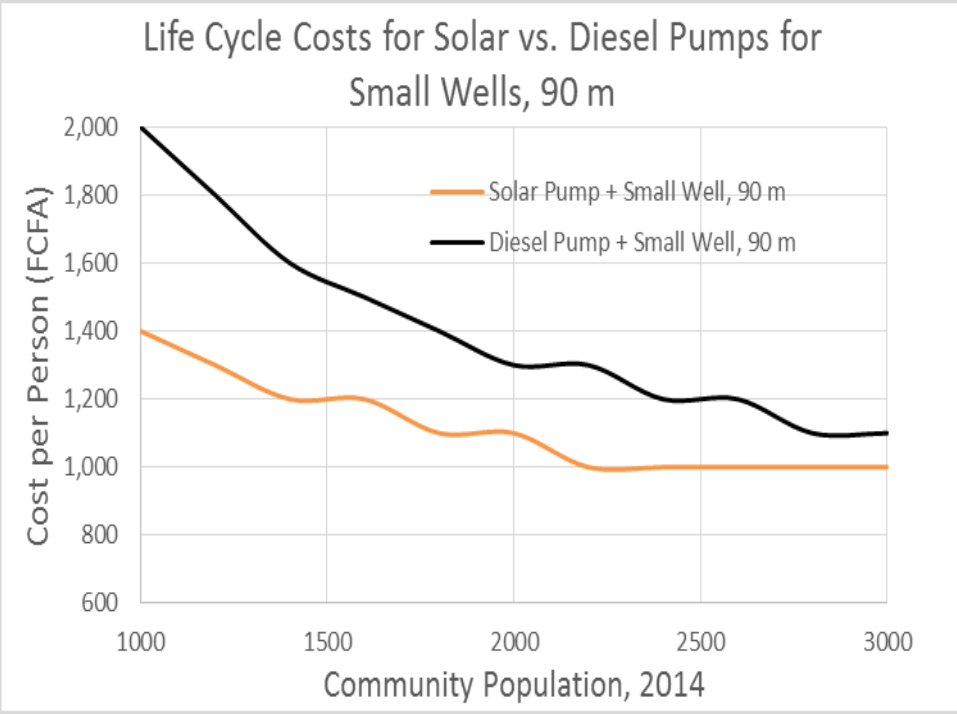

5. Synthesis: Medium Water Demands

Population	Cost (FCFA)	Solar Pumps				Diesel Pumps			
		30 m	50 m	70 m	90 m	30 m	50 m	70 m	90 m
1,000	Total initial	19.4 M	20.9 M	22.7 M	31.0 M	21.8 M	22.2 M	22.4 M	29.2 M
	Initial per person	*19,400*	*20,900*	*22,700*	*31,000*	*21,800*	*22,200*	*22,400*	*29,200*
	Life cycle cost per person per year	1,000	1,000	1,100	1,400	1,600	1,700	1,700	2,000
2,000	Total initial	31.6 M	34.3 M	37.7 M	47.8 M	29.2 M	29.5 M	29.8 M	36.6 M
	Initial per person	*15,800*	*17,200*	*18,800*	*23,900*	*14,600*	*14,800*	*14,900*	*18,300*
	Life cycle cost per person per year	800	800	900	1,100	1,000	1,100	1,200	1,300
3,000	Total initial	43.7 M	47.7 M	52.6 M	64.6 M	36.6 M	36.9 M	37.2 M	44.0 M
	Initial per person	*14,600*	*15,900*	*17,500*	*21,500*	*12,200*	*12,300*	*12,400*	*14,700*
	Life cycle cost per person per year	700	800	800	1,000	900	900	1,000	1,100

From a life cycle cost perspective, solar pumps are always less expensive, but from an initial cost perspective, solar pumps are more expensive, for large demands and deep wells.

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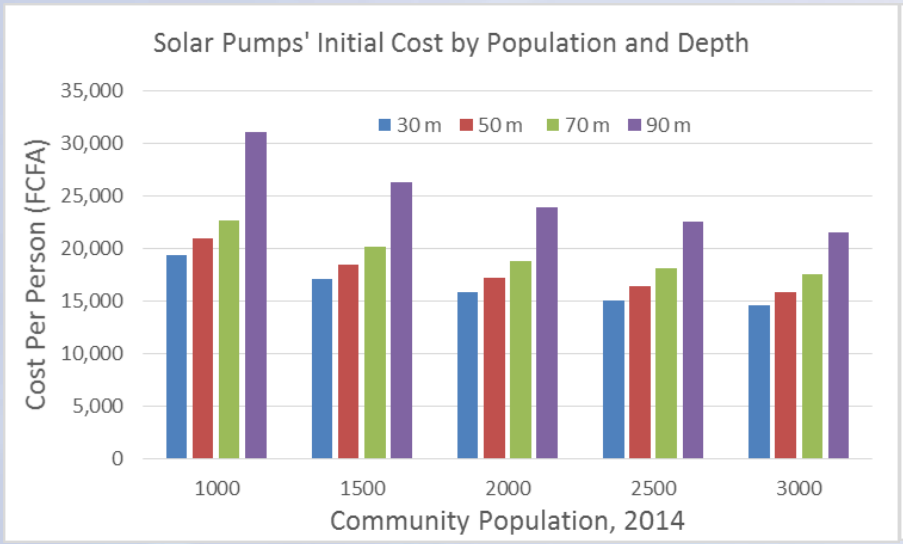
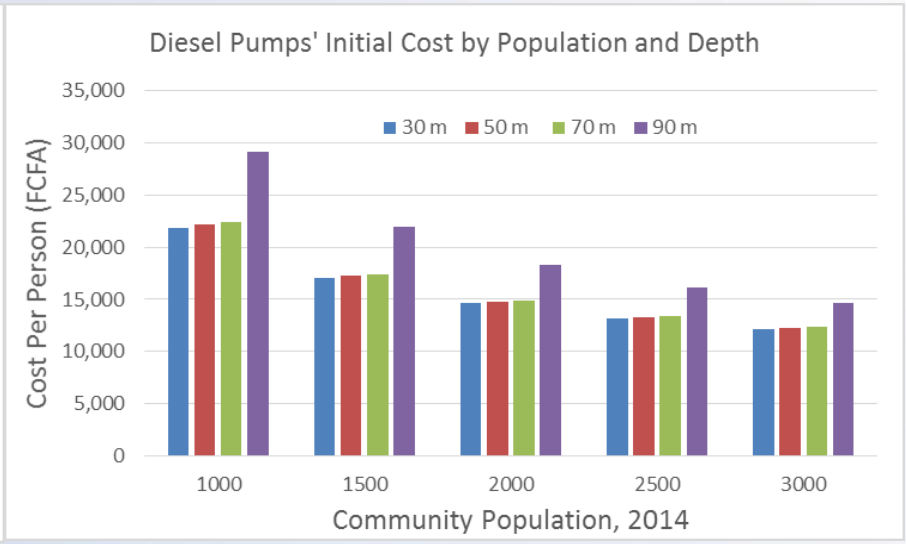
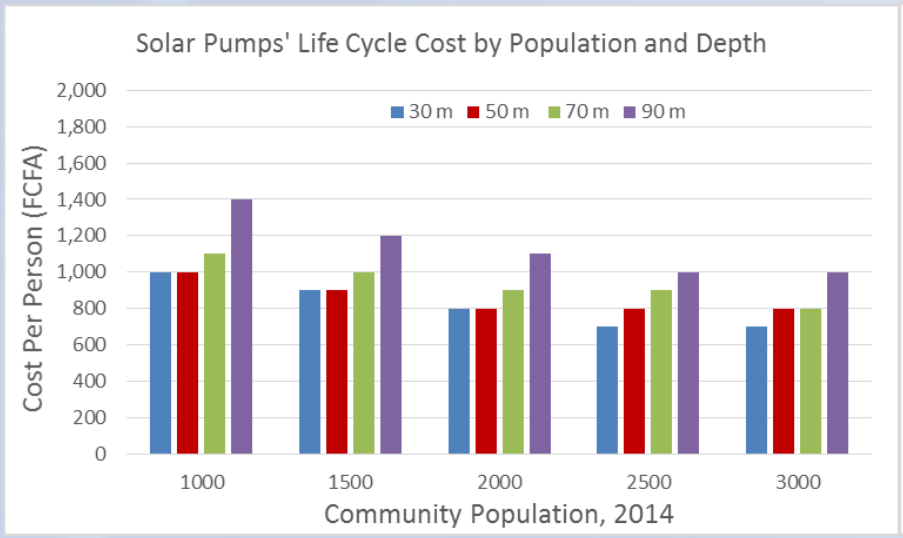
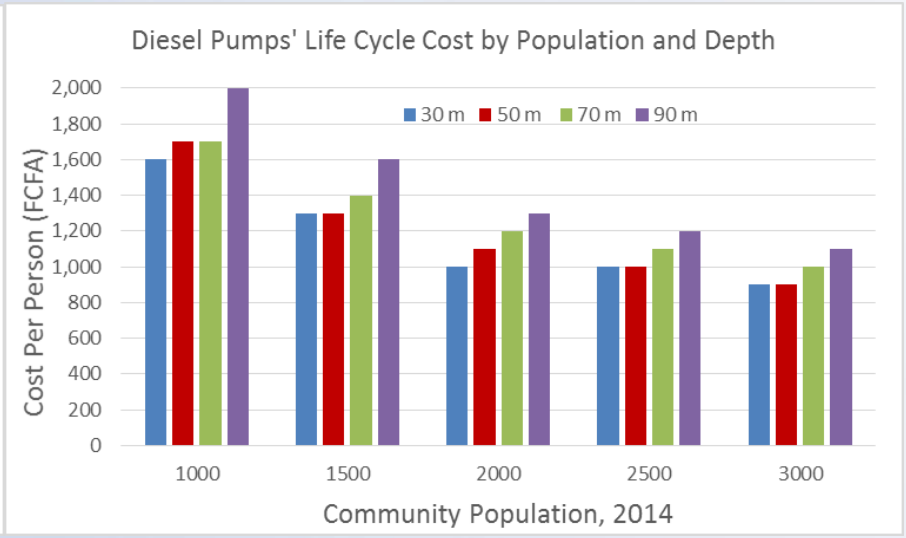
5. Synthesis: Solar vs. Diesel Pumps









6. Technology Options for Large Water Demands

One major option – with variations. Components include:

- Large drilled well – necessary for higher well yield
- Submersible pump powered by diesel engine/generator set and/or electric grid
- Elevated concrete storage tank
- Distribution (piping network) to users primarily via house connections, but also via standposts, livestock troughs

Variations

- Include nearby satellite communities ?
- Use of water for irrigation (and rural income) ?
- Extended electric power lines for electric pumps ?

6. Large Water Systems Rehabilitated / Built by Project

Dioulouloulou
Pop: 6,961
2 deep wells
9,701 m pipe
Much rehab
119 M FCFA

Ebinako
Pop: 7,836
2 deep wells
21,606 m pipe
Mostly new
261 M FCFA

Kartiak
Pop: 3,297
1 deep well
7,284 m pipe
Much rehab
105 M FCFA

Bessire
Pop: 1,784
2 deep wells
7,284 m pipe
Much rehab
105 M FCFA

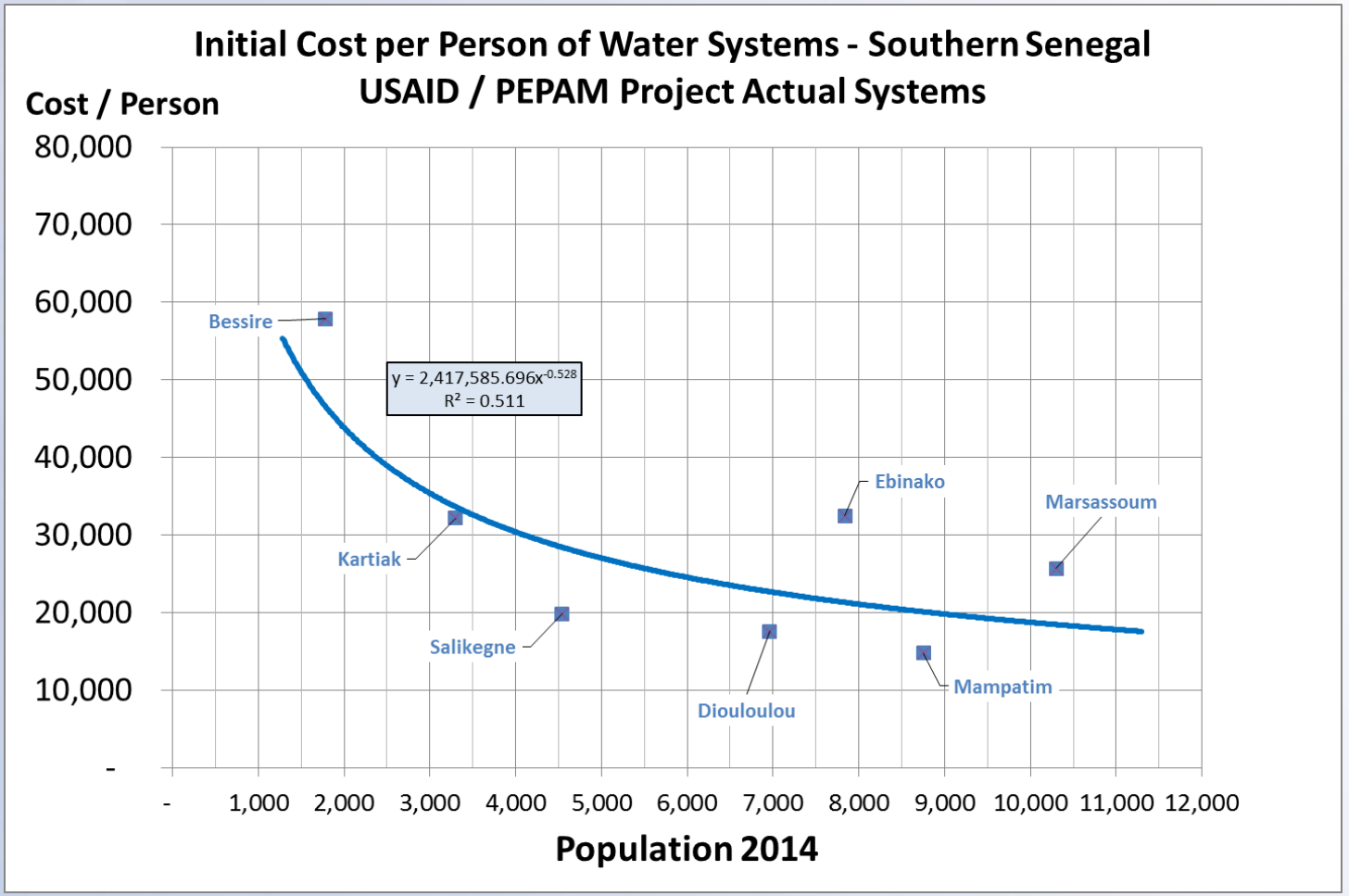
Marsassoum
Pop: 10,300
2 deep wells
25,980 m pipe
Mostly new
273 M FCFA

Salikegne
Pop: 4,543
1 deep well
7,446 m pipe
Mostly rehab
91 M FCFA

Mampatim
Pop: 8,755
1 deep wells
8,815 m pipe
Much rehab
137 M FCFA

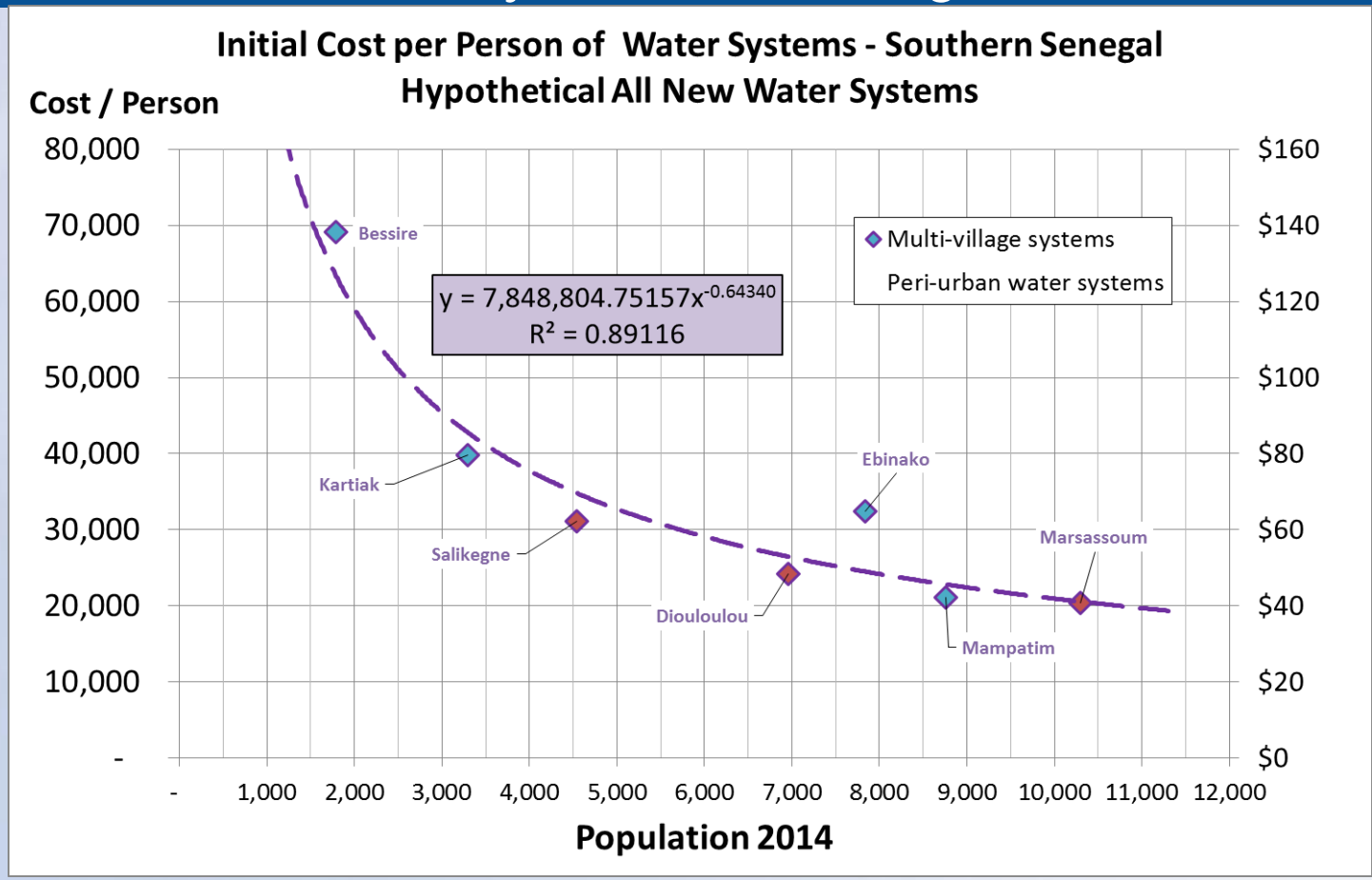
6. Cost of USAID/PEPAM Systems for Large Demands

These large water supply systems mostly involved significant rehabilitation of old, existing, non-functional infrastructure. Ebinako and Marsassoum cost more because they were mostly newly constructed infrastructure.



6. Estimated Cost of New Systems for Large Demands

For populations under 3000 people, the very high initial cost per person reflects much larger water distribution costs – especially due to the assumed use of direct household connections



Ebinako is a bit more costly, due to a very long pipe length because of line extensions to outlying villages.

6. New Systems for Large Water Demands: Cost

Population	Well Depth / Cost (FCFA)	30 m	50 m	70 m	90 m
3,000	Total initial cost	136 M	136 M	136 M	136 M
	Initial cost/person	*45,500*	*45,500*	*45,500*	*45,500*
	Life cycle cost/person/year	3,500	3,600	3,700	3,800
6,000	Total initial cost	175 M	175 M	175 M	175 M
	Initial cost/person	*29,100*	*29,100*	*29,100*	*29,100*
	Life cycle cost/person/year	2,100	2,100	2,200	2,300
9,000	Total initial cost	202 M	202 M	202 M	202 M
	Initial cost/person	*22,400*	*22,400*	*22,400*	*22,400*
	Life cycle cost/person/year	1,500	1,600	1,700	1,800
12,000	Total initial cost	224 M	224 M	224 M	224 M
	Initial cost/person	*18,600*	*18,600*	*18,600*	*18,600*
	Life cycle cost/person/year	1,300	1,300	1,400	1,500
15,000	Total initial cost	242 M	242 M	242 M	242 M
	Initial cost/person	*16,100*	*16,100*	*16,100*	*16,100*
	Life cycle cost/person/year	1,100	1,200	1,300	1,300

7. Synthesis –Small Demands Cost Comparison

Application	Options	Required Well Depth at Site			
		30 m	50m	70m	90m
Small Demands 100-1200 people 3.5-42 m^3/day **Uses / Distribution** Potable Water, Small Livestock ; no Distribution (Note: Line Extension system costs depend on population and length to the site, not well depth)	**Hand Pump 400 People**	***HD Well*** *Initial Cost: 4.6 M CFA* *Initial: 11 400 CFA/person* *Life Cycle: 1200 CFA/person/yr*	***SR Well*** *Initial Cost: 9.5 M CFA* *Initial: 23 600 CFA/person* *Life Cycle: 1600 CFA/person/yr*	***SR Well*** *Initial Cost: 9.9 M CFA* *Initial: 24 700 CFA/person* *Life Cycle: 2000 CFA/person/yr*	***LR Well*** *Initial Cost: 24.6 M CFA* *Initial: 61 500 CFA/person* *Life Cycle: 3000 CFA/person/yr*
	Solar Pump 400 people	***SR Well*** *Initial Cost: 12.0 MCFA* *Initial: 30 100 CFA/person* *Life Cycle: 1600 CFA/person/yr*	***SR Well*** *Initial Cost: 12.8 M CFA* *Initial: 32 000 CFA/person* *Life Cycle: 1700 CFA/person/yr*	***SR Well*** *Initial Cost: 13.7 M CFA* *Initial: 34 100 CFA/person* *Life Cycle: 1800 CFA/person/yr*	***LR Well*** *Initial Cost: 20.8 M CFA* *Initial: 52 100 CFA/person* *Life Cycle: 2400 CFA/person*
	Line Exten. 400 people	***1 KM*** *Initial Cost: 2.9 M CFA* *Initial: 7 200 CFA/person* *Life Cycle: 1800 CFA/person/yr*	***2 KM*** *Initial Cost: 5.5 M CFA* *Initial: 13 800 CFA/person* *Life Cycle: 2000 CFA/person/yr*	***3 KM*** *Initial Cost: 11.6 M CFA* *Initial: 29 000 CFA/person* *Life Cycle: 2500 CFA/person/yr*	***5 KM*** *Initial Cost: 19.2 M CFA* *Initial: 47 900 CFA/person* *Life Cycle: 3200 CFA/person/yr*
	Hand Pump 800 People	***HD Well*** *Initial Cost: 8.3 M CFA* *Initial: 10 300 CFA/person* *Life Cycle:1100 CFA/person/yr*	***SR Well*** *Initial Cost:* ***16.4*** *M CFA* *Initial:* ***20 600*** *CFA/person* *Life Cycle 1500 CFA/person/yr*	***SR Well*** *Initial Cost: 14.8 M CFA* *Initial: 18 500 CFA/person* *Life Cycle: 1500 CFA/person/yr*	***LR Well*** *Initial Cost: 36.9 M CFA* *Initial: 46 200 CFA/person* *Life Cycle: 2300 CFA/person/yr*
	Solar Pump 800 people	***SR Well*** *Initial Cost: 16.8 MCFA* *Initial: 21 000 CFA/person* *Life Cycle: 1100 CFA/person/yr*	***SR Well*** *Initial Cost: 18.0 M CFA* *Initial: 22 500 CFA/person* *Life Cycle: 1100 CFA/person/yr*	***SR Well*** *Initial Cost: 19.5 M CFA* *Initial: 24 400 CFA/person* *Life Cycle: 1200 CFA/person/yr*	***LR Well*** *Initial Cost: 27.4 M CFA* *Initial: 34 300 CFA/person* *Life Cycle: 1600 CFA/person*
	Line Exten. 800 people	***1 KM*** *Initial Cost: 4.0 M CFA* *Initial: 5 000 CFA/person* *Life Cycle: 1600 CFA/person/yr*	***2 KM*** *Initial Cost: 7.8 M CFA* *Initial:* ***9 800*** *CFA/person* *Life Cycle: 1800 CFA/person/yr*	***3 KM*** *Initial Cost: 11.6 M CFA* *Initial: 14 500 CFA/person* *Life Cycle: 1900 CFA/person/yr*	***5 KM*** *Initial Cost: 19.2 M CFA* *Initial: 30 600 CFA/person* *Life Cycle: 2500 CFA/person/yr*

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7. Synthesis –Medium and Large Demands Cost Comparison

Application	Uses / Distribution	Options	Required Well Depth at Site			
			30 m	50m	70m	90m
Medium 1,000-3,000 people 35 - 105 m^3/day	Potable Water, Small Livestock and Productive Uses; Small Storage, Limited Distribution, Stand-posts	**Solar Pump** **2,000 people**	Small Rig Well *Initial Cost: 31.6 M CFA* *Initial: 15 800 CFA/person* *Life Cycle: 800 CFA/person/yr*	Small Rig Well *Initial Cost: 34.3 M CFA* *Initial: 17 200 CFA/person* *Life Cycle: 800 CFA/person/yr*	Small Rig Well *Initial Cost: 37.7 M CFA* *Initial: 18 800 CFA/person* *Life Cycle: 900 CFA/person/yr*	Large Rig Well *Initial Cost: 47.8 M CFA* *Initial:23 900 CFA/person* *Life Cycle: 1100 CFA/person/yr*
		Diesel Pump **2,000 people**	Small Rig Well *Initial Cost: 29.2 M CFA* *Initial: 14 600 CFA/person* *Life Cycle:1000 CFA/person/yr*	Small Rig Well *Initial Cost: 29.5 M CFA* *Initial: 14 800 CFA/person* *Life Cycle: 1100 CFA/person/yr*	Small Rig Well *Initial Cost: 29.8 M CFA* *Initial: 14 900 CFA/person* *Life Cycle: 1200 CFA/person/yr*	Large Rig Well *Initial Cost: 36.6 M CFA* *Initial: 18 300 CFA/Person* *Life Cycle: 1300 CFA/person/yr*
Large 3,000-15,000 people 150-750 m^3/day	Potable Water, Larger Livestock and Productive Uses; Large Storage, Long Distribution, House Connections	**Diesel Pump** **5,000 people**	Large Rig Well *Initial Cost: 163 M CFA* *Initial: 32 800 CFA/person* *Life Cycle: 2300 CFA/person/yr*	Large Rig Well *Initial Cost: 163 M CFA* *Initial: 32 800 CFA/person* *Life Cycle: 2400 CFA/person/yr*	Large Rig Well *Initial Cost: 163 M CFA* *Initial: 32 800 CFA/person* *Life Cycle: 2500 CFA/person/yr*	Large Rig Well *Initial Cost: 163 M CFA* *Initial: 32 800 CFA/person* *Life Cycle: 2600 CFA/person/yr*
		Diesel Pump **10,000 people**	Large Rig Well *Initial Cost: 209 M CFA* *Initial: 20 900 CFA/person* *Life Cycle:1400 CFA/person/yr*	Large Rig Well *Initial Cost: 209 M CFA* *Initial: 20 900 CFA/person* *Life Cycle: 1500 CFA/person/yr*	Large Rig Well *Initial Cost: 209 M CFA* *Initial: 20 900 CFA/person* *Life Cycle: 1600 CFA/person/yr*	Large Rig Well *Initial Cost: 209 M CFA* *Initial: 20 900 CFA/person* *Life Cycle: 1700 CFA/person/yr*

7. Example Application of Cost Data for Technology Selection

Imagine an area with an existing town with water supply, and several outlying communities – of various sizes and at various distances. The table below shows the costs of different options for each outlying site, assuming groundwater conditions require a 50m deep well.

Population	Distance	Option	Total Initial Cost	Initial Cost / Person	Life Cycle Cost / Person / Year	Data Sources	Selection Comments
200	1 km	Hand Pump	4.7 M CFA	23,600 CFA	*1,600 CFA*	Slide 23	**Hand pump seems best,** but LE has much lower initial cost
		Solar Pump	9.6 M CFA	48,200 CFA	2,700 CFA	Slide 29	
		Line Exten.	2.9 M CFA	14,400 CFA	2,200 CFA	Slide 26	
400	2 km	Hand Pump	9.5 M CFA	23,600 CFA	*1,600 CFA*	Slide 23	**Hand pump seems best**, but LE has much lower initial cost
		Solar Pump	12.8 M CFA	32,000 CFA	1,700 CFA	Slide 29	
		Line Exten.	5.5 M CFA	13,800 CFA	2,000 CFA	Slide 26	
1,200	3 km	Hand Pump	25.9 M CFA	21,600 CFA	1,500 CFA	Slide 23	**Solar pump seems best**, but LE has much lower initial cost
		Solar Pump	23.3 M CFA	19,400 CFA	*1,000 CFA*	Slide 29	
		Line Exten.	14.8 M CFA	12,300 CFA	1,800 CFA	Slide 26	
2,000	5 km	Solar Pump	34.3 M CFA	17,200 CFA	*800 CFA*	Slide 39	**Solar pump seems best**, but diesel fairly close
		Diesel Pump	29.5 M CFA	14,800 CFA	1,100 CFA	Slide 39	

7. Operations and Maintenance

- Without proper O&M any water supply investment will fail prematurely. Life cycle cost analysis accounts for all the costs of proper O&M.
- During the course of the project, a Water Management Committee was formally established in all locations with a legal mandate, bank account and elected officers. Fees were to be paid by all users. Committees retained services of paid O&M personnel. Bank accounts and expenses monitored by the Project and local NGOs
- The large water supply systems received a major training programs on technical, operational, governance and administrative matters

7. Summary and Conclusions

- Selection of water supply technologies in Senegal using life cycle costs leads to different selections than when using initial costs.
- The use of hand drilled wells and small well rigs, in combination with reliable (or locally serviceable) hand pumps changes the landscape of preferred water supply technologies, where groundwater conditions are favorable. These technologies are conducive to local business.
- While initial costs can be high, solar pumps have lower life cycle costs for some small water demands (bigger demands and deeper wells, but are always lower than diesel pumps for medium water demands.

7. Summary and Conclusions

- For large towns – above 5,000 people - where deep wells must be used to provide sufficient yield, the conventional designs remain the best option, but the cost is high, and ongoing O&M support is critical.
- House connections add considerably to the cost but the greatly increased convenience and health benefits can lead users to prefer them
- Large systems can also provide additional benefits – such as small irrigation
- Life Cycle Cost comparisons are important, but governance, O&M, and user preferences also need to be included in policy formulation and implementation.