The Case for Rainwater Harvesting: Where Value and Cost Collide

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Thesis:

- Compared to centrally-supplied water, harvesting systems viewed as expensive, unreliable
- They remain a good hedge against water supply shortage or interruption, and a viable source in underserved areas
- Knowledge and system cost remain the most significant barriers to wide-spread adoption

Discussion:

- Harvesting system components and costs
- Cost comparisons
- Efficacy analyses
- Conclusions and parting thoughts

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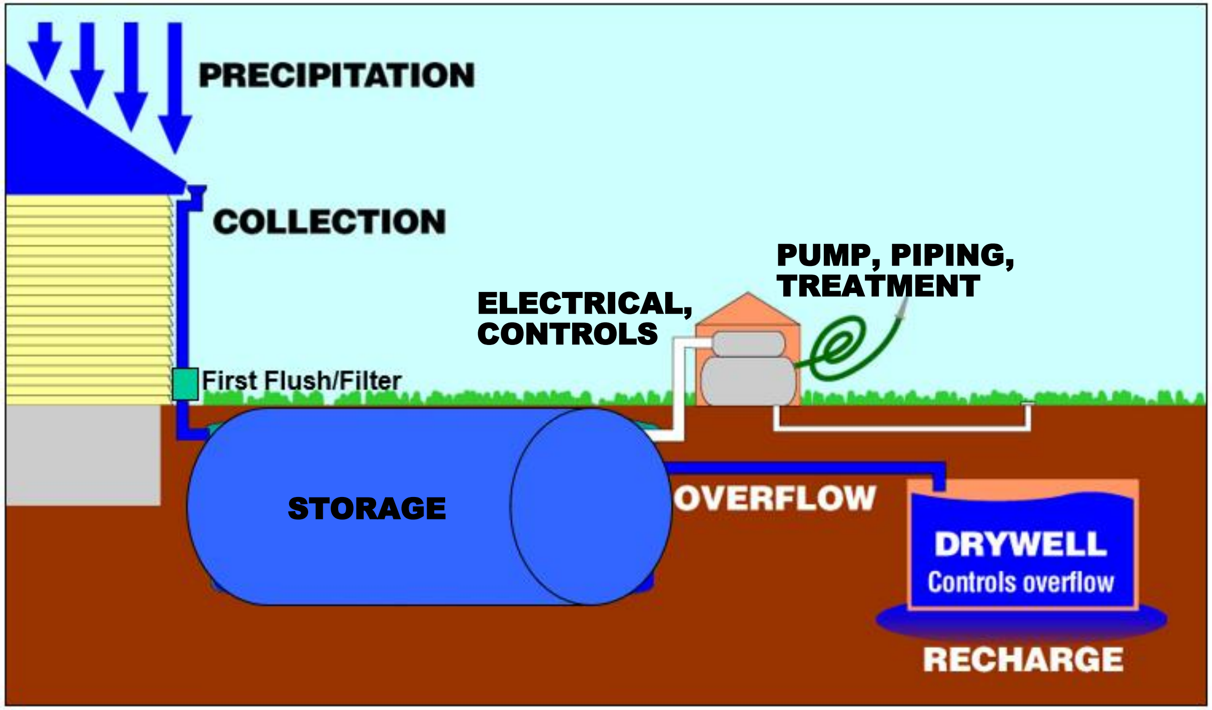
Components



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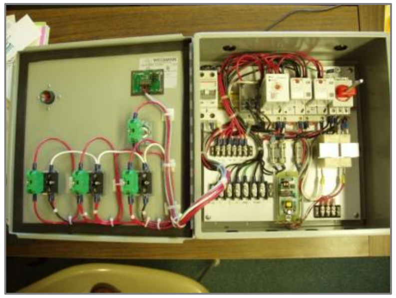
Components

Collection and Overflow

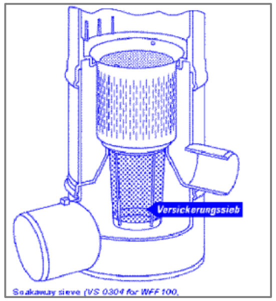
Pumpworks

Storage – can take nearly any shape, size

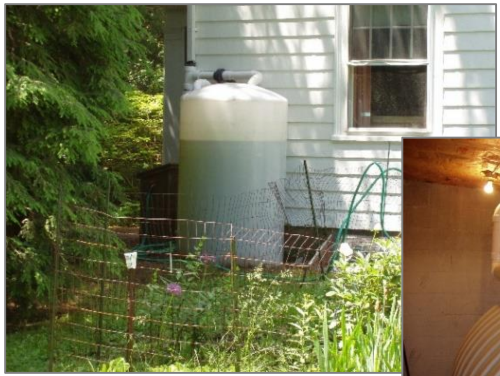
Controller



Filtering & Treatment



Storage – small systems



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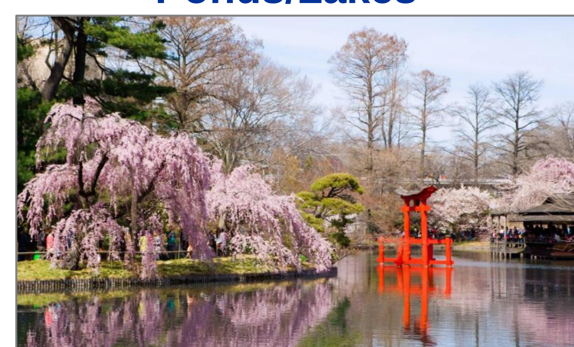
Storage – large systems

Pre-cast, CIP concrete

Modular Vault (plastic)

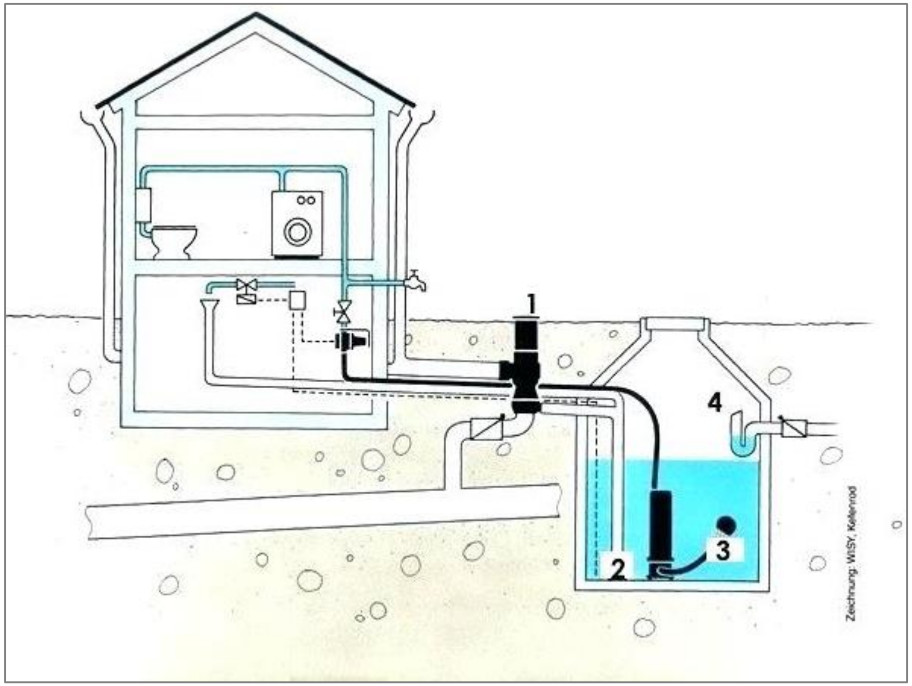
Fiberglass (FRP)

Ponds/Lakes



Context for Cost Comparison:

- Household/commercial scale, potable water
- Non-passive: electrically powered pump system and water quality treatment to emulate centrally supplied water
- Most suitable for areas with reasonable precipitation pattern – storage typically sized for 2 weeks of water demand
- ‘Integrated’ systems have automated fail-over/fail-back interface valve to primary domestic supply (where present)



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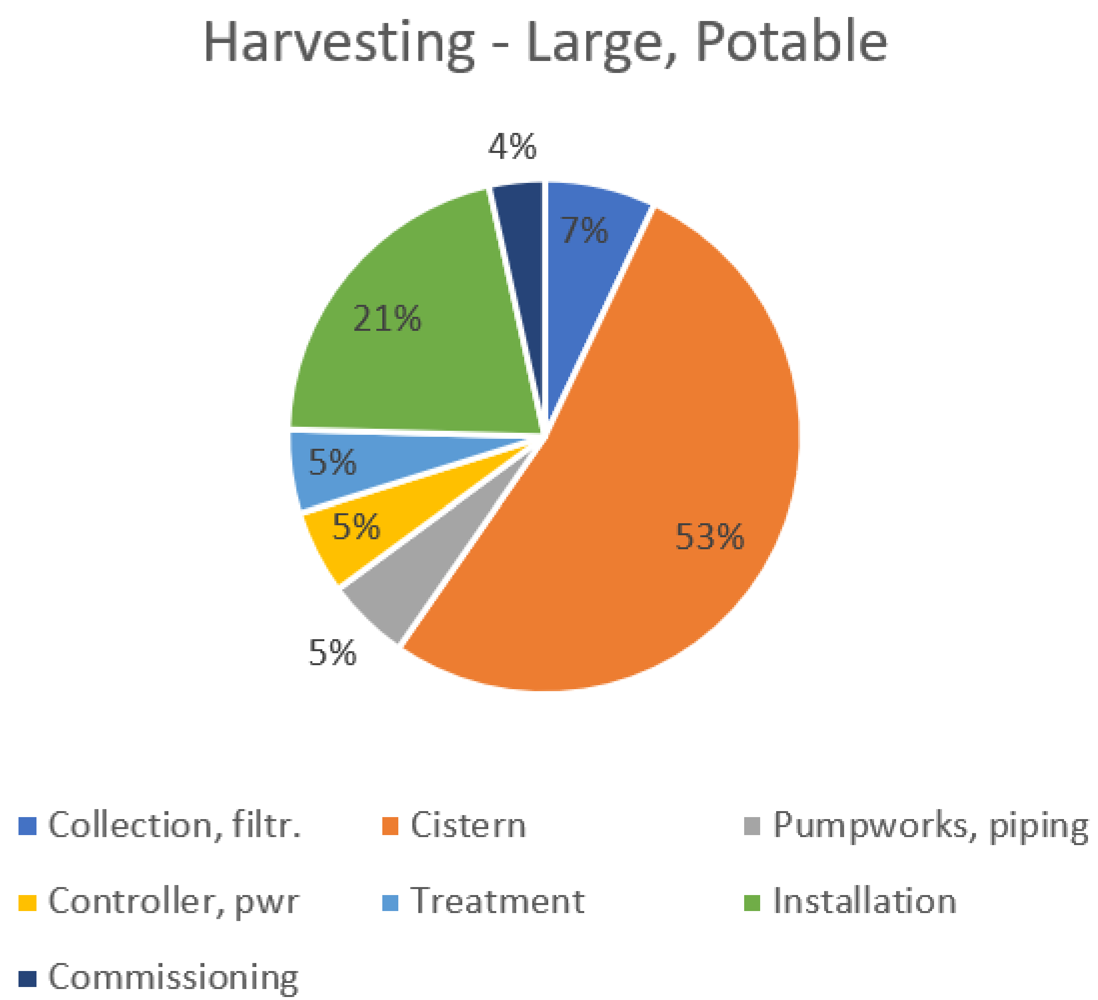
Costs



USD 20,000 – 100,000+

10 – 200+ m^3 storage

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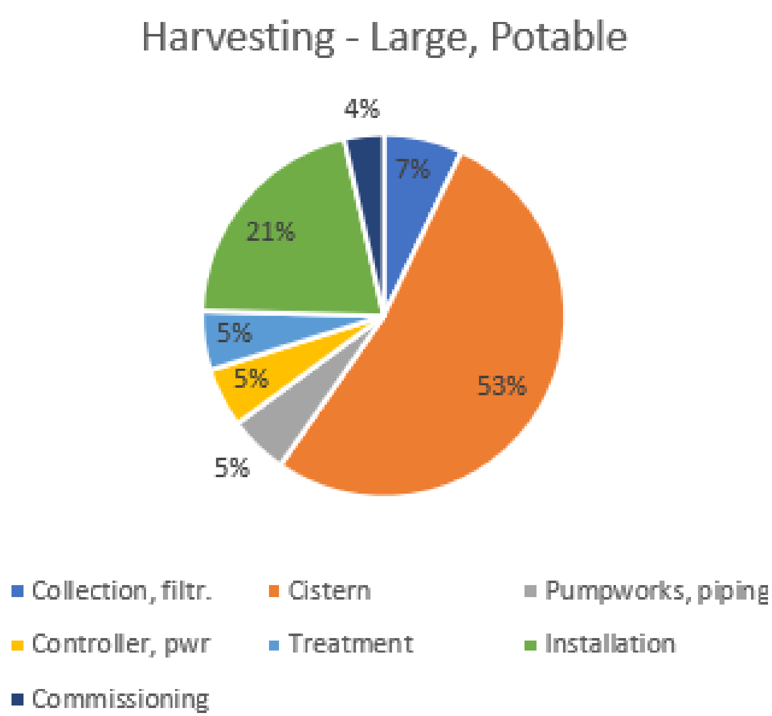
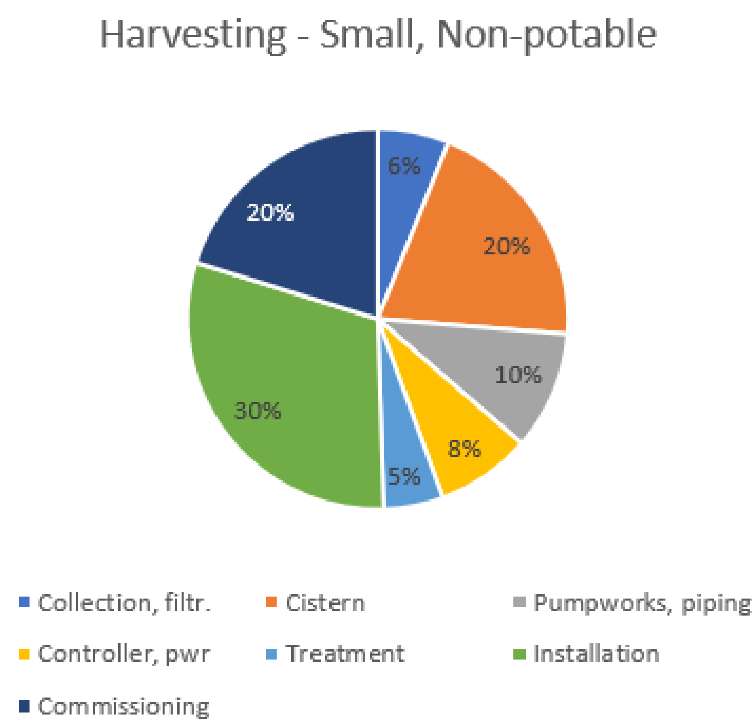
Costs





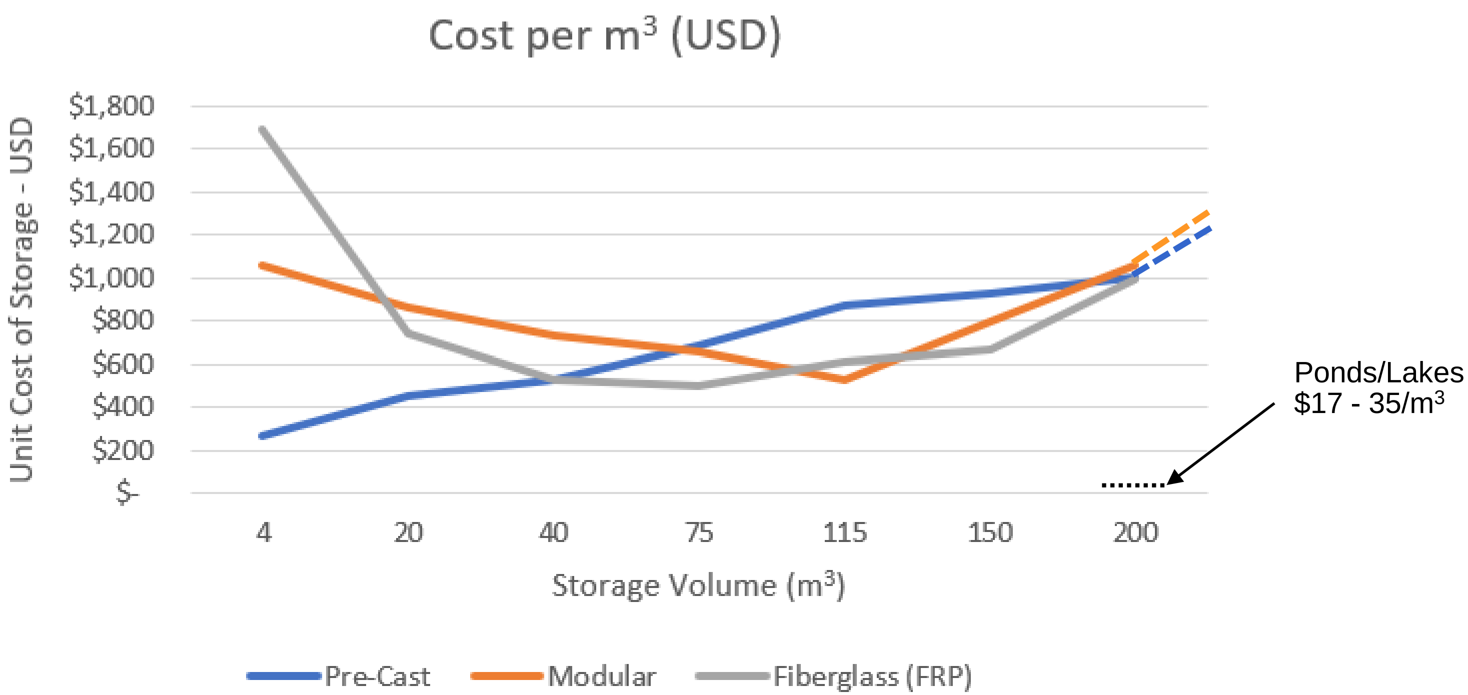
USD 20,000 – 100,000+

10 – 200+ m^3 storage

USD 1,500 – 3,000+

2 – 10 m^3 storage

Storage Costs



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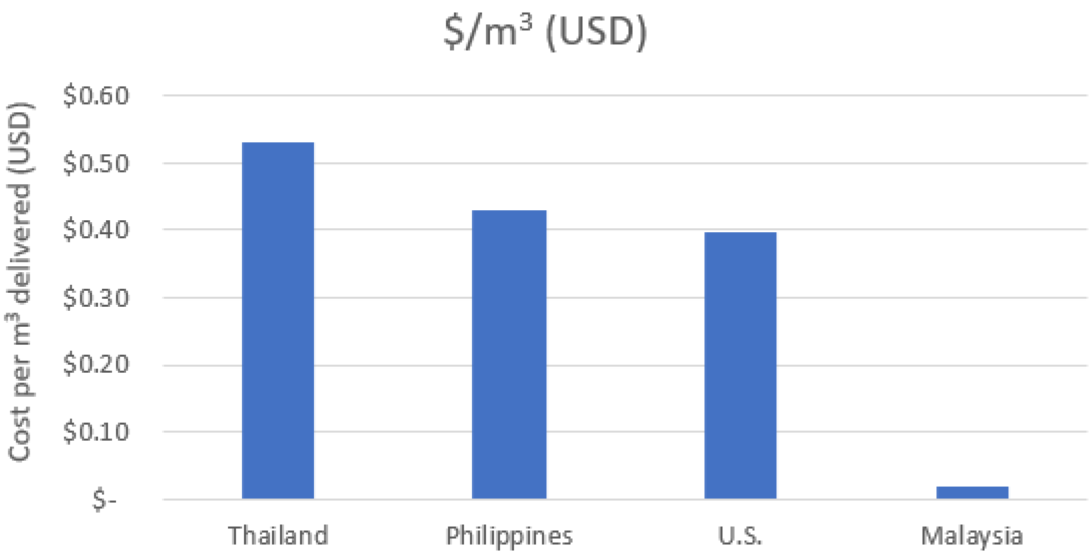
Costs Comparison – Centralized Supplies



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Costs Comparison

Supply Type	System/Geometry	Installed Cost USD	Use per Month[1]	Monthly Cost[2,3] USD	Cost vs. Centralized (x)
Harvesting (2 weeks supply storage)	Collection piping and inlet filtration, 23 m^3 cistern, pump set and distribution piping, 2-stage fine particulate filtration, ozone or UV disinfection, activated carbon filtration	$28,500	45 m^3	$188	10
Drilled Well	Depth 45 m, 1 hp well pump set and distribution piping, 2-stage fine particulate filtration, ozone or UV disinfection, activated carbon filtration	$11,400	45 m^3	$75	4
Centralized Water Supply	Government or government contracted water supplier	N/A	45 m^3	$18	1

Notes

1. Usage — Household of 5 @ 300 litres/person/day = 1,500 litres/day = 45.5 m^3 per month
   - Harvesting — Assumes 100 mm precip./mo. in 2 week blocks on 445 m^2 collection area. Ground collection necessary due to area required.
   - Drilled Well — Avg. yield requirement ~8 litres/min for 4 hrs daily use

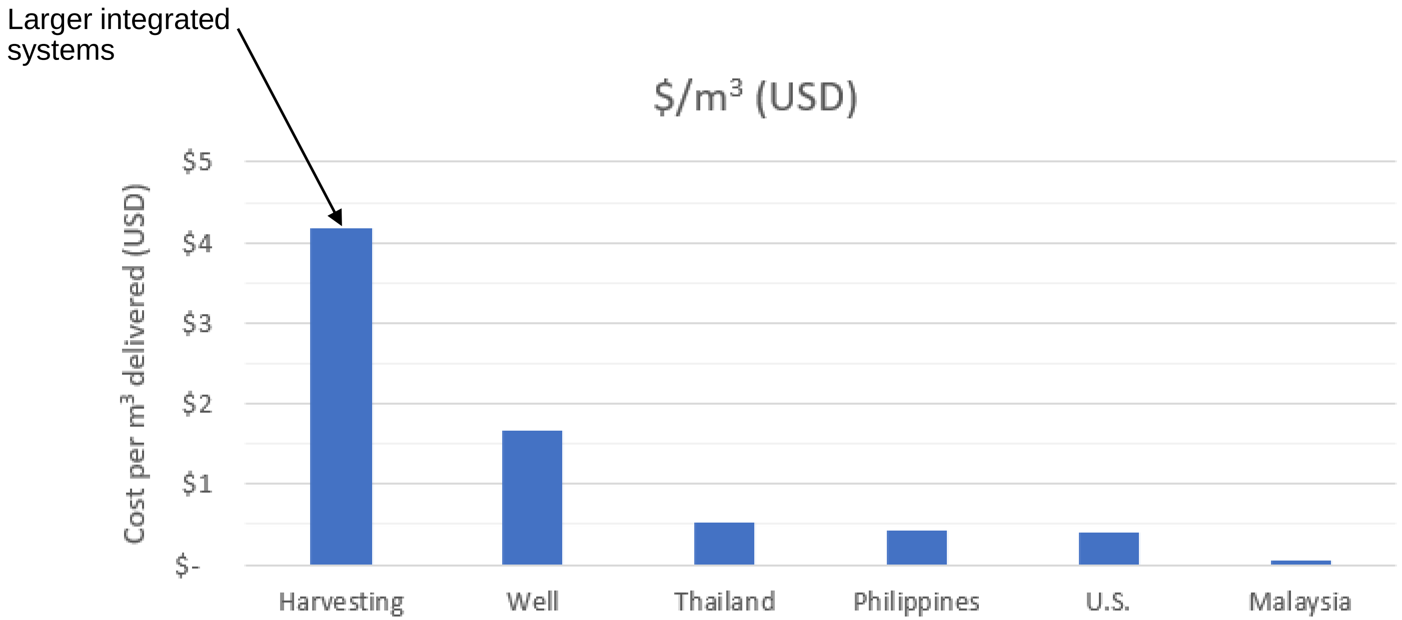
2. Ammortized Cost (20 yr. ROI, 5% interest rate) (large system)

	Harvesting	Drilled Well
Cost:	-$28,500	-$11,400
Term (months):	240	240
Rate (APR):	5%	5%
Ammort. (PMT):	$188.09	$75.23

3.1 Excludes periodic maintenance and filter element replacement.

3.2 Centrally supplied cost is from US; Excludes any escalation in water rates.

Costs Comparison – Centralized vs. Alternates



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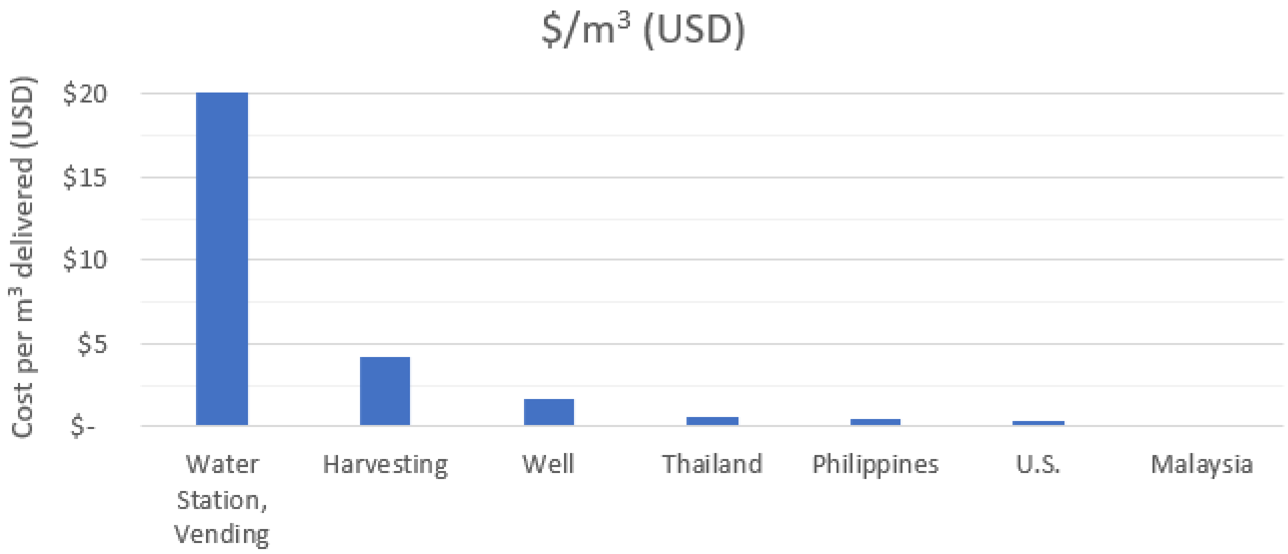
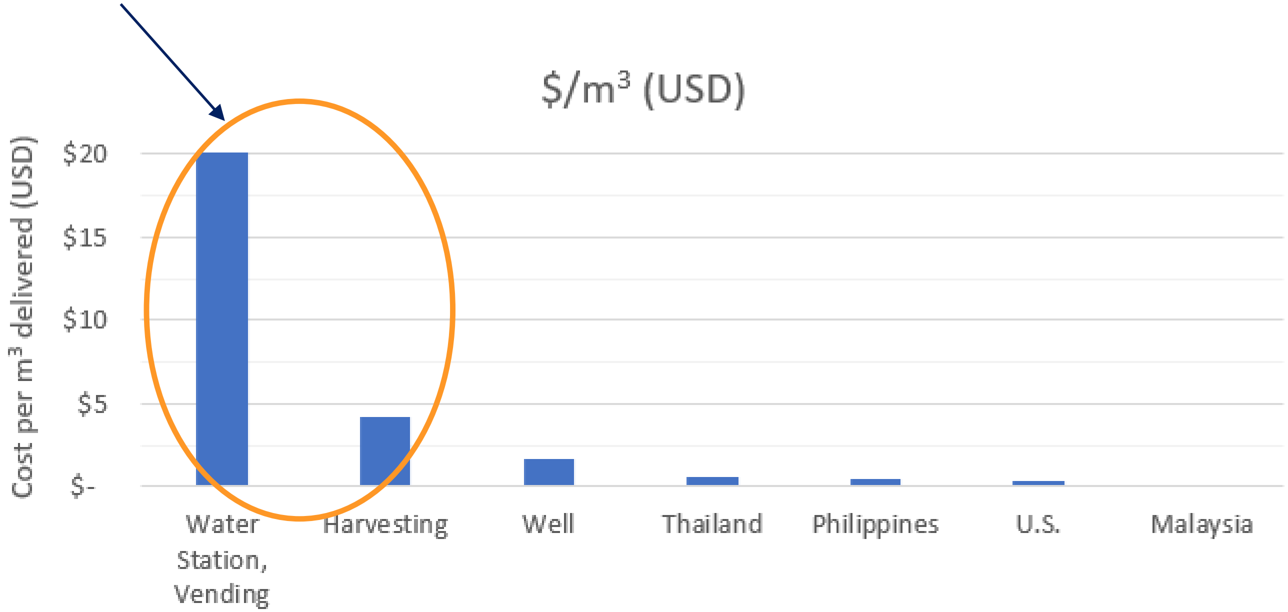
Costs Comparison – Centralized vs. Alternates, Retail



Costs Comparison – Centralized vs. Alternates, Retail

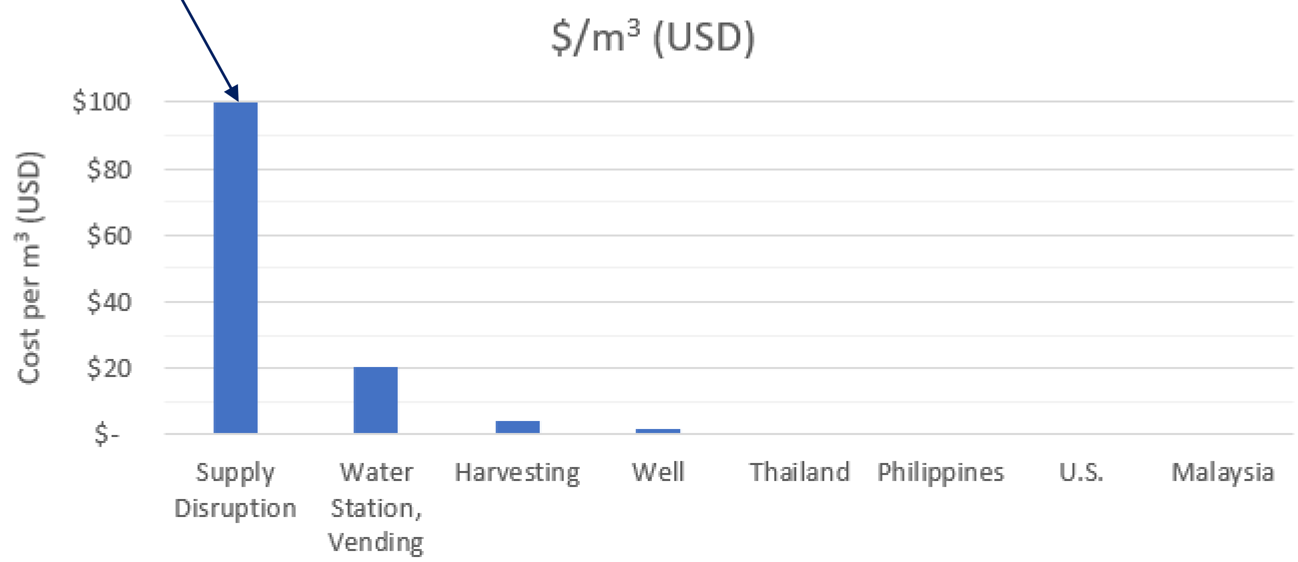
Harvesting has high relative value in areas with:

- Poor quality centralized water supplies
- Untreated well water as primary domestic supply



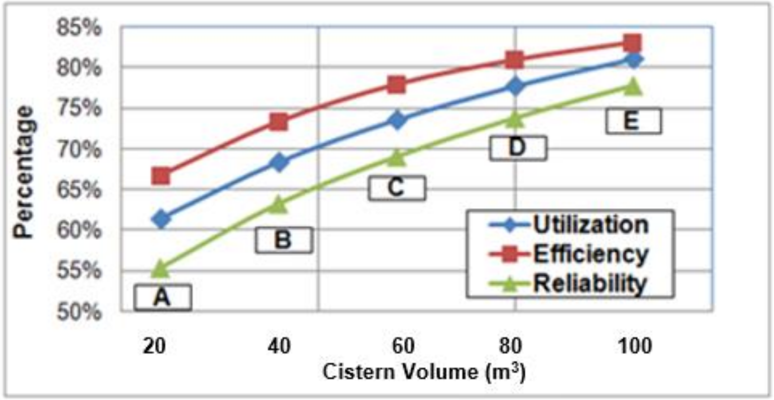
Costs Comparison – vs. broad supply disruption

Hypothetical: economic value not calculated



So, how well do they work?

Harvesting System Efficacy/ Performance Metrics



- Utilization: % of total water demands met
- Reliability: % of days water demands are fully met
- Efficiency: % of total precipitation captured. Represents reduction in flows to stormwater infrastructure (urban applications)

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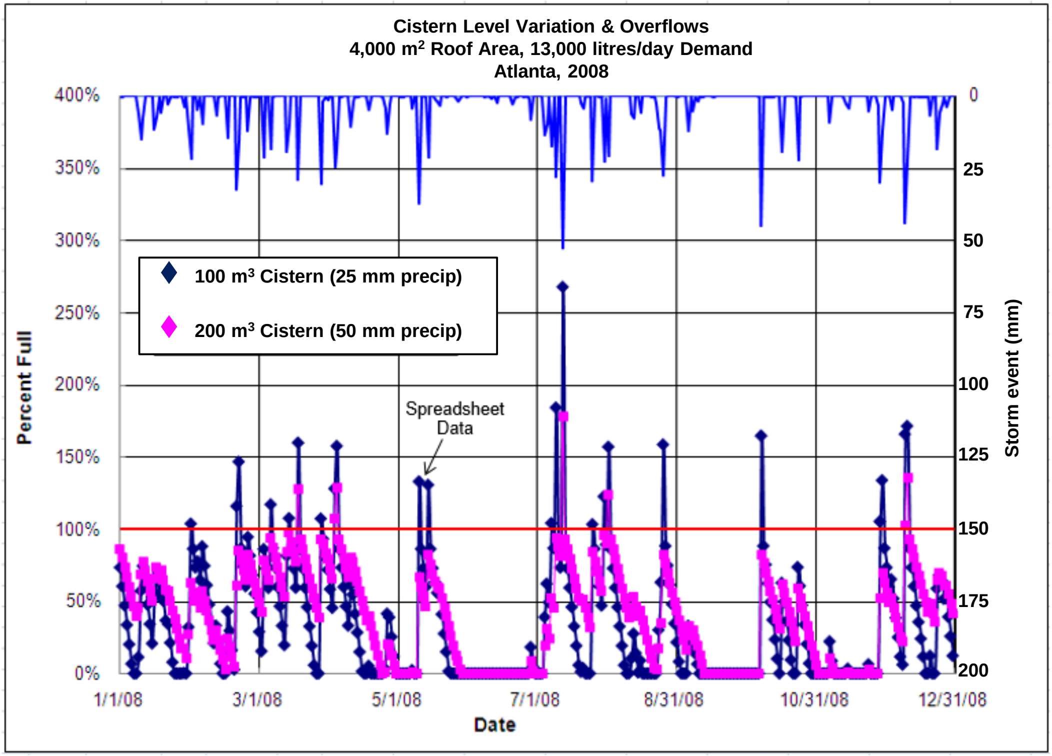
Analytical Model
(Simplified*)

Atlanta, GA Precip. Data
100 m³ Cistern (25 mm precip)
Assumes 5% Harvesting Losses

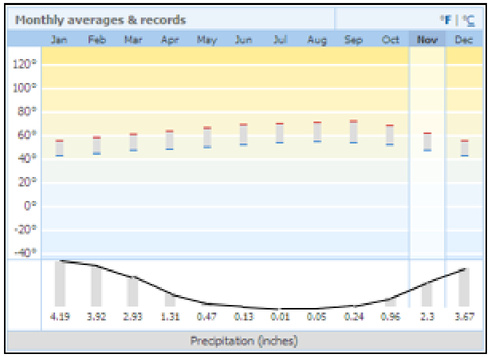
Spreadsheet Data in Gallons

Date	P (in)	V_0 (gal)	V_{free} (gal)	$Vrw_{harv,pot}$ (gal)	$V_{harv,actual}$ (gal)	V_{demand} (gal)	V_1 (gal)	V_{backup} (gal)	$V_{overflow}$ (gal)	Ctr.	Rel. Ctr.	Level incl. Overflow (%)
4/30/08	0	6,636	19,364	0	0	3,500	3,136	0	0	1	1	12%
5/1/08	0	3,136	22,864	0	0	3,500	0	364	0	1	0	0%
5/2/08	0	0	26,000	0	0	3,500	0	3,500	0	1	0	0%
5/3/08	0.02	0	26,000	516	516	3,500	0	2,984	0	1	0	0%
5/4/08	0.005	0	26,000	129	129	3,500	0	3,371	0	1	0	0%
5/5/08	0	0	26,000	0	0	3,500	0	3,500	0	1	0	0%
5/6/08	0	0	26,000	0	0	3,500	0	3,500	0	1	0	0%
5/7/08	0	0	26,000	0	0	3,500	0	3,500	0	1	0	0%
5/8/08	0.16	0	26,000	4,127	4,127	3,500	627	0	0	1	1	2%
5/9/08	0	627	25,373	0	0	3,500	0	2,873	0	1	0	0%
5/10/08	0	0	26,000	0	0	3,500	0	3,500	0	1	0	0%
5/11/08	1.48	0	26,000	38,176	29,500	3,500	26,000	0	8,676	1	1	133%
5/12/08	0	26,000	0	0	0	3,500	22,					
5/13/08	0	22,500	3,500	0	0	3,500	19,					
5/14/08	0.005	19,000	7,000	129	129	3,500	15,					
5/15/08	0.85	15,629	10,371	21,926	13,871	3,500	26,					
5/16/08	0	26,000	0	0	0	3,500	22,					
5/17/08	0	22,500	3,500	0	0	3,500	19,					
5/18/08	0.04	19,000	7,000	1,032	1,032	3,500	16,					
5/19/08	0.06	16,532	9,468	1,548	1,548	3,500	14,					

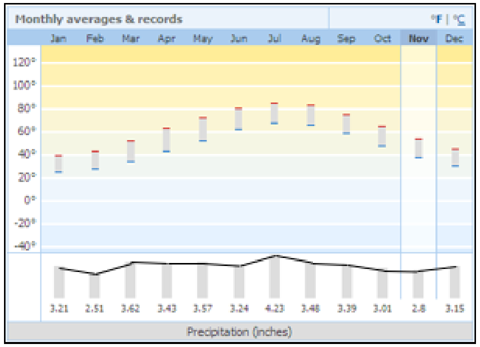
*No Intra-day data
No Seasonal demands
No Irrigation / Evapotranspiration algorithms
No Weather based controller / soil moisture depletion algorithm

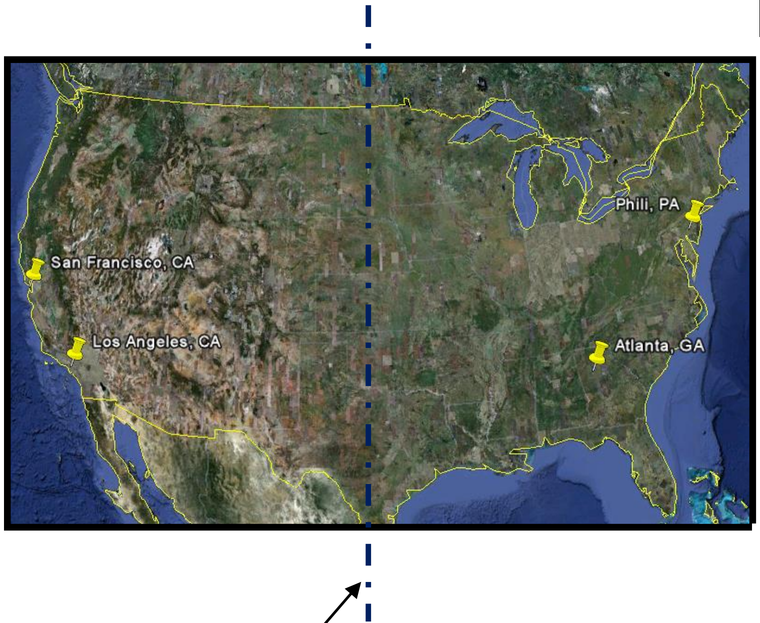


San Francisco ~ 500 mm per year

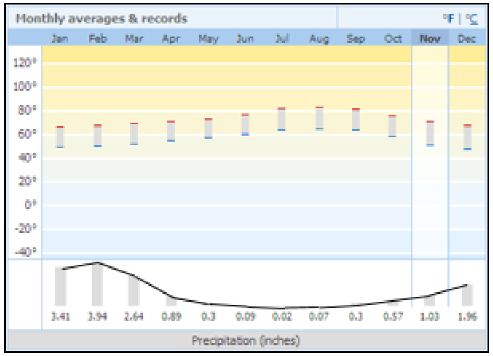


Philadelphia ~ 1,000 mm per year



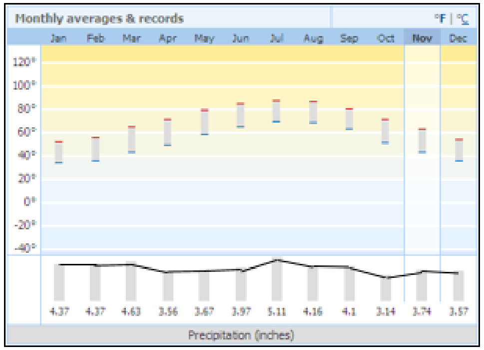


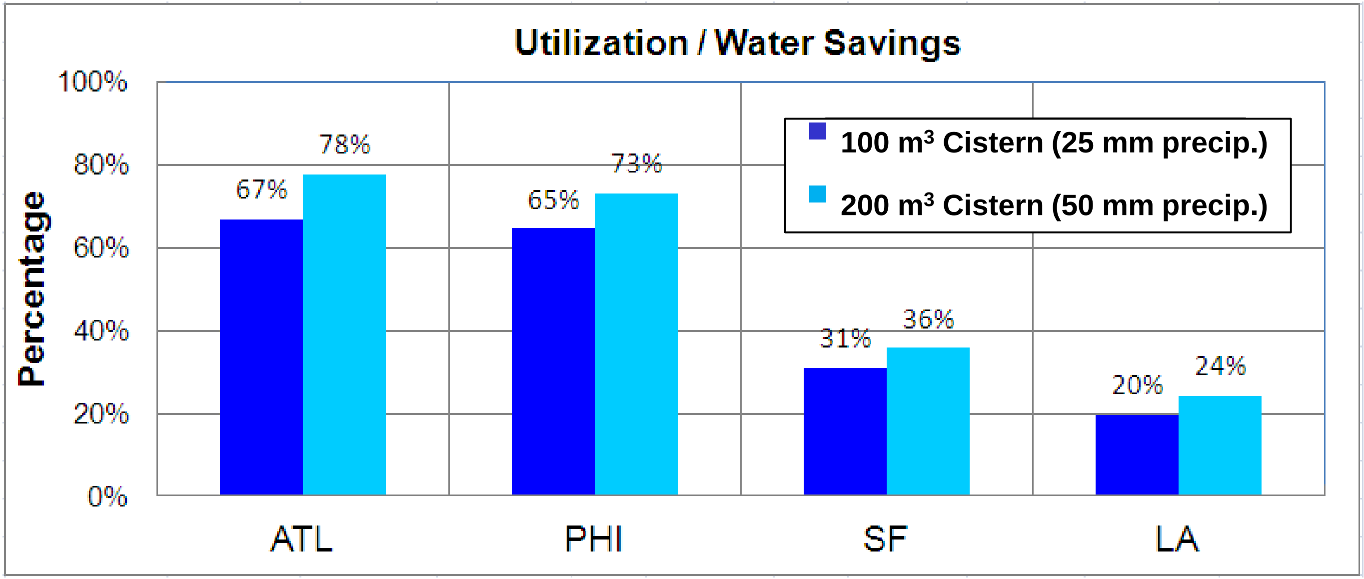
Los Angeles ~ 300 mm per year



Predominantly arid climate west of approx. 100˚ longitude

Atlanta ~ 1,200 mm per year





Overall water demands met by system:

- Non-linear with respect to cistern size
- Significantly dependent on regularity of precipitation
- Short-duration, high-intensity storm events typically reduces Utilization

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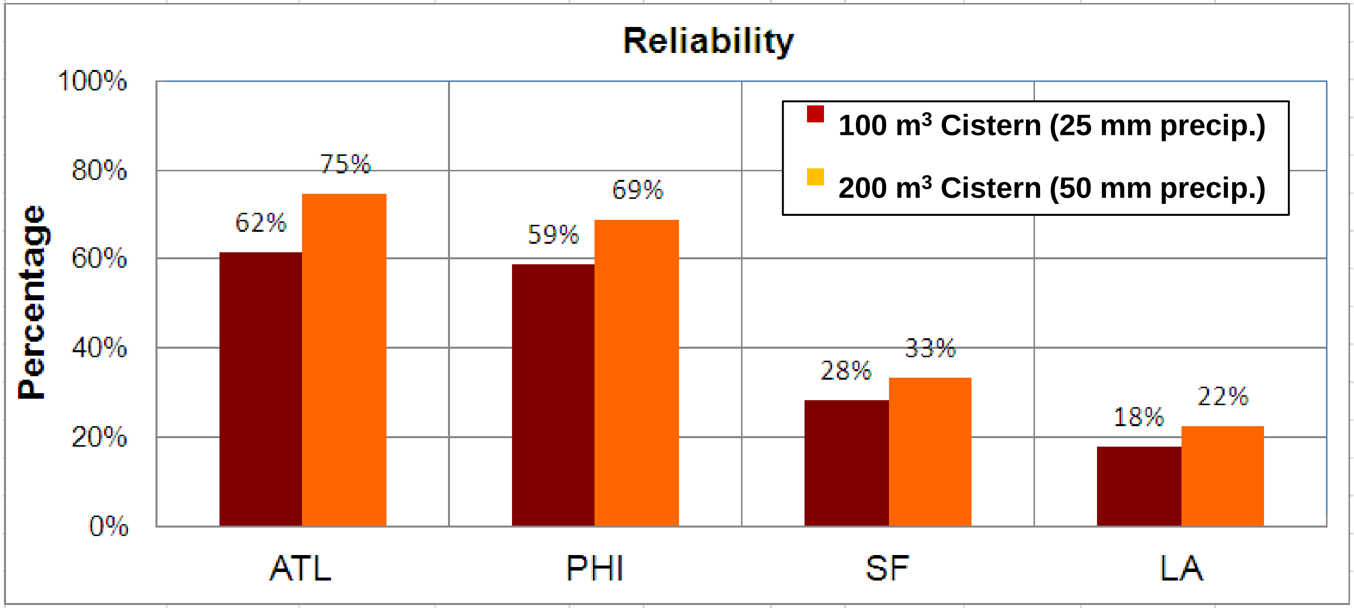

Daily demands met by system:

- Non-linear with respect to cistern size
- Significantly dependent on regularity of precipitation
- Short-duration, high-intensity storm events typically reduces Reliability

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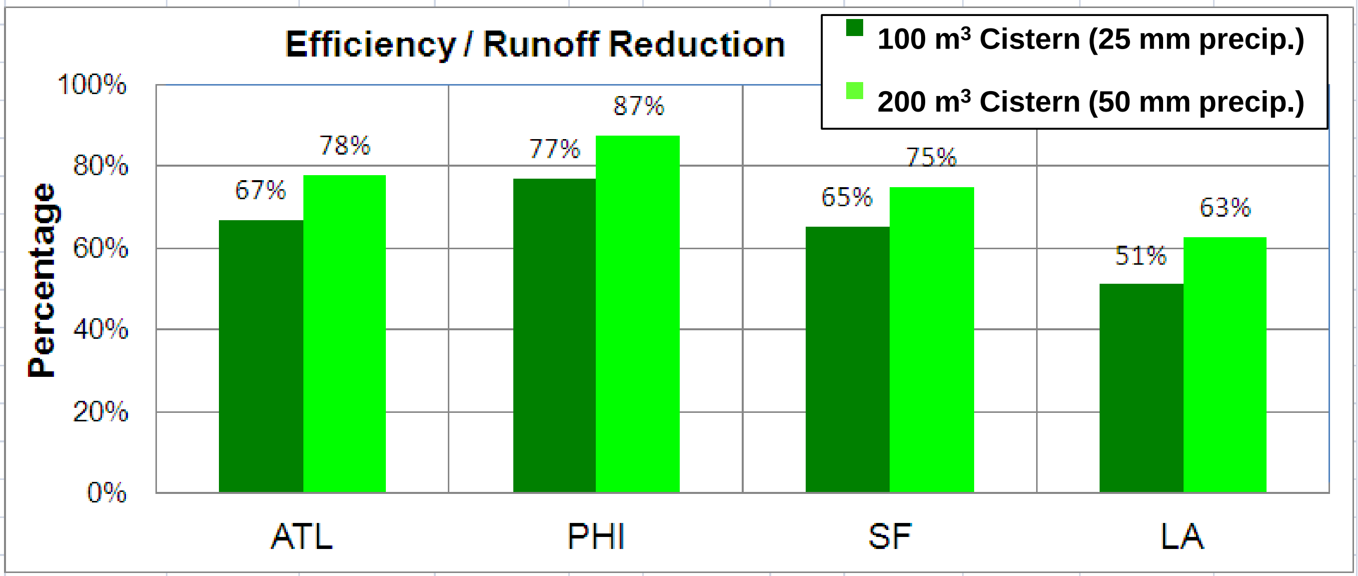

Overall stormwater flows captured by system:

- **Non-linear with respect to cistern size**
- **<u>Less</u> dependent on regularity of precipitation**
- **Good performance for stormwater control across varied precipitation profiles**

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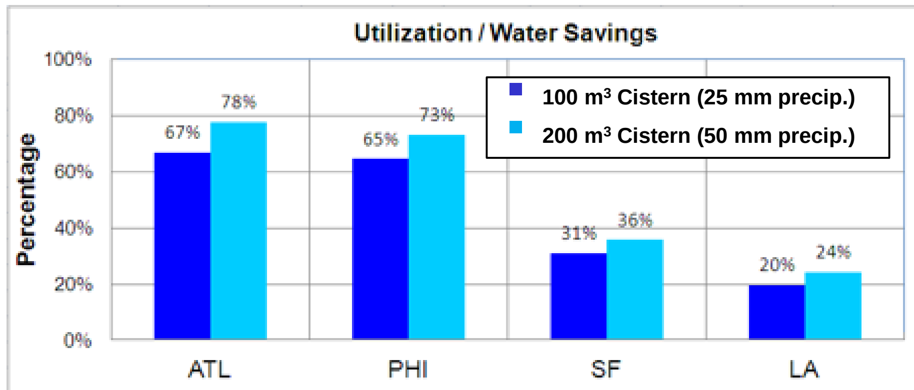
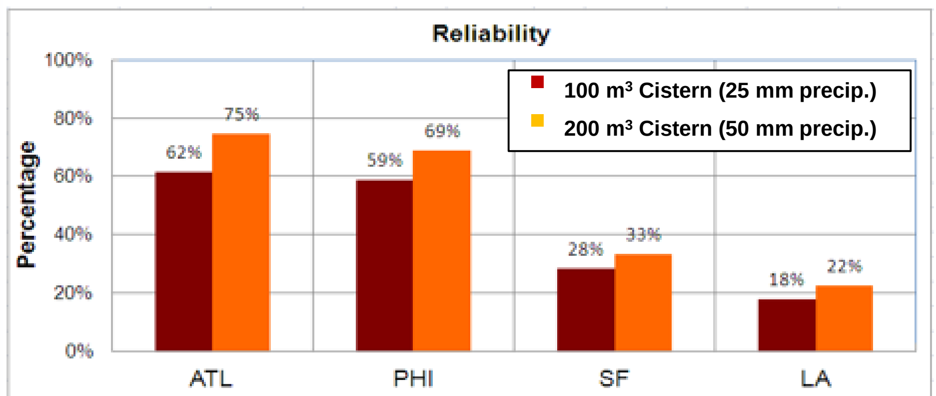
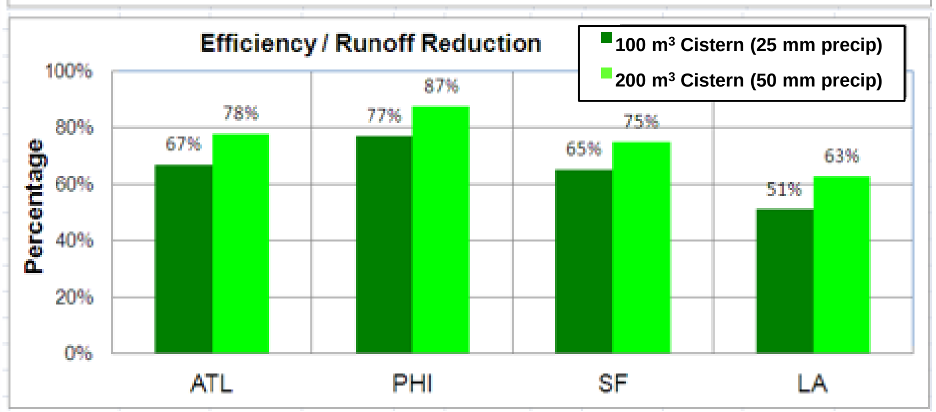

Utilization / Water Savings
Percentage
100%
80%
60%
40%
20%
0%
100 m³ Cistern (25 mm precip.)
200 m³ Cistern (50 mm precip.)
67%
78%
65%
73%
31%
36%
20%
24%
ATL
PHI
SF
LA


Reliability
Percentage
100%
80%
60%
40%
20%
0%
100 m³ Cistern (25 mm precip.)
200 m³ Cistern (50 mm precip.)
62%
75%
59%
69%
28%
33%
18%
22%
ATL
PHI
SF
LA


Efficiency / Runoff Reduction
Percentage
100%
80%
60%
40%
20%
0%
100 m³ Cistern (25 mm precip)
200 m³ Cistern (50 mm precip)
67%
78%
77%
87%
65%
75%
51%
63%
ATL
PHI
SF
LA

Conclusions and parting thoughts:

- Significant benefits where centrally managed water supplies are stressed or of low quality
- Stresses on water supplies increasing from
  - Population growth and urbanization
  - Developing nations ⇨ increased demands
  - System mis-management and under-maintenance
  - Climate change
  - Lack of awareness, appreciation, and education
  - Poor pricing practices, low perceived value of centrally-supplied water
- Significant benefits for disconnected or underserved communities
- Harvesting system efficacy f(precipitation pattern)
- Water supply systems seldom consider ‘true’ cost of centrally supplied water
- Consider ‘use hierarchy’ in system design
- Harvesting dates to the beginnings of humanity – so why not now?

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Thank you!

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