Multiple household water sources in Pacific Island Countries: adaptation to changes in seasonal precipitation

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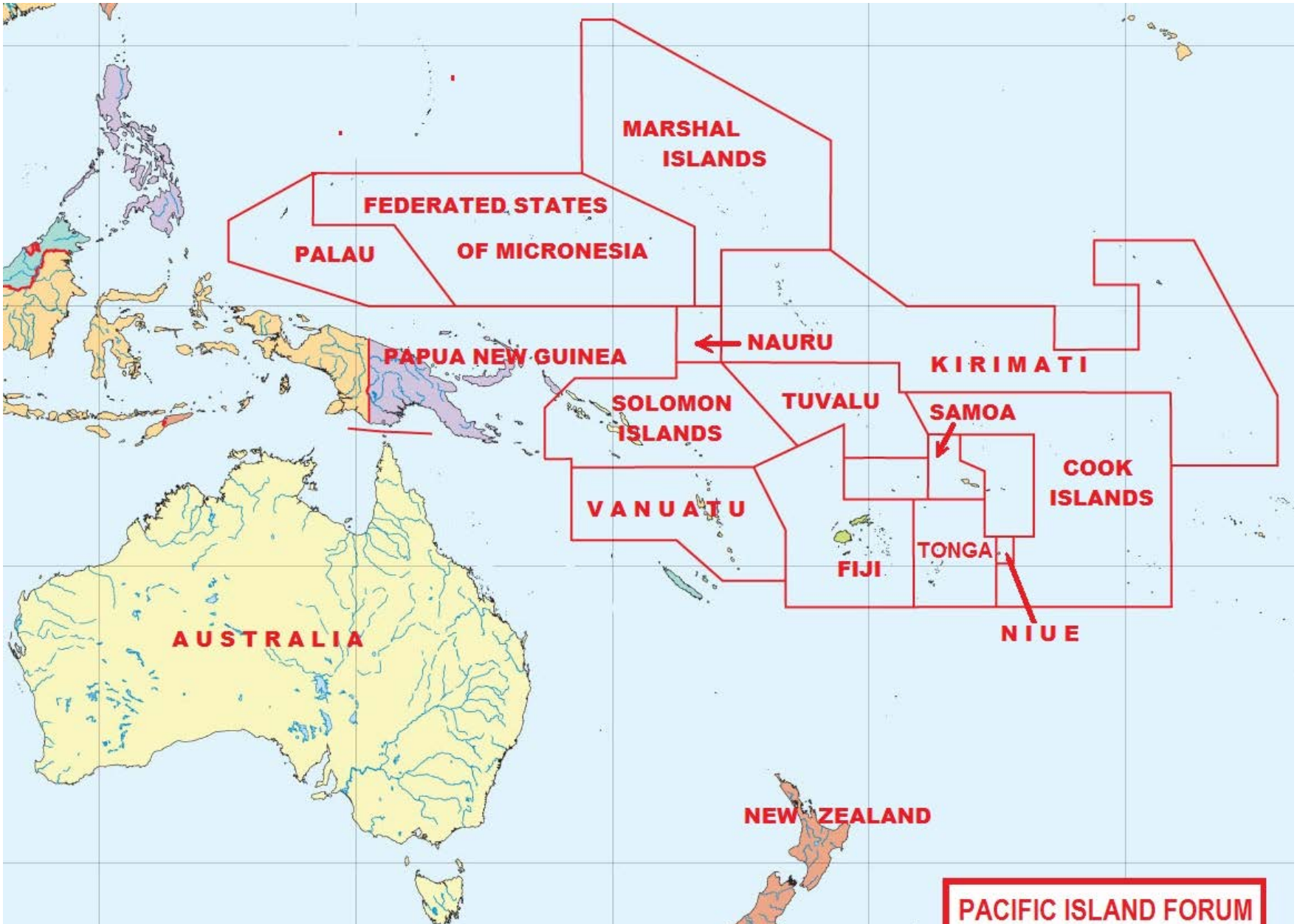
Pacific Island Countries



Pacific Island Countries

- The Millennium Development Goal (MDG) region “Oceania”
- American Samoa, Cook Islands, Fiji, Guam, Kiribati, ***Republic of the Marshall Islands (RMI)***, Micronesia (Fed. States of), Nauru, New Caledonia, Niue, Northern Mariana Islands, Palau, Papua New Guinea (PNG), Samoa, ***Solomon Islands***, Tokelau, Tonga, Tuvalu and Vanuatu

Republic of the Marshall Islands (RMI)

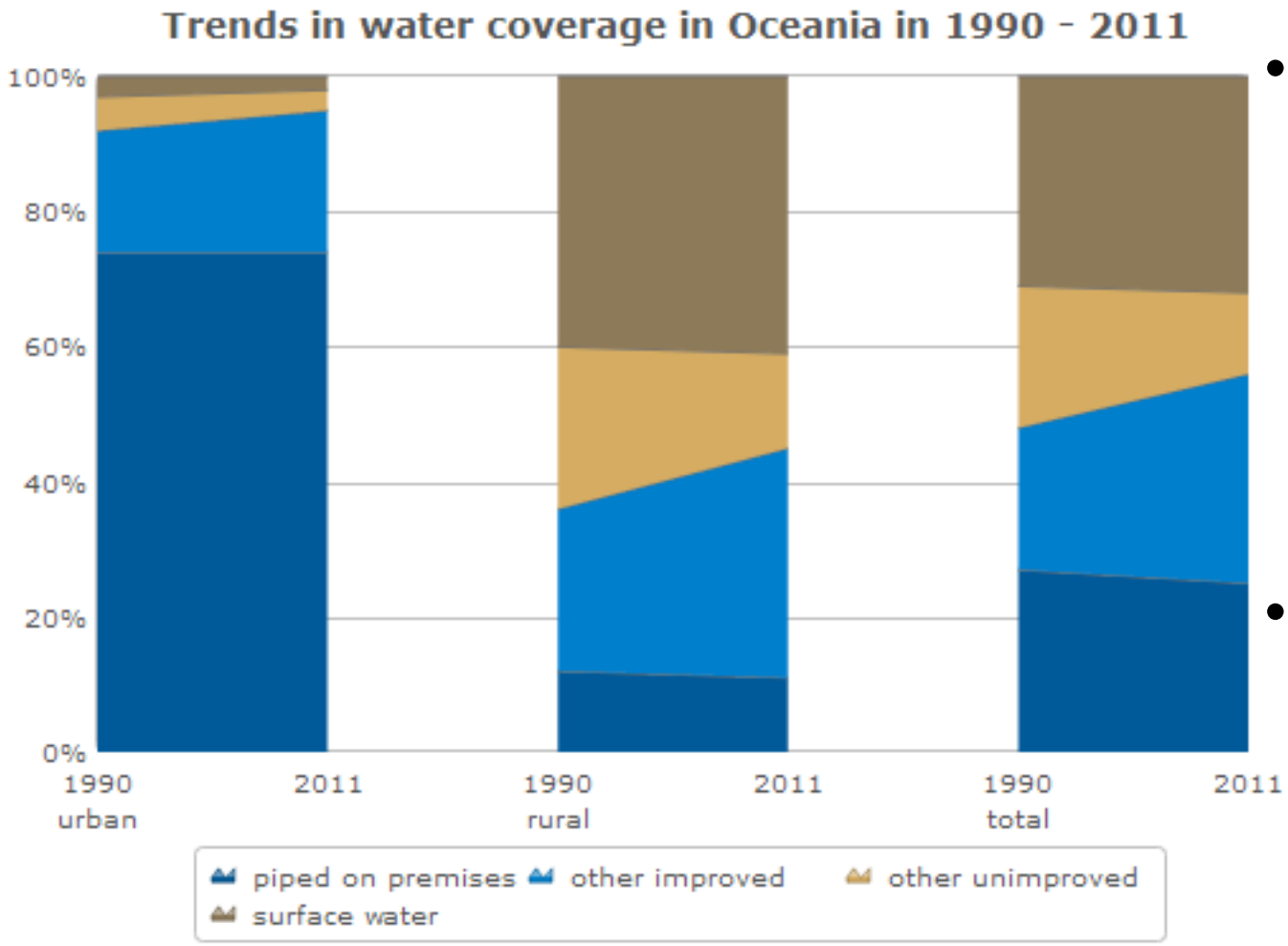
- 29 coral atolls
- 70 sq. mi. of land spread over 750,000 sq. mi. of ocean
- Wider atolls have a fresh groundwater lens over seawater
- No surface water
- Very low-lying: avg. about 2 meters above sea level

Republic of the Marshall Islands (RMI)

Solomon Islands

- Larger islands
- Topography similar to Hawaii
- Inland rivers and springs
- Frequent, major flooding

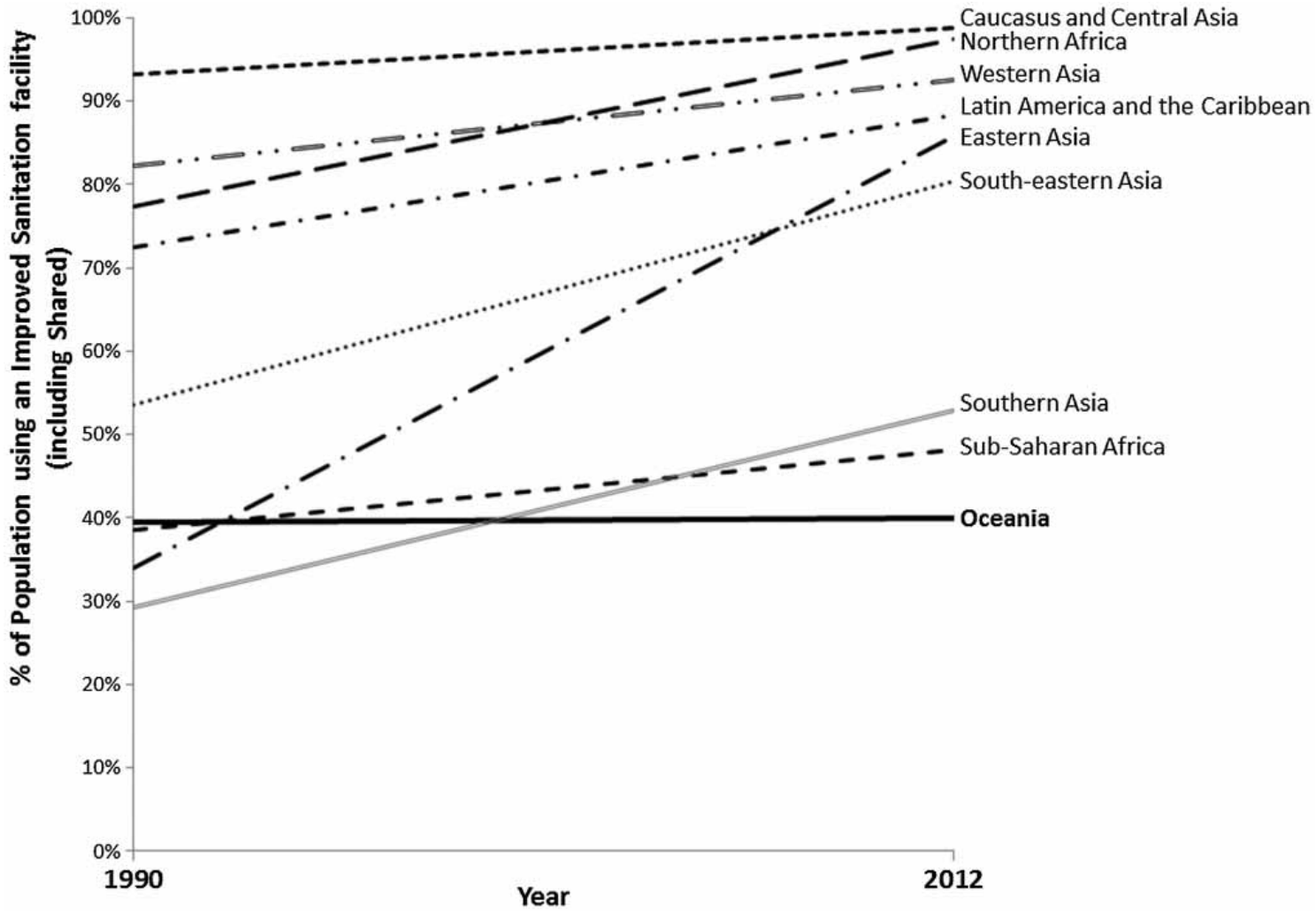
MDG progress - drinking water in PICs



- Lowest proportion of people with improved drinking water (56%).
- 32% of the population still rely on raw surface water.

Figure from WHO/UNICEF JMP 2013 Report

Regional trends in improved sanitation facilities (including shared)



Source: Hadwen et al. (2015) Putting WASH in the water cycle: climate change, water resources and the future of water, sanitation and hygiene challenges in Pacific Island Countries. *J Wat San Hygiene Development*. 5:183-191

Climate change in PICs

Marshall Islands

- Water resources extremely vulnerable to changes in precipitation
  - Rooftop rainwater harvesting
  - Fresh groundwater lenses
- State of national emergency declared in 2013 due to severe drought
  - Drinking water carboys and reverse osmosis units (for desalination) brought by ship to outer atolls
- Low-lying settlements vulnerable to sea-level rise

Climate change in PICs

Solomon Islands

- Flooding is a constant threat
- Major flooding on main island of Guadalcanal in 2009 (1800 homes destroyed, 9 dead) and 2014 (50,000 impacted, 22 dead)
- Waterborne disease outbreaks following flooding

Household (HH) Water Use

- Many households in developing countries use multiple sources for daily water needs (e.g., one for drinking, another for bathing, etc.)

- Poorly understood by water, sanitation and hygiene (WaSH) researchers and practitioners

- Primary HH drinking water source in global surveys (e.g., DHS) and data sources (e.g., JMP) focus exclusively on primary drinking water source

Household Water Use

- Knowledge gaps on multiple sources have been recognized by WaSH researchers (e.g., Evans et al., 2013; Shaheed et al., 2014)
  - Not addressed/no solution offered
  - One reason: data collection is difficult/complicated

- Filling these knowledge gaps around HH water management is essential to understand or model the impacts of water on:
  - Health/hygiene
  - livelihoods
  - climate change resilience and adaptation

Research Objectives

As part of a broad, inter-disciplinary project on climate and WaSH in PICs. This presentation focuses on:

- the role of multiple water sources in daily household (HH) water management
- the adaptation of HH water sources and practices to differences in seasonal precipitation

Methods – Household Survey

- Household interviews were conducted five communities; two in the Solomon Islands (SI) and three in Republic of the Marshall Islands (RMI)

- n = 143 households (HHs)
  - 99 in RMI
  - 44 in SI

Methods – Household Survey

- Field work is ongoing
  - Spring 2015 field work in SI cancelled after torrential rains washed out roads and made communities inaccessible
  - About 7 more communities
  - Expect n = 320 after summer/fall 2015 field work
- Initial surveys conducted on paper in SI
  - Based on a survey instrument developed by Dale Whittington and colleagues (UNC)
  - Extremely complicated and time-consuming to deliver

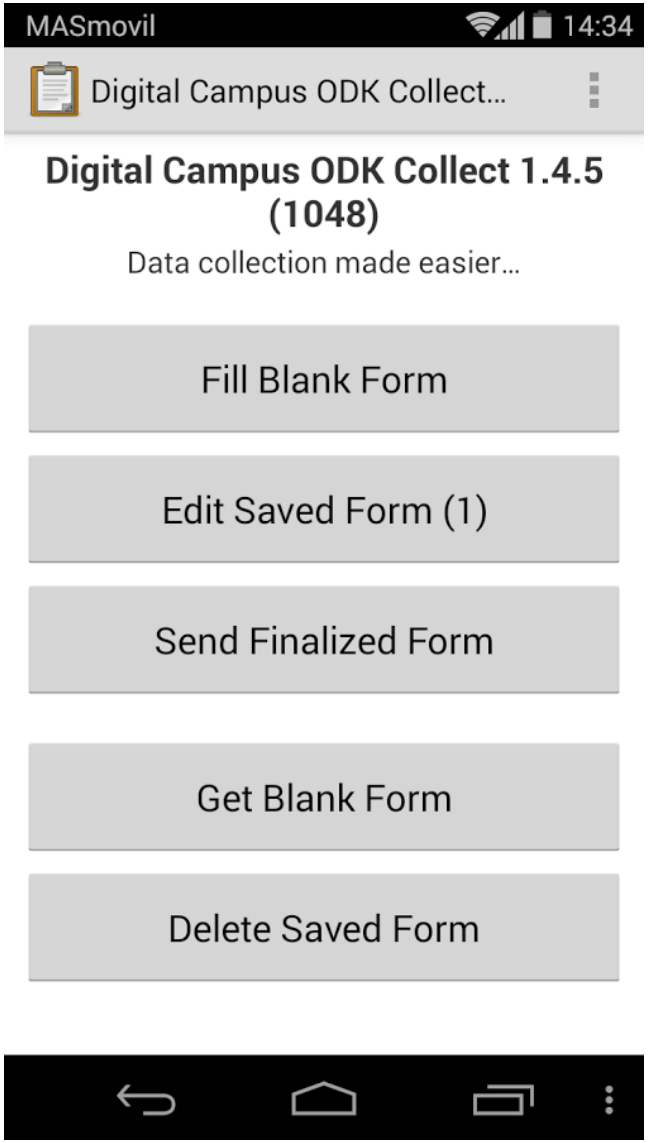
Methods – SurveyCTO Android App

Baseline water usage (examining seasonal variability)

SN	SOURCES OF WATER IN THIS VILLAGE OR COMMUNITY.	1. Is it possible for households in this area to get water from the following sources? *GO DOWN THE LIST TO VERIFY WHICH SOURCES ARE AVAILABLE TO THE HOUSEHOLD.* (1) YES (2) NO (>> NEXT SOURCE)	2. Who from your household collects/uses water from ...SOURCE...? (1) ADULT WOMAN (2) ADULT MAN (3) FEMALE CHILD (4) MALE CHILD (5) ENTIRE FAMILY (99) OTHER (SPECIFY)	3. How far away is the nearest ...SOURCE...? MINUTES OF ONEWAY WALKING TIME / MINUTES	5. Do you store drinking water from ...SOURCE...? YES >> Specify storage container (1) NO STORAGE (2) COOKING POT (3) PLASTIC POT (4) LARGE STORAGE TANK (5) RAINWATER TANK (6) PET BOTTLES (7) JERRY CANS (8) OTHER, specify	6. Does your household pay for water from ... SOURCE ...? If so, how? (1) DOES NOT PAY (2) FIXED AMOUNT PER MONTH (3) PRICE PER LITER (4) BOTH (ABOVE TWO) (5) OTHER	7. How would you judge the safety of the water from ...SOURCE...? (before the household does any treatment) (for health) (1) NO RISK (2) LITTLE RISK (3) SOME RISK (4) SERIOUS RISK (99) DON'T KNOW	4. Do you ever treat your drinking water from ...SOURCE...? YES >> Specify treatment type (1) NO TREATMENT (>>Q9) (2) BOILING (3) ALUM (4) BLEACHING POWDER (CHLORINE) (5) SAND FILTER (6) CLAY FILTER (7) CLOTH (8) SOLAR (9) Reverse Osmosis (99) OTHER, specify	8. How would you judge the safety of the water from ...SOURCE... after treatment? (for health) (1) NO RISK (2) LITTLE RISK (3) SOME RISK (4) SERIOUS RISK (99) DON'T KNOW
1	Lake								
2	River/stream								
3	Public taps Source: _____								
4	Public Well ☐ Electric pump ☐ Hand pump ☐ Rope and bucket								
5	Private well ☐ Electric pump ☐ Hand pump ☐ Rope and bucket								
6	Rainwater (shared) Roof type: _____ ☐ Communal ☐ Households (#___)								
7	Rainwater (private) Roof type: _____								
8	Natural spring								
9	Bottled water								
10	Other: _____								

Methods – SurveyCTO Android App

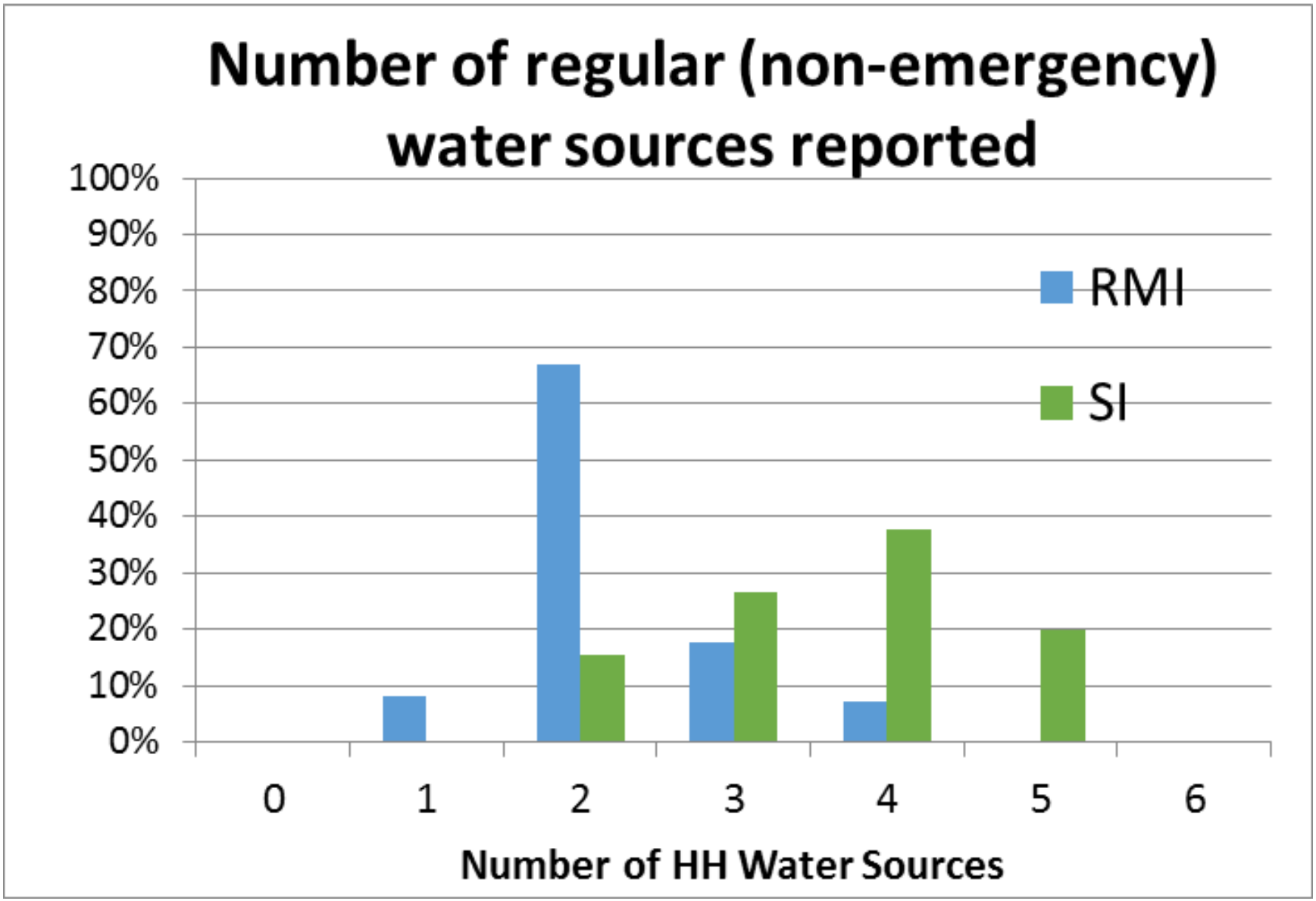
- Transitioned to SurveyCTO (Android app) for tablet-based surveys
  - Some leg work up front
  - Code survey in Excel
- Major improvement over paper-based surveys for complicated survey designs
  - Time savings: surveys themselves take <half as long to deliver
  - No need for parallel data entry for quality control
  - Less errors: skip patterns integrated into code



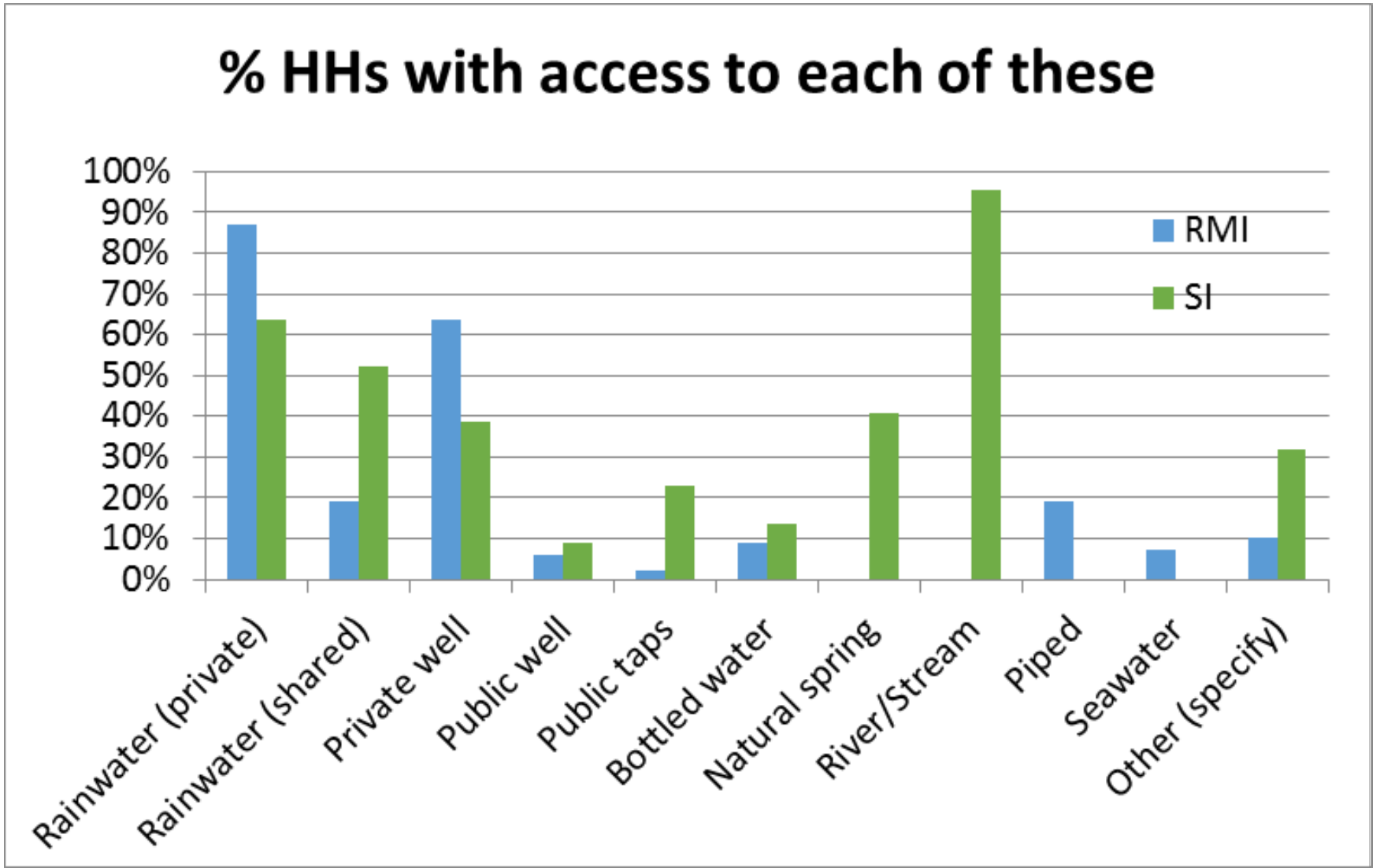
Results

- Household water sources:
  - Multiple water sources used by nearly all HHs for “regular” daily HH activities (does not include emergency conditions)
  - Number of sources and their use varied widely across countries/communities
- Of 143 households in the preliminary sample
  - 135 (94.4%) reported using at least two water sources for their daily HH needs.
  - All 8 (5.6%) that reported using only one water source were in RMI and relied solely on private rainwater harvesting (RWH) tanks.
- Mean number of regular, daily water sources used:
  - In RMI was 2.23 (range one to four)
  - SI was 3.68 (range two to five)

Results


Number of regular (non-emergency) water sources reported
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
RMI
SI
0
1
2
3
4
5
6
Number of HH Water Sources

Results – Sources used during (baseline) wet season conditions



Results – Typical use in RMI

Water sources/uses in RMI. A typical HH in RMI used:

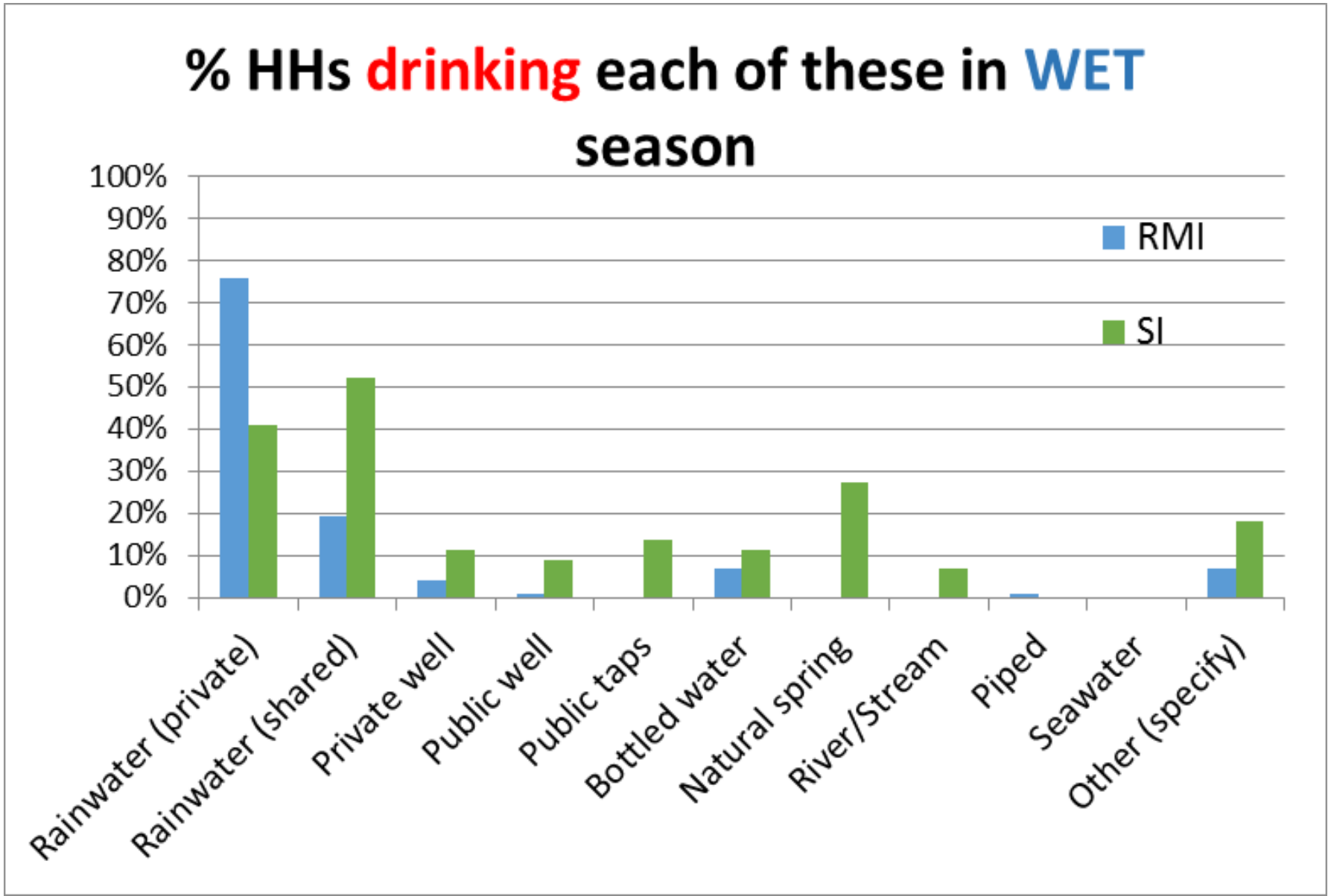
- Consumptive (drinking and cooking): large (800-3000 liter) private rainwater tank(s)
- Non-consumptive: a private well in the yard for handwashing, washing clothes, bathing.
- Majority of RMI HHs also reported sharing water with neighbors.

Results – Typical use in SI

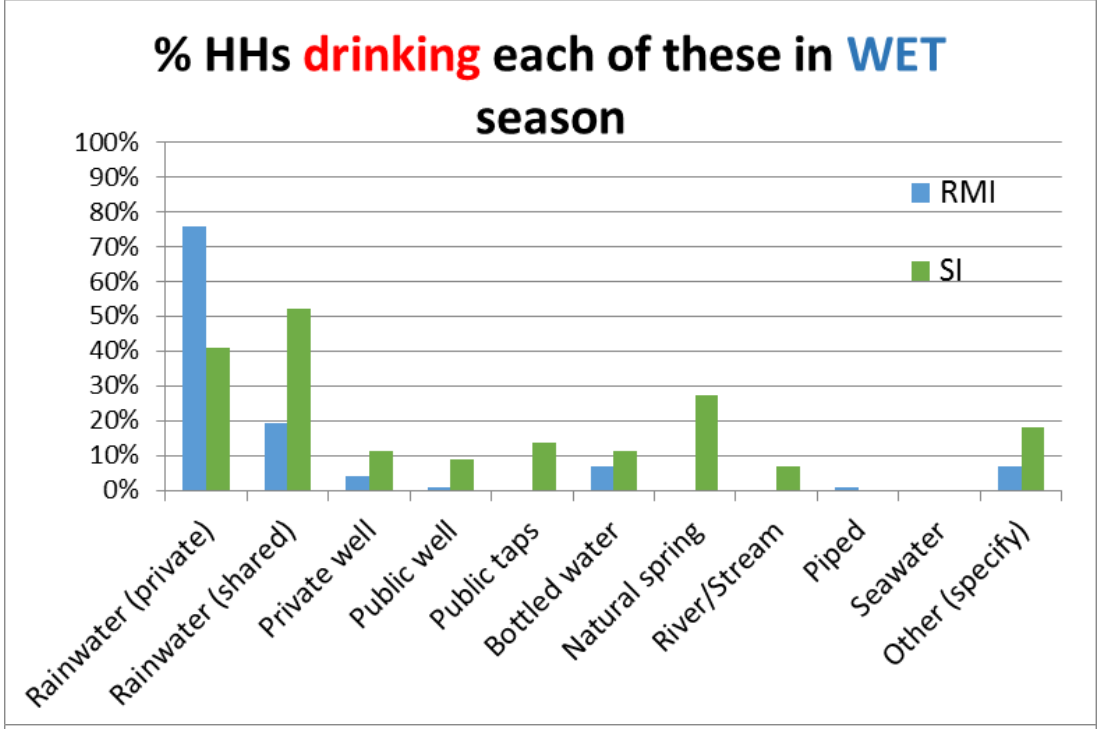
Typical water sources/uses for a HH in SI during wet season:

- Consumptive use: private or shared rainwater, alongside a well or spring.
  - Private RWH typically small containers like buckets, not large tanks as in RMI.
- Non-consumptive: river water for handwashing, bathing and washing clothes.
- Only one SI HH reported sharing water with neighbors.

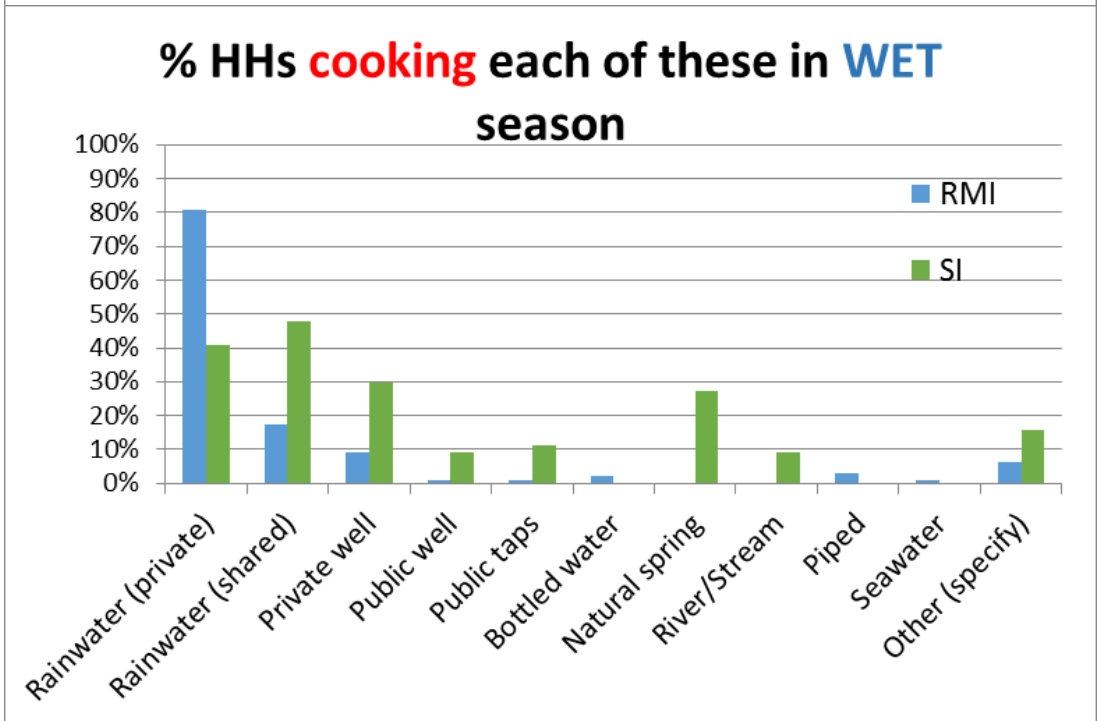
Results – Drinking water sources



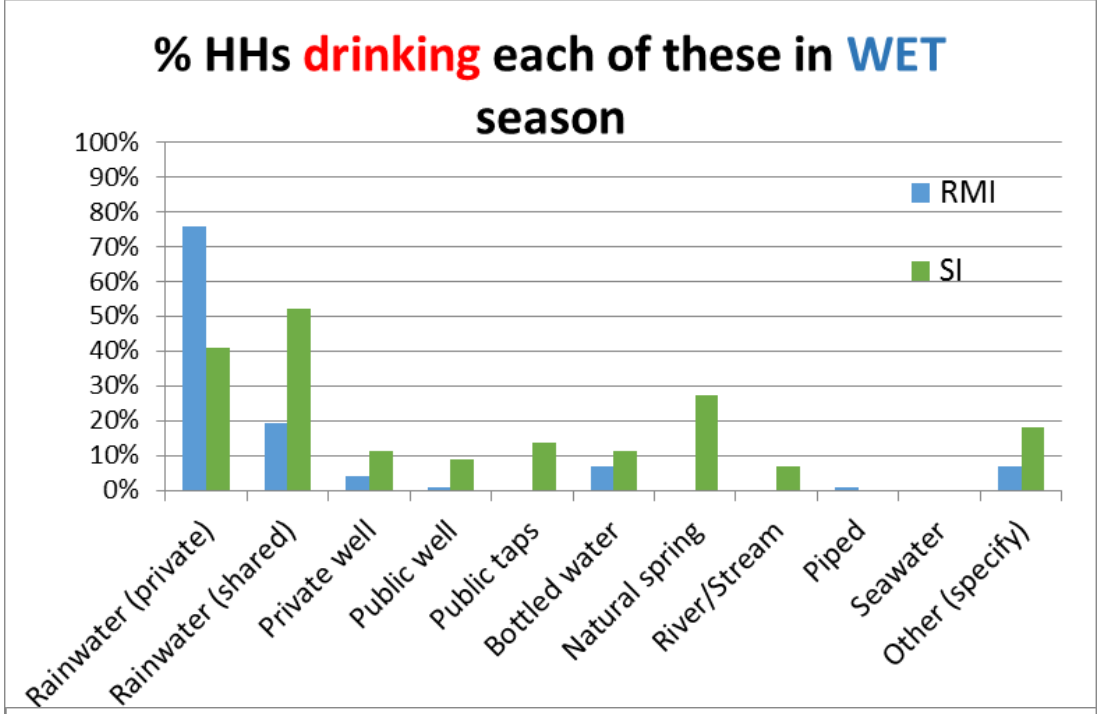
Drinking (consumptive)



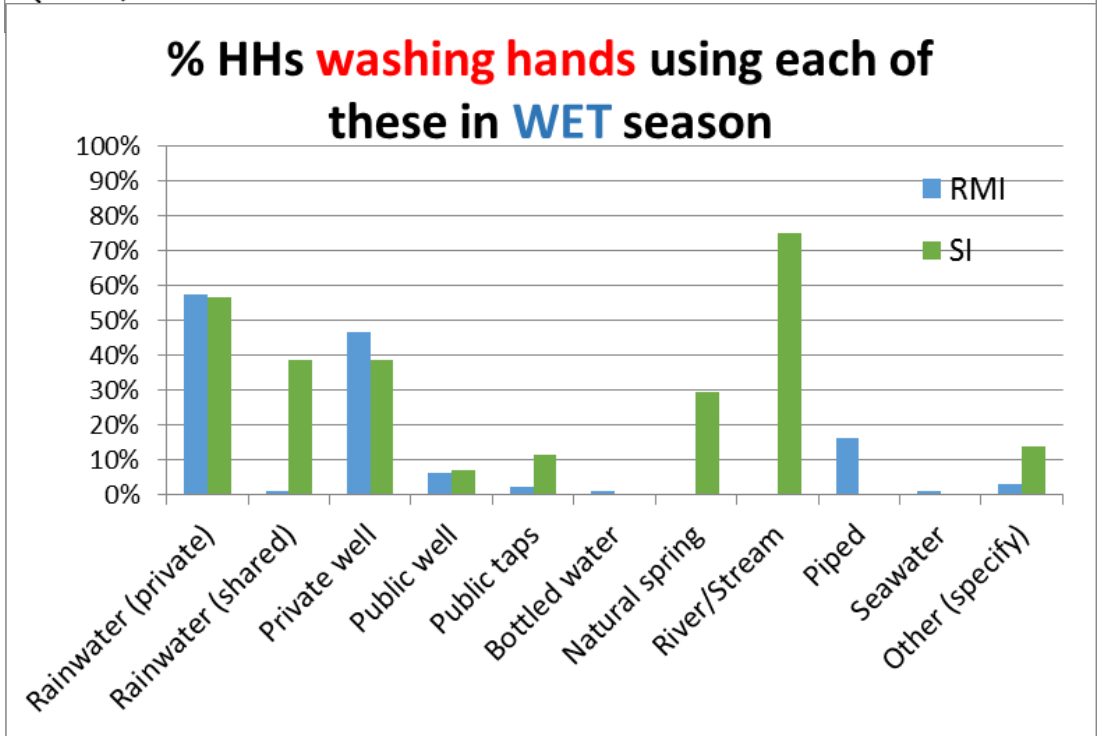
Consumptive



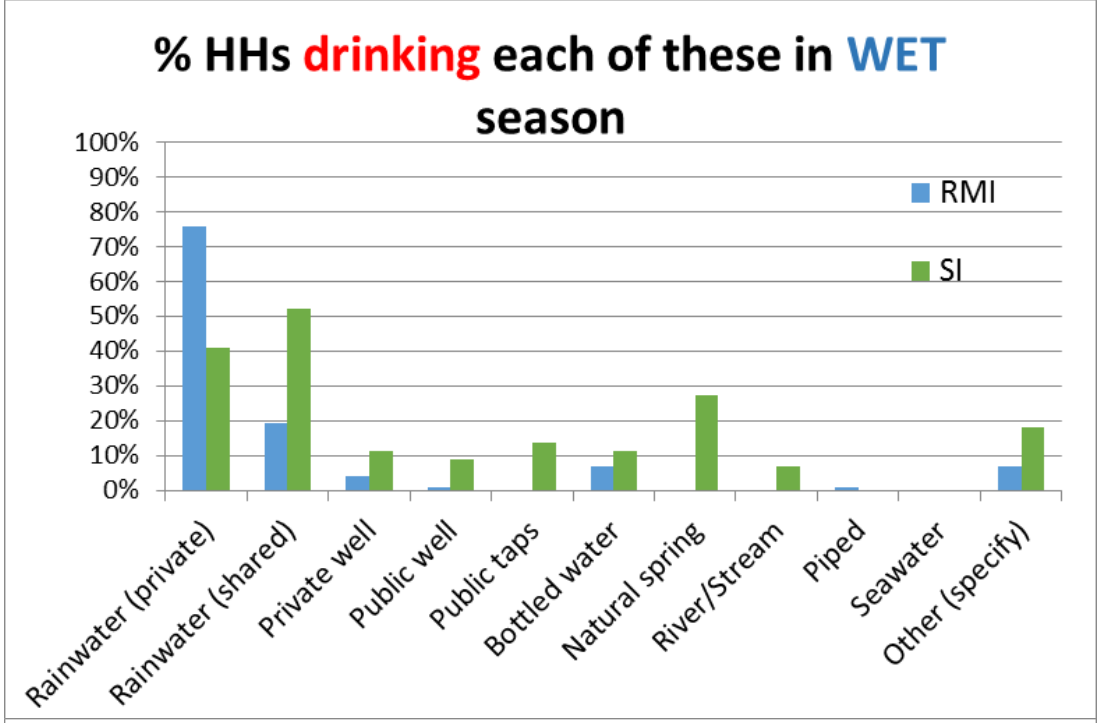
Drinking (consumptive)



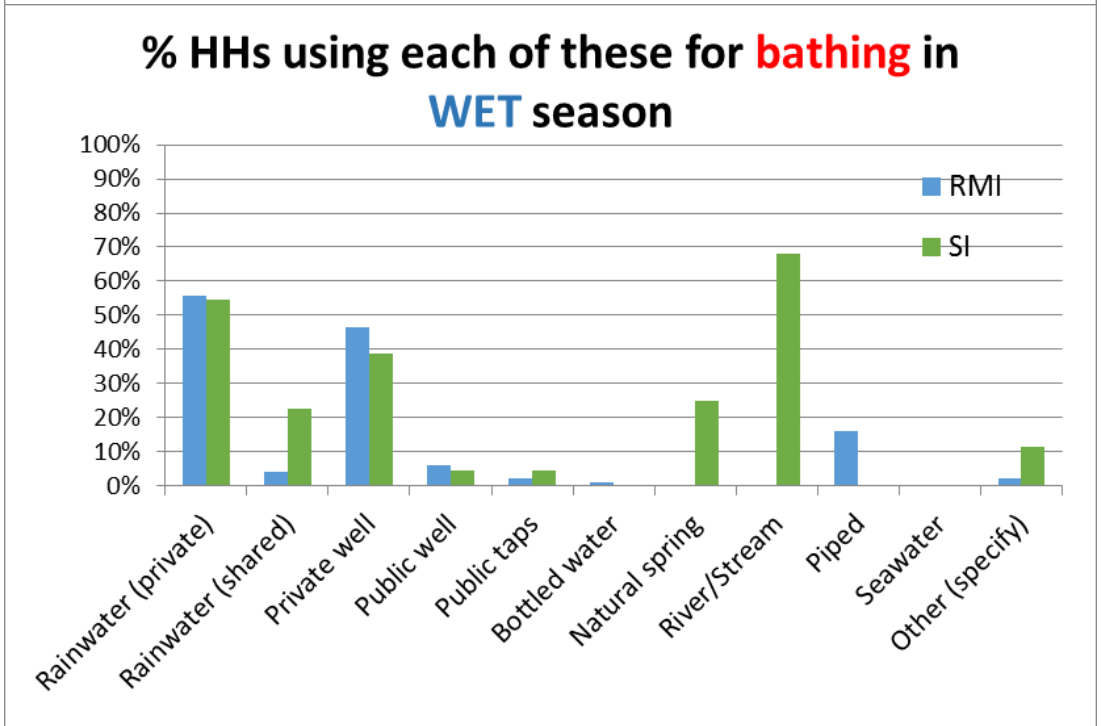
Non-consumptive



Drinking (consumptive)

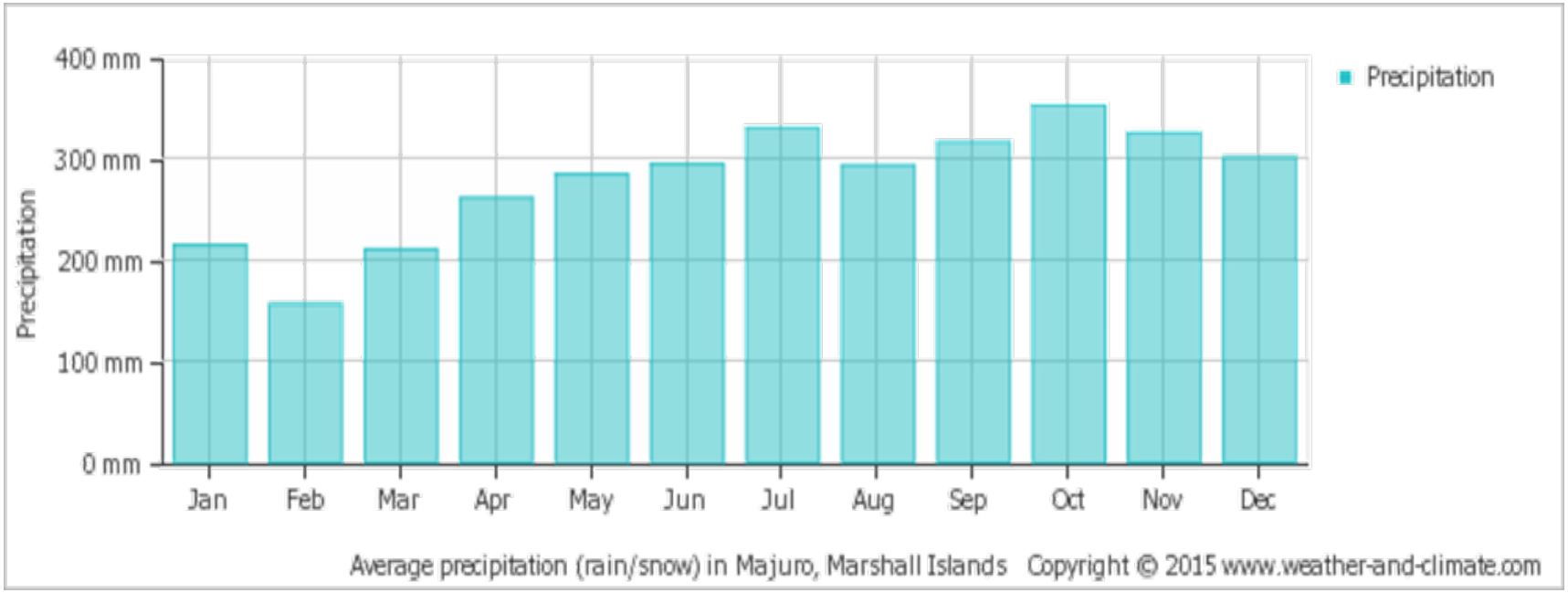


Non-consumptive



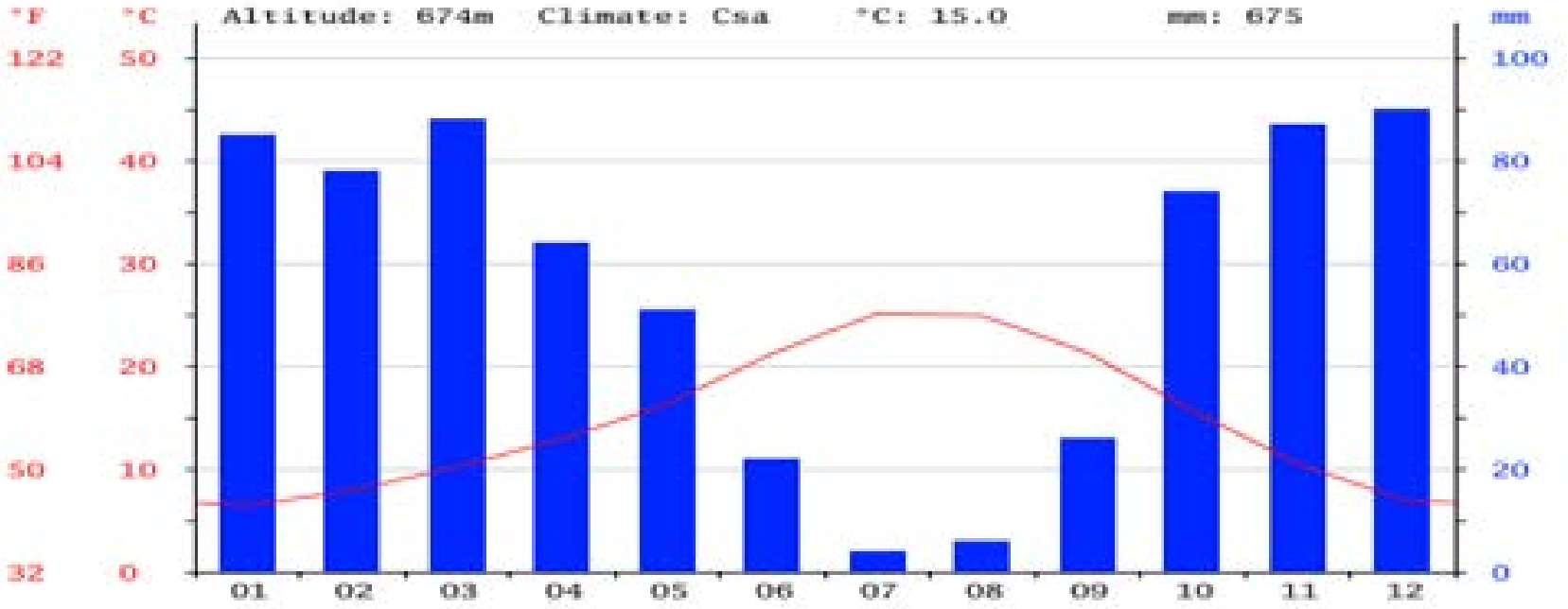
Water Use in Wet vs Dry Season

- RMI “inner islands” (our communities in these data) are very wet >300 cm/125 in rain per year
  - Our next field trip is to outer islands
- Small seasonal difference in average precipitation on Majuro & Arno (RMI atolls surveyed thus far)



Water Use in Wet vs Dry Season

- SI: 20% of the annual rainfall received by RMI inner islands (~60 cm/25 in per year)
- SI also has a very dry winter period
  - Pattern similar to SE Asian monsoon countries

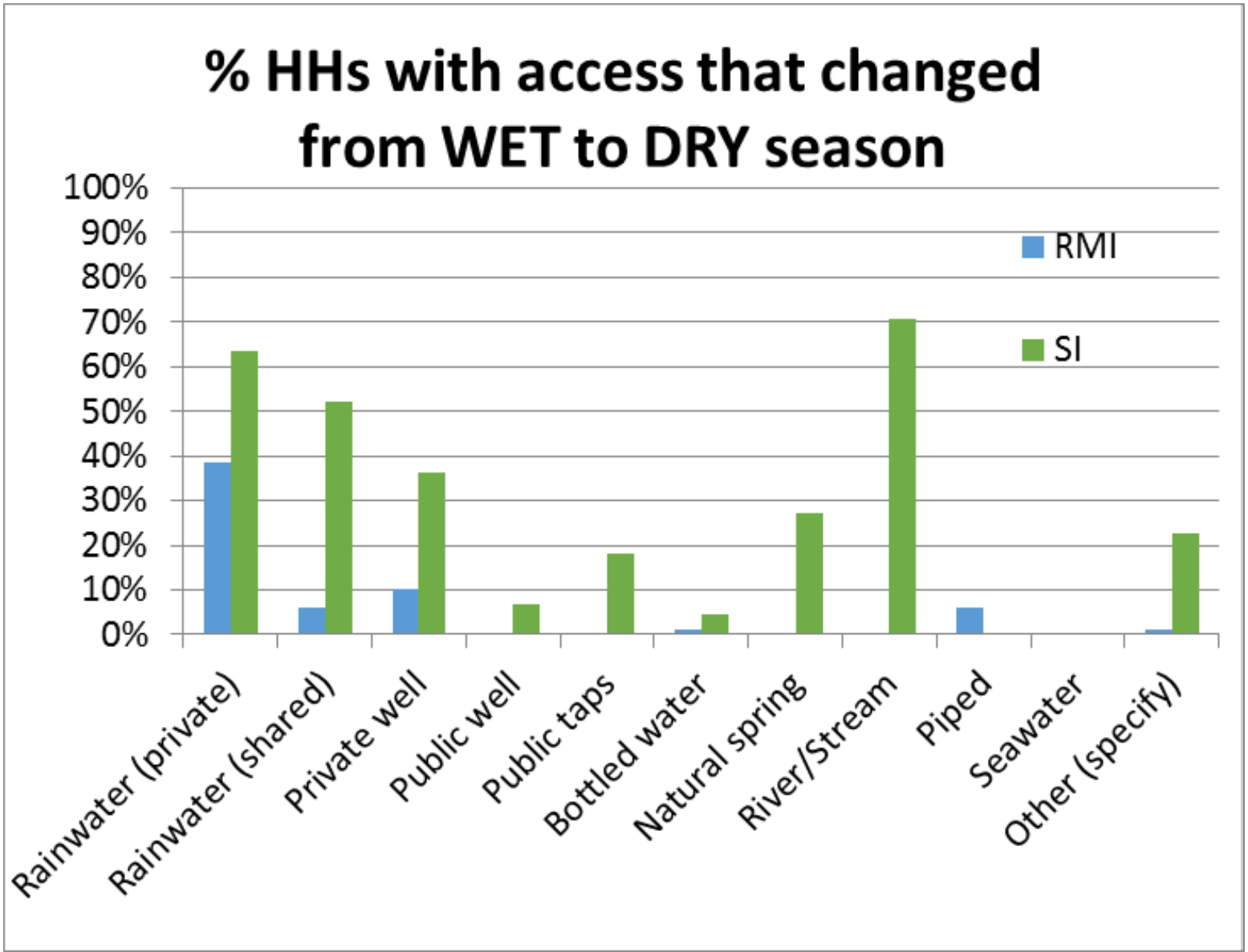


Results - Wet vs Dry Season

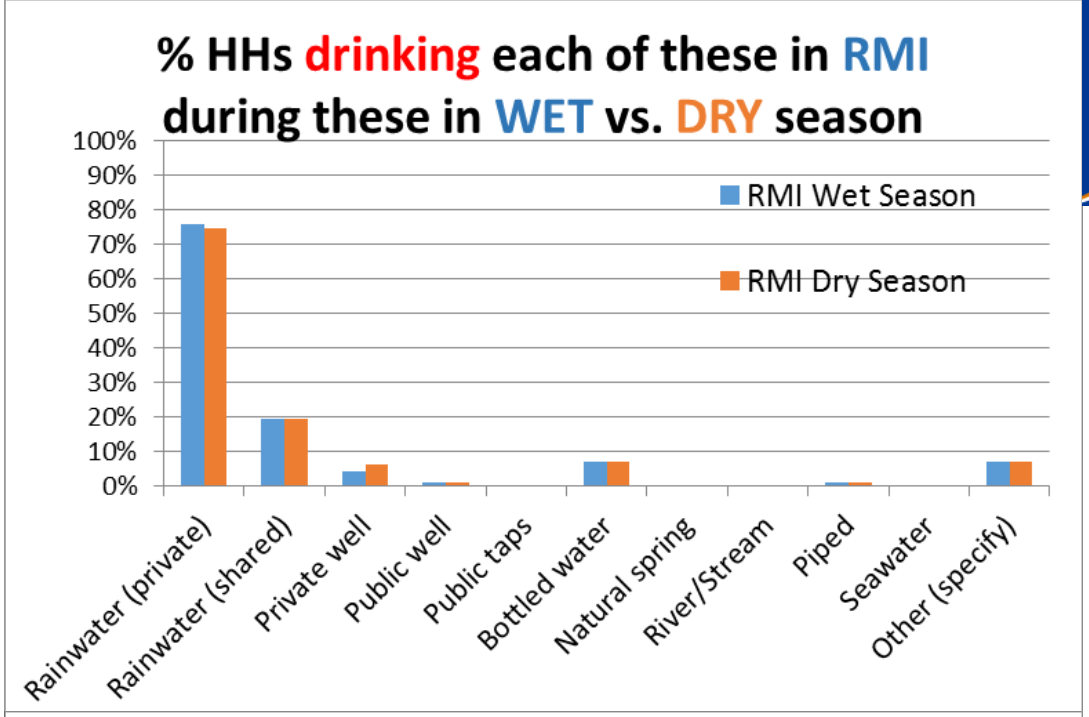
- All SI households reported that they changed water use and management practices between wet and dry seasons

- In contrast, about half of RMI households reported changing their practices by season
  - Primary change was practicing some form of “austerity” in reserving rainwater for consumptive uses

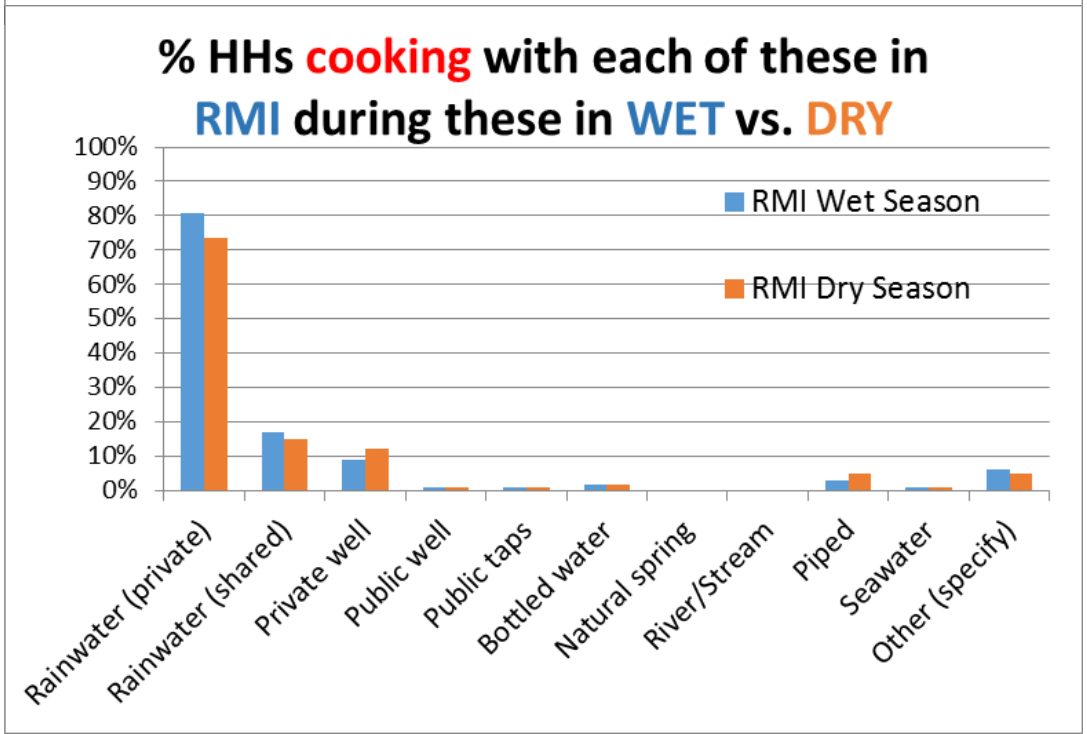
Water Use in Wet vs Dry Season



Drinking (consumptive)



Consumptive



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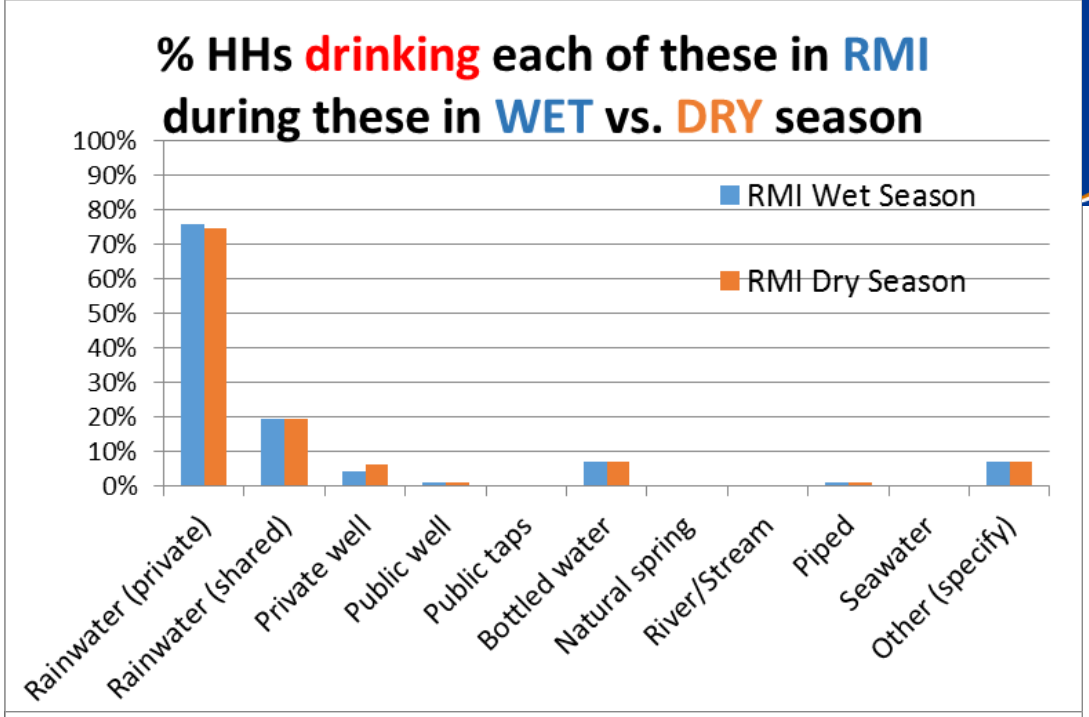

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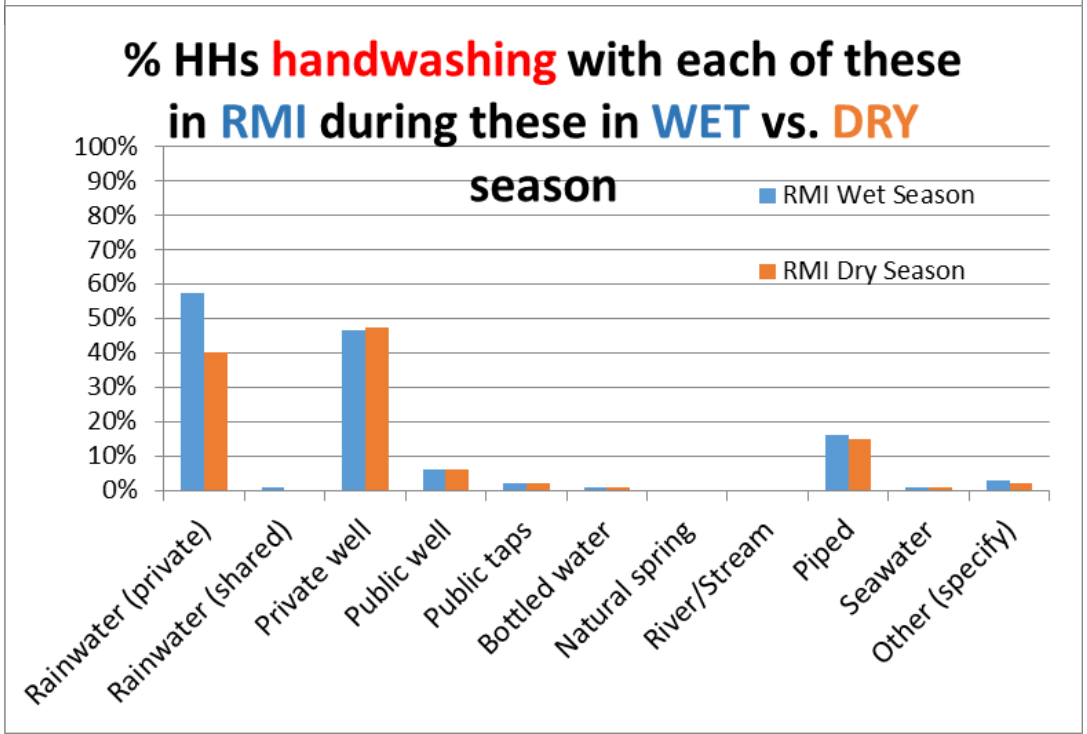

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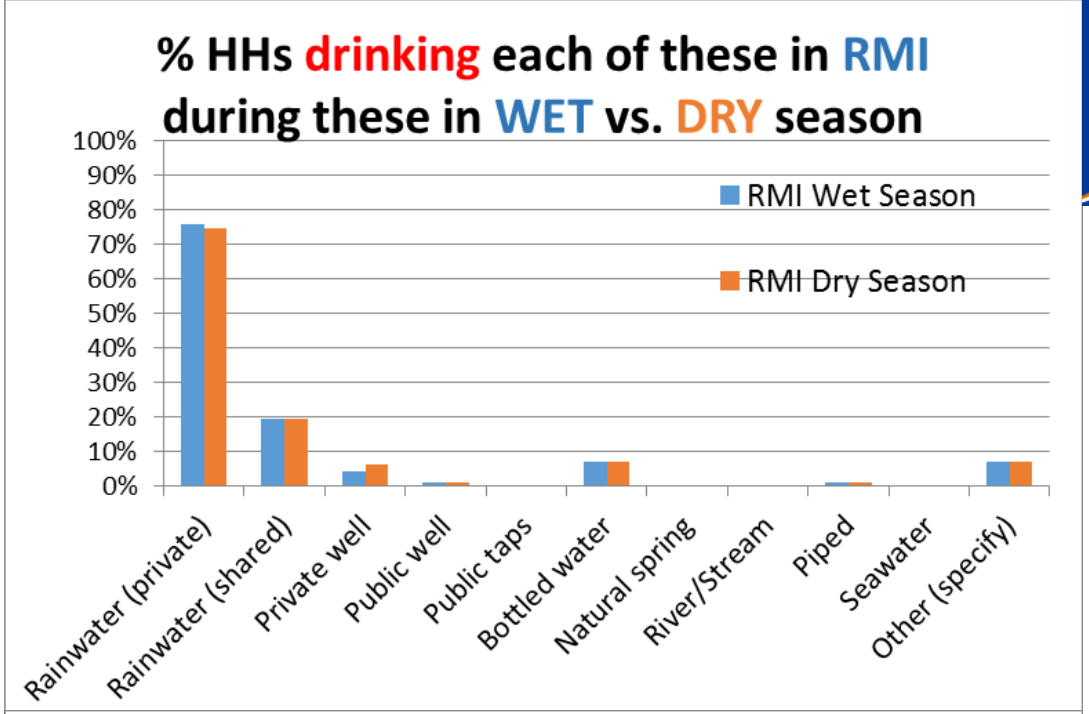

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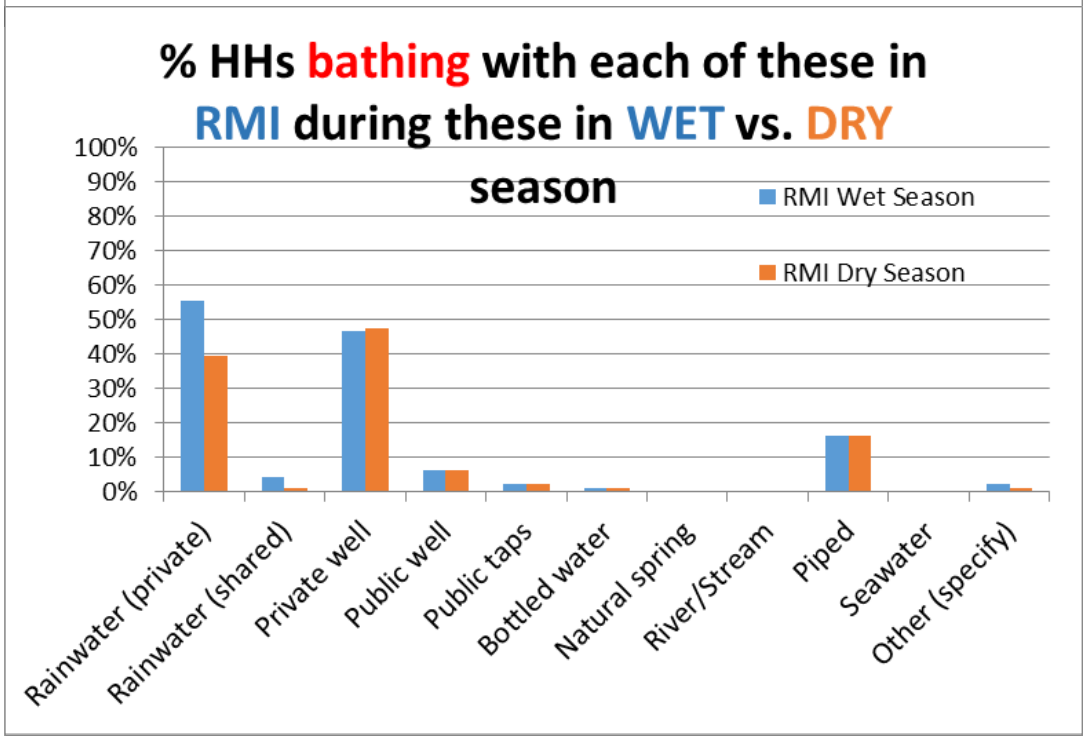
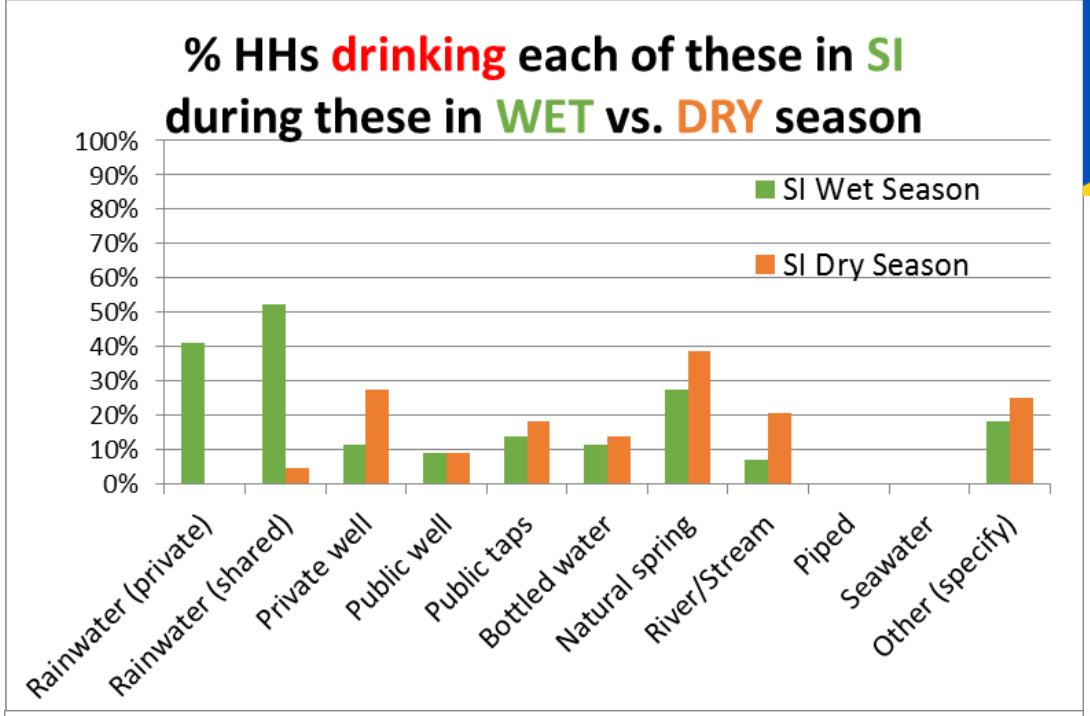


Water Use in Wet vs Dry Season

- In SI, nearly all rainwater use was discontinued in the dry season

- Use shifted to wells, springs, and rivers
  - Substantial increases in consumptive use of all these sources
  - River water: a 200% increase in households drinking (6% in wet season → 20% in dry season) and cooking (10% → 30%) with river water in dry season

Drinking (consumptive)



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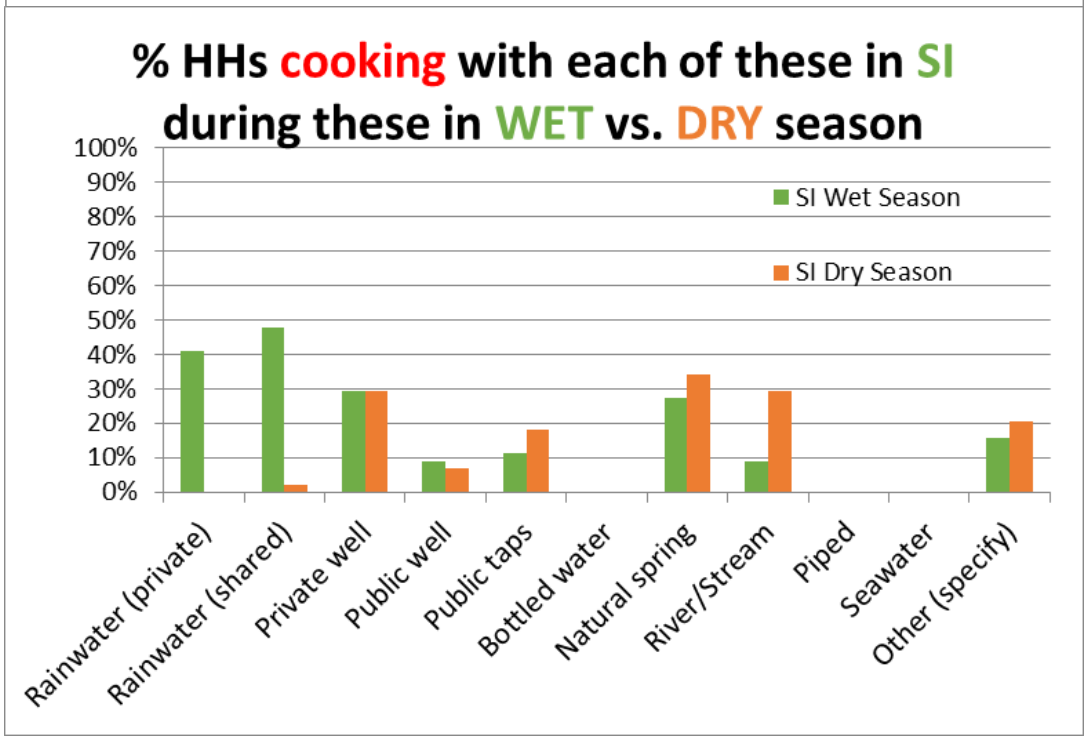

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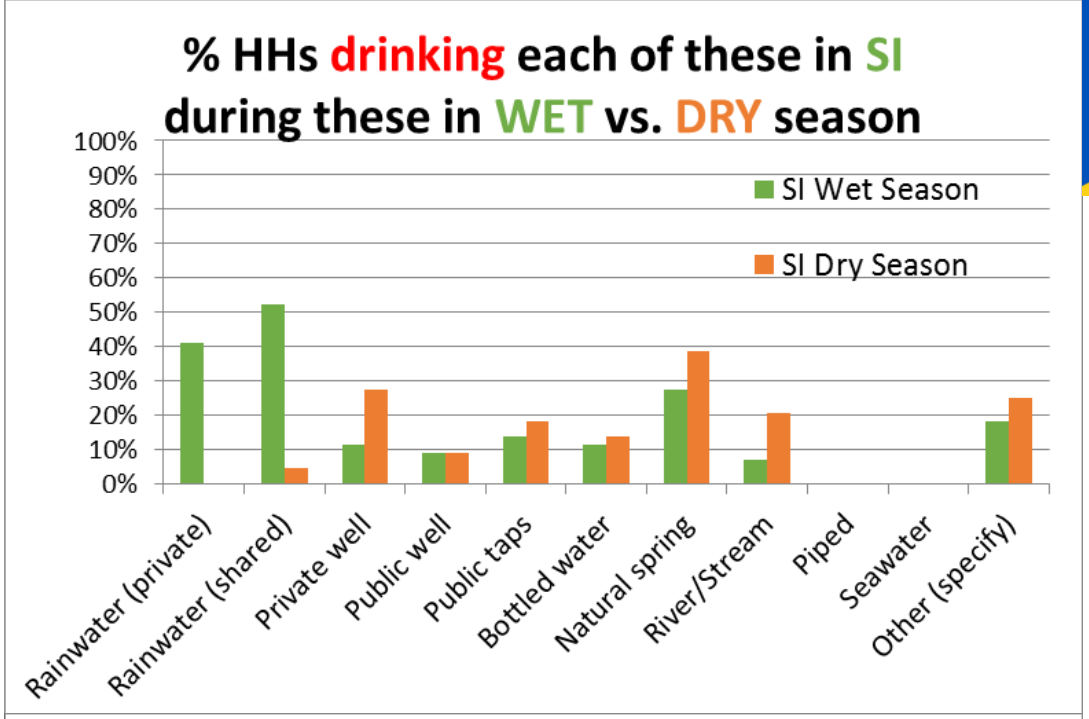

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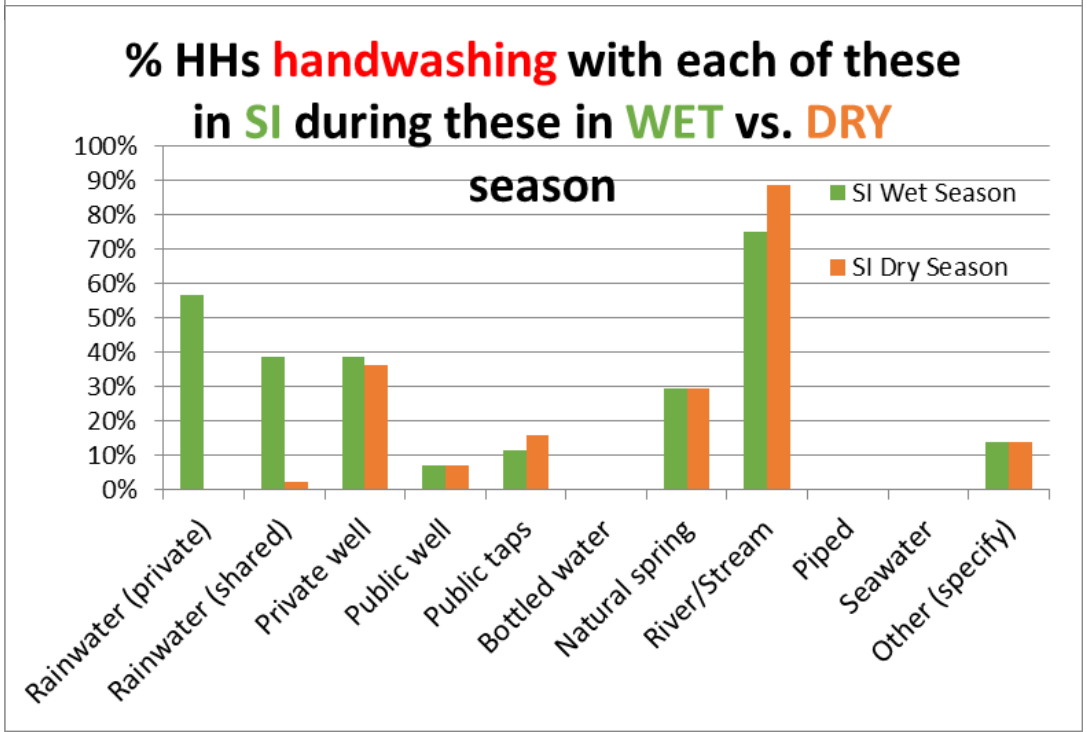

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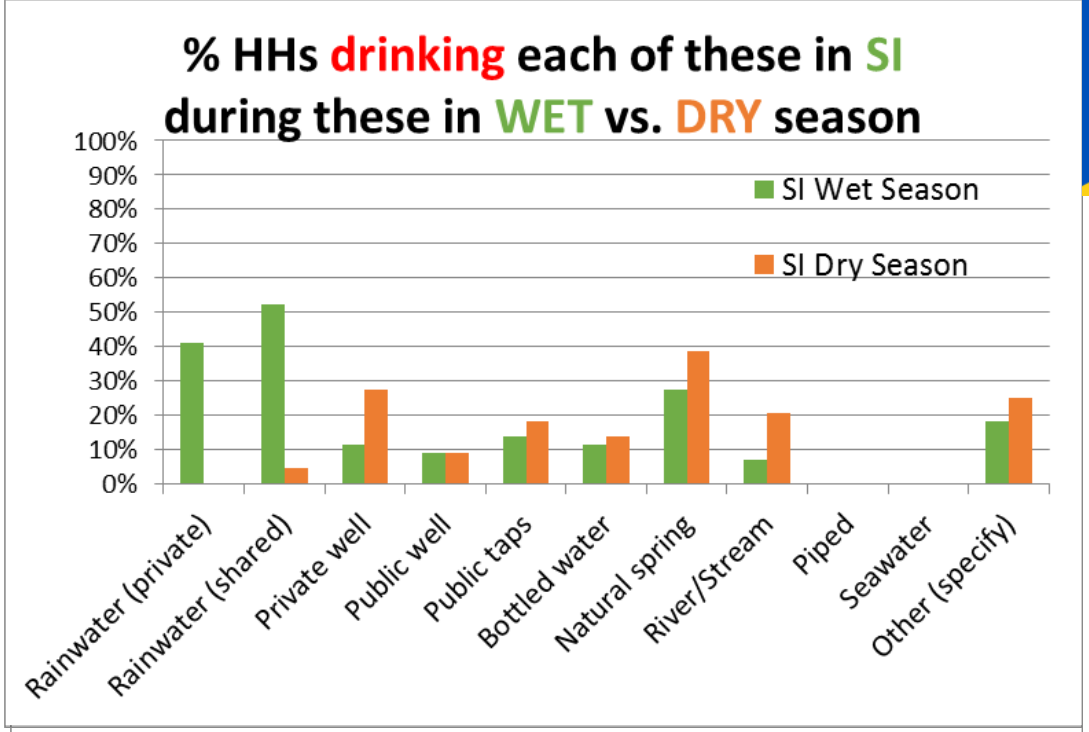

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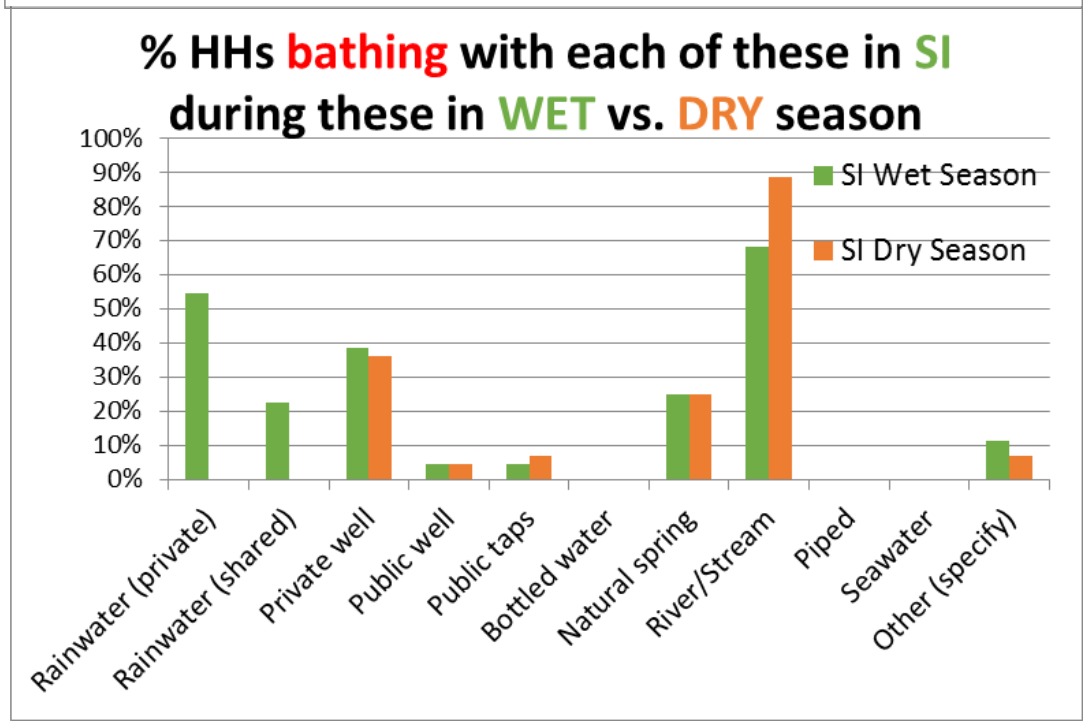

Water Use in Wet vs Dry Season

- Differences in the way HH water management has evolved in these communities have likely emerged from differences in:
  - annual precipitation volume/pattern
  - the availability of fresh groundwater and surface water

RMI Drought in 2013

- RMI outer islands experienced a severe drought in 2013
  - "Unprecedented" length/severity
  - Freshwater lenses brackish
- Reverse osmosis (RO) units were shipped to the outer islands and installed by Majuro Water and Sewer Authority (MWSC)
  - Installed on beaches, desalinating shallow beach groundwater
  - First use of desalination on outer islands

RMI Drought in 2013

- Drought ended and MWSC returned to claim RO units in 2014
  - Communities very reluctant to surrender RO units
- Reports of:
  - Dependency: requesting RO unit from capital during typical dry periods
  - Moving units to more convenient locations (may endanger fresh groundwater lens)

Summary

- Similar seasonal use patterns for consumptive purposes (drinking/cooking) and for non-consumptive (bathing/handwashing/clothes)
  - Likely indicates some level of health-consciousness around water
- Communities adapt to seasonal changes in precipitation through use of multiple water sources
  - Rainwater preferred for consumptive use when available, shift to other sources when unavailable
  - Austerity to retain rainwater for drinking/cooking
  - Some dry season behaviors will increase disease risk (e.g., shifting to drinking river water)

Summary

- HH water management strategies have evolved based on historical water availability and precipitation patterns
  - Climate change jeopardizes the adequacy of these historical adaptations
  - However, multiple sources may provide more ability and opportunity to adapt
  - Especially relevant in settings with vulnerable water resources or limited/no storage capacity
- Tablet-based HH survey instruments provided major time-savings
  - Make complex HH surveys feasible

Ongoing Work

- Data analysis on reported water practices under extreme climatic conditions
  - Drought, flood and cyclone
  - "Emergency" water sources
- More HH surveys in RMI and SI
  - RMI: conduct surveys in outer islands
    - Success of RO units for drought relief
  - SI: will conduct surveys in other and more remote islands
- Will evaluate options to increase adaptive capacity
  - E.g., increased rainwater harvesting volume in SI

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