Rainwater harvesting practices and attitudes in the Mekong Delta of Vietnam

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ABSTRACT

Access to safe drinking water is limited in the Mekong Delta region of Vietnam. Rainwater harvesting (RWH) at household level is among the primary sources of drinking water in the region and is widely practiced throughout Southeast Asia. It has recently been increasingly advocated as an alternative or supplemental approach to household water supply. However, relatively little research has been done on current RWH practices and attitudes. We interviewed residents of 619 households in three provinces to understand the current practice of and preferences for rainwater harvesting. We found that rainwater was the most common water source for all domestic activities in the rainy season; however, it was reserved for high-value uses in the dry season. Residents ranked color, perceived safety, smell, taste and reliability of rainwater very highly compared to other water sources. Most households practice daily first-flush and/or boil water before drinking. Storage capacity seems to be a major barrier to RWH providing an adequate supply of domestic water year-round. Because other improved water supplies are not widely available in the rural delta, rainwater harvesting seems to be a promising way to expand access to improved water sources for the residents.

Key words | attitudes, improved drinking water, perception, rainwater, Vietnam

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INTRODUCTION

Nearly one billion people lack sustained access to improved drinking water sources and even more lack access to safe water (United Nations 2008). Unsafe drinking water contributes to 1.8 million deaths per year caused by diarrheal illness in addition to massive morbidity and the economic costs associated with illness (Beaglehole *et al*. 2004).

Access to improved drinking water for the 17.7 million inhabitants in the 4 million ha Mekong Delta region of Vietnam is limited by contamination of surface water with pathogenic microbes and groundwater with arsenic (Berg *et al*. 2007; Nguyen & Itoi 2009). Additionally, both surface and groundwater are subject to saltwater intrusion, especially during the dry season when intrusion is up to 30 km inland (Le *et al*. 2007; Nguyen 2007). Few residents of the Mekong Delta region have access to piped water supplies, particularly in rural areas, and water treatment options are limited. According to government survey data, the main water supplies in the delta for household daily use (other than drinking and cooking) are rivers, lakes and ponds (36%), followed by wells (34%) and piped systems (21%). For drinking and cooking, rainwater is a primary source (23%) together with wells (26%), and rivers, lakes and ponds (25%) (General Statistics Office of Vietnam 2008). With rapid and sustained economic growth in Vietnam since the 1990s (World Bank 2002), demand for improved water sources and services is expected to increase.

Rainwater harvesting (RWH) is increasingly advocated as an alternative or supplemental approach to household water supply in tropical regions (Thomas & Martinson 2007).

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Rainwater is an improved source according to the WHO/UNICEF Joint Monitoring Program (JMP) and is recommended for expansion to meet the Millennium Development goals. Current RWH practice in the region varies widely; contamination may occur through improper handling practices and storage may be insufficient during the dry season. Approximately 90% of annual precipitation falls during the rainy season (usually May through October or November); the average rainfall per month is over 250 mm during the rainy season and less than 20 mm in the dry season (http://www.worldclimate.com/cgi-bin/data.pl?ref=N10E106+2100+48900W). Rainwater harvesting entails a significant investment for many households in the Mekong Delta, necessitating large storage capacity during the six-month dry season. Non-governmental organizations and international donors are interested in facilitating increased and improved practice of RWH, but the costs and the uncertainty of current practices and attitudes has limited a comprehensive approach.

Relatively little research has been done in Southeast Asia on current RWH practices and attitudes (Islam *et al.* 2010, 2011). Previous RWH studies focused on water quality (Efe 2006; Garrett *et al.* 2008; Islam *et al.* 2010; Sung *et al.* 2010; Ahmed *et al.* 2011), health impacts (Garrett *et al.* 2008) and technical aspects (Mwenge Kahinda *et al.* 2007; Han & Ki 2010). Few studies investigated the acceptability or adoption of rainwater harvesting by farmers (He *et al.* 2007) or households (Ward *et al.* 2008; Baguma & Loiskandl 2010; White 2010). Baguma & Loiskandl (2010) found that socio-economic characteristics had no effect on households' adoption of RWH in rural Uganda, but the primary significant factor was subsidy of RWH construction materials. Islam *et al.* (2011) showed that slum dwellers in Dhaka, Bangladesh, would be willing to harvest rainwater if the government provided incentives to pay the high up-front costs.

This paper summarizes findings from a field study with a sample of residents in the Mekong Delta region of Vietnam. The objective of this paper was to understand the current practice of and preferences for RWH as one option among several for accessing water. We present the current uses of RWH, households' attitudes towards available water sources, water treatment practices, current storage capacity for RWH and costs.

METHODS

Data were collected through in-depth, in-person interviews in July and August 2009, in the Mekong Delta provinces of Ben Tre, Soc Trang and Vinh Long. We interviewed two 'decision makers' in randomly selected households (usually the head of household and a spouse or the eldest son or daughter). Two approaches were used to randomly select households for the study: random number generation to randomly select households from a list of residents living in Ben Tre province, and in other provinces, where lists of households or maps of the areas were unavailable, we chose every other street in a commune and every fifth house on a street.

The survey instrument was developed through focus group and pretest interviews that helped in developing and finalizing the survey instrument and confirming that the wording of the survey questions was easy and clear for local people to understand. We received Institutional Review Board approval from the University of North Carolina at Chapel Hill and University of Alabama and ethical clearance from the Vietnamese authorities.

The final questionnaire collected information on social problems and local infrastructure needs in the area, current water supply systems, households' preferences for improved water supply systems, current RWH techniques and practices, and socio-economic and demographic questions. All statistical analyses were performed using STATA version 10 (StataCorp 2007). We used a logit regression to analyze preferences for wishing to store more water as a function of household characteristics, current water storage capacity and water sources.

RESULTS AND DISCUSSION

Sample socio-economic characteristics

Table 1 presents select socio-economic characteristics of the study sample. The sample size was 619 households. The median household size was four and the mean household monthly income was about VND2.9 million ($161; the exchange rate at the time of the survey was US$1 = VND18,000). The mean years of schooling for the primary interviewee was six, and 5% of respondents had never attended school. Almost all households (97%) had

Table 1 | Socio-economic characteristics of the study sample

Number of households surveys	619
Mean household size	4
Mean monthly household income (VND million)	2.9
Mean monthly food expense (VND million)	1
Own a house	92%
Rent a house	0.5%
Have electricity	97%
Have telephone (land and cell phones)	75%
Mean monthly electricity bill (VND million)	0.062
Mean monthly telephone bill (VND million)	0.095
Married	85%
Mean years of education	6
Had never attended school	5%
Can read newspaper easily	64%
Farming	53%

electricity and 75% had either a land-based telephone or a cell phone or both. The average monthly bill was about VND62,000 ($3.4) for electricity and VND95,500 ($5.3) for telephone.

Water supply sources and uses

Table 2 shows the percentage of households using different water sources, with more reporting rainwater use (88%) than any other source (private wells (44%), canals (28%), vendors (18%), rivers (16%), bottled water (14%) and private piped connection (13%)). No households used public wells or public standpipes. However, the degree/type of water use changed substantially between the rainy and dry season. Although rainwater use for daily activities decreased substantially in the dry season, it remained the most widely used source for drinking (84%) and cooking (64%). Water bought from vendors was much more widely used in the dry season than the rainy season, particularly for drinking and cooking; 4% reporting drinking purchased water and 8% using it for cooking in the former, but only 0.2% reporting drinking and 0.5% using for cooking in the latter. The lack of rainwater in the dry season forced households to diversify their water supplies, with decreasing use of rainwater for all consumptive and household uses and increasing use of all other sources.

Table 3 summarizes households' perceptions of the quality of various water sources in the rainy season, and the difference in ratings between the rainy and dry season. The value in the rainy season represents the percentage of households (among those who use a given source) that rated that source as 'good' or 'very good' (4 or 5 on a 5-point scale) for that characteristic; the value in the dry season represents that change from the rainy season percentage. All characteristics of rainwater received high ratings from most households during the rainy season and ratings fell slightly during the dry season; not surprisingly, the largest decrease was for reliability. The taste of surface water sources was generally not rated highly in

Table 2 | The percentage of households (HHs) that use different water sources and the purposes for which they use those sources, by season. The survey was conducted in the rainy season (July–September)

		Rainy season (%)[b]					Change from rainy-to-dry season (%)[c]				
Water source	**% of HHs that use each source[a]**	**Drink**	**Cook**	**Bathe**	**Wash**	**Animals**	**Drink**	**Cook**	**Bathe**	**Wash**	**Animals**
Piped system	13	1	3	6	7	4	+1	+1	+5	+5	+3
Well	44	9	17	30	33	23	+2	+1	+7	+6	+3
Vendor/tanker	18	0.2	0.5	1	1	0.3	+4	+8	+13	+14	+8
River	16	4	8	14	14	5	+3	+4	+1	+1	+0
Canal/lake/pond	28	1	3	13	15	12	+2	+3	+9	+9	+4
Rainwater	88	85	78	66	64	32	−1	−14	−53	−55	−30
Bottled water	14	10	0.5	0	0	0	+3	+0	+0	+0	+0

[a]Households were instructed to select all water sources that they used at any point during the year. Therefore, percentages sum to greater than 100%.
[b]Percentage that use a given source for a given purpose during the rainy season.
[c]Difference between the rainy season % (the corresponding value on the left) and the dry season %. To calculate the percentage of HHs that use a given source for a given purpose in the dry season, take the rainy season % and add this value; e.g. 11% (9% + 2%) of HHs reported using well water for drinking during the dry season.

Table 3 | The perceptions of households (HHs) about the quality of various water sources in the rainy and dry seasons. Percentage of households that rated characteristics of a water source as 'good' or 'very good' (representing a score of 4 or 5 on a 5-point scale) in the rainy season, and the change in that rating from the rainy season to the dry season. The survey was conducted in the rainy season (July–September)

	Rainy season (%)					Change from rainy-to-dry season (%)[a]				
	Taste[b]	Color	Safety	Reliability	Smell	Taste	Color	Safety	Reliability	Smell
Piped system	19	59	44	64	69	−6	+18	+11	−21	+2
Well	22	80	70	96	69	−4	−8	−7	−18	−2
Vendor/tanker	6	15	17	22	20	+7	+49	+48	+59	+55
River	4	2	28	95	55	+8	+52	+6	−29	+10
Canal/lake/pond	3	8	23	88	44	+0	+33	+3	−21	−1
Rainwater	84	98	98	97	99	−6	−1	−1	−17	−5
Bottled water	82	94	94	93	93	+3	+6	+6	+6	+5

[a]This is the difference between the rainy season percentage (the corresponding value on the left) and the dry season percentage. To calculate the percentage of HHs that perceived a characteristic to be 'good' or 'very good' in the dry season, take the rainy season % and add this value. For example, 13% (equal to 19% − 6%) of HHs perceived the taste of water from a piped system to be 'good' or 'very good' during the dry season.

[b]The categories were rated as follows: Taste: percentage of households who rated the taste of water supply as good or very good. Color: percentage of households who rated the color of water supply as clean or very clean. Safety: percentage of households who rated the safety of water supply as no or little risk. Reliability: percentage of households who rated the reliability of water supply as regular or very regular. Smell: percentage of households who rated the smell of water supply as no or little smell.

either season. Other notable changes during the dry season include: the perception that bottled and vended water have improved characteristics and the decline in the perceived reliability of all sources other than bottled or vended.

Rainwater practices

Of the residents who harvest rainwater, almost all use their house roof to catch rainwater. About 42% of the these households reported using corrugated metal, 28% fibrocement, 22% brick tiles and 7% thatched roof. A majority of households harvesting rainwater (69%) reported usually having sufficient quantity throughout the six-month rainy season. Those running out of rainwater reported buying from neighbors, collecting from canals and rivers and using bottled or well water. Households who reported storage lasting throughout the dry season had significantly more storage (mean = 5,329 L; median = 4,800 L) than the households running out of water in dry season (mean = 3,060 L; median = 2,000 L) (p value <0.01).

The mean household storage capacity owned was 4,092 L, and the mean number of storage containers owned was 10 (median storage capacity is 3,200 L and 9 storage containers). The mean volume of storage capacity per capita was 1,333 L. Therefore, in a typical six-month long dry season, the rainwater available per capita per day (pcpd) would be 7.4 L, assuming no additional water collection during the dry season. A review revealed minimum recommended volumes of 5 L pcpd for drinking and 20 L for cooking (Gleick 1996). Based on these volumes, about 67% of the households in our sample had adequate storage capacity to store enough rainwater for drinking through the dry season but only 20% of households could store enough for both drinking and cooking.

About 78% of households owned at least one concrete container, 44% a ceramic container and 6% a plastic container. Figure 1 shows linear predictions between the total number of containers (for different container types) households own and household monthly income (US$), in which as household income increases, concrete containers

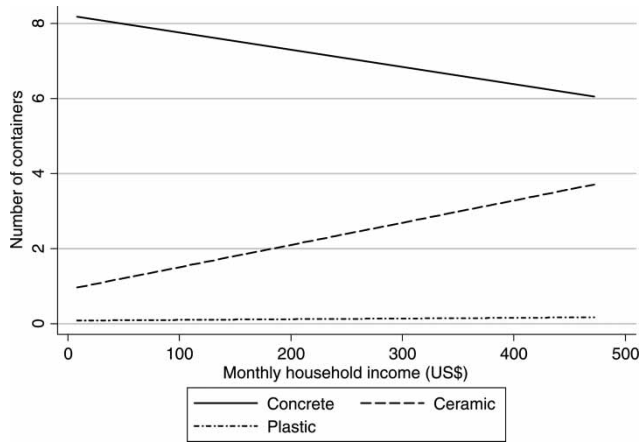

Figure 1 | Linear prediction between number of containers and household income (US$).

decrease, ceramic containers increase and plastic containers remain the same (linear prediction were calculated in STATA as the prediction for a y variable from a linear regression of y on x and plot the resulting line). Figure 2 shows the linear prediction between the total volume of household water storage (for different container types) and household income, in which the volumes of both concrete and ceramic storage increase as income increases, but ceramic storage increases faster.

A majority (64%) of households reported that the material of the container affects the taste of the rainwater during storage, with almost all (99%) of these reporting that a ceramic container yields the best tasting water. We also asked respondents the most important attribute when choosing an outdoor storage container; 63% reported 'durability' and 13% reported 'how the container affects the taste'. Ceramic containers are reported to be more durable than concrete containers, based on conversations with ceramic manufacturers and households. Although ceramic containers have advantages over others in durability and taste, the total number and volume of concrete containers owned by sample households were statistically significantly greater than for ceramic containers ($p < 0.1$); a household, on average, owned 444 L of ceramic container store capacity or 1.6 ceramic containers; while they owned 3,610 L of concrete storage capacity or 8 concrete containers. Likely explanations for this are as follows. (1) The concrete containers were available in the area in larger sizes, including storage capacities >1,000 L, compared to typical ceramic container volumes of 150 to 250 L. For example, 20 households (about 3%) reported having larger concrete tanks over 3,000 L with a cost ranging from VND2 million to VND25 million. (2) The cost per storage volume was higher for ceramic than for concrete containers. (3) Concrete containers were locally produced, whereas ceramic containers were manufactured only in Binh Duong Province (north of Mekong Delta).

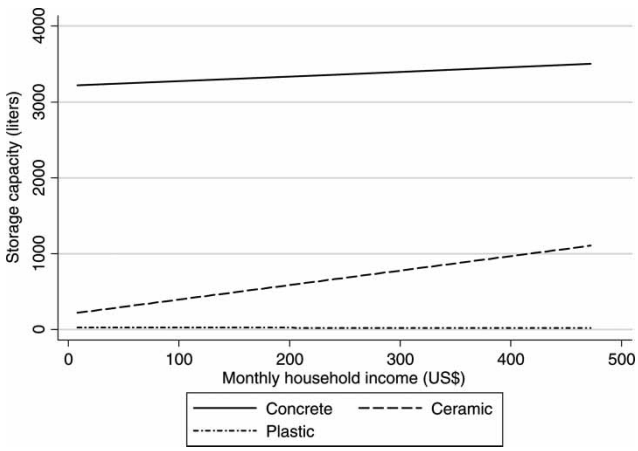

Figure 2 | Linear prediction between total storage and household income (US$).

Expenditure on rainwater storage and willingness to borrow

The mean (median) expenditure per household on RWH storage in the past five years was VND252,417/US$14.02 (VND102,910/US$5.72). This corresponds to a monthly expenditure of VND4,593/US$0.26 to VND5,268/US$0.29, if an annual discount rate of 3 to 8% is used. This is relatively low when compared to the average monthly household expenditures on electricity (VND62,000) and phone (VND95,500).

The expenditure per volume of storage was significantly different among the different provinces (all p values <0.02). The expenditure was VND74, VND182 and VND220 per liter for households who lived in Ben Tre, Vinh Long and Soc Trang provinces, respectively. Soc Trang is the furthest province from Ho Chi Min City, the largest city in southern Vietnam, and furthest from Binh Duong province where the ceramic containers are mostly manufactured in the region, so the materials may be more expensive in Soc Trang than the other provinces.

Of the respondents who harvest rainwater, half reported that they wished to store more rainwater. Of these, 81% said they could not afford additional storage. However, the volume of storage was not significantly different between subjects who said they wished to have more storage and those who did not (p value = 0.30). Table 4 presents the logistic parameter estimates for probability of wishing to store more rainwater as a function of household characteristics and water use. Running out of rainwater in the dry season and household size were significantly positively associated with the probability of wishing to increase storage capacity. Having a piped water system or collecting water from a well or a river had significantly negative associations with the wish to increase storage capacity.

About 57% of the households who expressed a wish to store more rainwater reported that they would purchase

Table 4 | Logistic regression estimates

Dependent variable: would like to have more storage	Estimate	Standard error	*T* ratio	*p*-value
Ln (volume of storage)	−0.112	0.247	−0.450	0.651
Run out of water in dry season	−1.486	0.380	−3.910	0.000
Ln (household income)	−0.128	0.194	−0.660	0.509
Household size	0.191	0.096	1.990	0.047
Live in Bentre	0.053	0.628	0.080	0.933
Live in Soctrang	−1.228	0.646	−1.900	0.057
Years of education, respondent 1	−0.023	0.041	−0.560	0.578
Years of education, respondent 2	0.068	0.044	1.570	0.117
Married, respondent 1	−0.380	0.645	−0.590	0.556
Married, respondent 2	−0.121	0.580	−0.210	0.835
One of the respondents is male	0.344	0.292	1.180	0.239
Have a phone	−0.074	0.336	−0.220	0.826
Number of household members with diarrhea in the past week	0.086	0.312	0.280	0.783
Use piped water	−0.959	0.463	−2.070	0.038
Use well water	−0.913	0.390	−2.340	0.019
Use vendor water	−0.278	0.346	−0.800	0.421
Use river water	−1.527	0.675	−2.260	0.024
Use canal water	−0.775	0.418	−1.850	0.064
Use bottled water	0.975	0.576	1.690	0.091
Constant	4.473	3.042	1.470	0.141

additional storage containers if delayed payment were possible. One fifth of the households who desired more storage were willing to borrow money for RWH storage at the current annual interest rate of 10.8% However, previous research has suggested that entry barriers, transaction costs, complex procedures and local politics might limit the opportunities for securing loans in the Mekong Delta (Reis & Mollinga 2009).

Current practice on rainwater treatment and safety

Almost all households who harvest rainwater practiced some sort of water quality protection. Methods included first-flush (allowing an initial volume of rainfall to run off, washing the rooftop clean before water is diverted into storage containers) (Thomas & Martinson 2007), household water treatment and others. The most common of these practices were daily first-flush (84%), seasonal first-flush (41%), cleaning the inside of the storage containers (80%), keeping storage containers covered (97%) and pre-screening with cloth or mesh prior to storage (65%). Additionally, a majority of households practiced some form of water treatment prior to drinking. Of those who treated harvested rainwater, the most common treatment techniques were boiling (79%) and sedimentation without the use of alum or other coagulants (40%); only 5% treated drinking water using a household filter.

CONCLUSIONS

Rainwater was found to be the most commonly used water source in the rural households we surveyed in the Mekong Delta of Vietnam for all activities in the rainy season. It was, however, reserved for high-value uses, such as drinking and cooking in the dry season. Users perceived that rainwater provided advantages over other available water sources in terms of smell, color, taste, safety and reliability, especially in the rainy season.

The average household owned enough rainwater storage containers to provide 7.4 L pcpd in the dry season, which is enough for drinking but not enough for cooking according to the minimum water requirements reported in the literature (Gleick 1996). Both statistics and focus group interviews suggest that storage capacity is the major limitation in rainwater harvesting and about one-third of the sampled households reported running out of rainwater during the six-month dry season. Households seem to value water quality and most households practice daily first-flush, keep containers covered and boil water before drinking. The capital costs of purchasing storage containers constituted the main component of the cost of RWH. Once households invested in storage, the recurring costs were relatively low.

This study is a first attempt to document current practices of, expenditures on, and attitudes about RWH in the Mekong Delta of Vietnam. Our data indicate household demand for additional rainwater storage and willingness to

take loans to purchase additional storage containers. Microcredit may be something to explore given the high capital costs and high demand for RWH. Because treated piped water and other improved supplies are not widely available in the rural Mekong Delta, rainwater seems the best available option for improved water access. The role of inexpensive and readily available rainwater to satisfy the demand for water and the financial sustainability of piped water systems warrants further investigation.

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