Research Paper

Who is being left behind? An analysis of improved drinking water and basic sanitation access in the Vietnamese Mekong Delta

Caitlin A. Grady, Kien Van Nguyen, Thai Van Nguyen and Ernest R. Blatchley III

ABSTRACT

The global community has made tremendous strides in providing access to water and sanitation in recent decades. Driven by the United Nations Millennium Development Goals, which sought to halve the proportion of the global population without sustainable access to safe drinking water and basic sanitation, billions of people now have access to these basic human rights. As the global community works to implement the next generation of development goals, the Sustainable Development Goals (SDGs), it is critical to determine how unserved populations can be reached. To investigate indicators of water and sanitation access, surveys were conducted among 300 households in the Vietnamese Mekong Delta. Households with and without access to improved water or basic sanitation were identified and data from these surveys were subjected to multiple regression analyses to identify household characteristics that correlate with access. It was found that for households without access to either water or sanitation, three variables were statistically significant predictors of access: distance to local government, household floor material, and the gender of the household water manager. Predictors of access to water and sanitation were evaluated separately. This integrated water and sanitation case study draws several implications for this next phase of SDG development programming.

Key words | access, clean water, Millennium Development Goals, sanitation, Sustainable Development Goals, Vietnam

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INTRODUCTION

Water, sanitation, and hygiene (WASH) development has been a top priority in recent years for many local, regional, and international organizations. Through collaboration among the United Nations, the World Health Organization, country governments, non-governmental organizations, and private corporations, billions of people have gained access to water and sanitation in recent decades. More than 2.6 billion people now have access to improved drinking water and more than 2.1 billion have gained access to basic sanitation

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facilities since 1990 (UNICEF & World Health Organization 2016). The new Sustainable Development Goals (SDGs) have set ambitious targets for 2030 to 'ensure availability and sustainable management of water and sanitation for all' (United Nations 2015). To achieve these universal access targets by 2030, substantial progress will need to be made in improving access to unserved populations.

Despite the progress of providing water and sanitation access to billions of people through the implementation of the Millennium Development Goals (MDGs), UNICEF and WHO continue to point towards disparities across regions, rural and urban areas, and marginalized communities (UNICEF & World Health Organization 2013, 2016). The Joint Monitoring Program (JMP) identified several inequalities in access to both water and sanitation between urban and rural households and households in different wealth quintiles (UNICEF & World Health Organization 2016). Additionally, implementers are beginning to identify the challenges and increased costs associated with conducting projects in the most difficult-to-reach areas (Hutton & Varughese 2016; UNICEF 2017; World Bank 2017). Providing access to improved sanitation facilities remains a more difficult challenge than providing improved drinking water sources due to the complex nature of both engineering and societal challenges (Moe & Rheingans 2006; Fry *et al.* 2008; Hueso 2016; Willetts *et al.* 2017). Moe & Rheingans (2006) identified several barriers to progress in water and sanitation access including declining international investment, poor marketing of sanitation products, and not learning from mistakes of previously implemented projects. Several authors have articulated multiple reasons why sanitation interventions have not progressed as rapidly as water interventions, including the lack of capacity of local governments to manage such interventions, ineffective or corrupt incentive programs, a lack of private investments, and difficulties overcoming societal norms (Perez *et al.* 2012; Hueso 2016). Recently, a study of rural households in Indonesia and Vietnam highlighted the logistical and financial barriers that prevent poor remote households from accessing sanitation (Willetts *et al.* 2017). The UN-Water Global Analysis and Assessment of Sanitation and Drinking Water report, for example, presented data from over 94 countries showcasing that the vast majority of households without access to drinking water and sanitation live in rural areas, yet the bulk of financial investments are currently allocated to improving services in urban areas (World Health Organization 2014). Numerous researchers have sought to use post-implementation evaluation studies of water and sanitation interventions to determine measures of success including drinking water quality, levels of satisfaction, community practices and attitudes, or health indicators as measures of success (Prokopy 2005; Clasen *et al.* 2007; Whittington *et al.* 2009; Freeman *et al.* 2012). Looking toward implementation of the 2030 Agenda for Sustainable Development, current available literature provides important insights into technical, social, and financial barriers to access, yet they do not convey information about how to reach the households that still remain without access to improved water and sanitation. Furthermore, few studies seek to identify patterns of inequalities in access at the household scale. Seeking a greater understanding in patterns of inequalities in water and sanitation access at a household scale, a case study survey analysis was applied for analysis of three communities in the Vietnamese Mekong Delta to investigate indicators for households without access to water and sanitation.

Implementing the SDGs: an investigation of the Vietnamese Mekong Delta

This work investigated the usage and status of both water and sanitation facilities in the Vietnamese Mekong Delta (VMD) and the socioeconomic characteristics of households with and without access to improved water and basic sanitation. Water access in Southeast Asia has rapidly expanded since the implementation of the MDGs. In 1990, 72% of the Southeast Asian population had access to improved water. The improved water coverage grew to 90% of the population by 2015. The basic sanitation coverage mirrored this growth with access rates at 54% of the population in 1990 growing to 82% coverage by 2015 (UNICEF & World Health Organization 2016). In Vietnam, access to improved water covers 92% of the population while 78% of the population have access to basic sanitation (UNICEF & World Health Organization 2016). Due to these high rates of reported access, this area is well suited for an evaluation of inequalities in water and sanitation access. To examine factors predicting access of improved water and sanitation, data were collected through cross-sectional sampling in three villages in the VMD. Interviews with key officials, household surveys, and water quality samples for microbial and other analyses were completed. The objective of this study was to identify populations without access to water and sanitation and determine what proxy household characteristic indicators correlated to these unserved populations. The work presented herein draws on limitations of current development strategies and considers how these issues might be addressed in future strategies working to achieve the 2030 Sustainable Development Agenda.

METHODOLOGY

Site description

The geography of the VMD and the influence of both seasonal pulse flooding from the Mekong River and sea level rise from the South China Sea allowed three villages to be selected with different ecological vulnerabilities to these important water resources challenges. The An Phu and Tri Ton Districts of An Giang province and Binh Thuy District of Can Tho City represent both different risk levels to sea level rise (SLR) and to annual seasonal flooding conditions of the delta (Figure 1 and Table 1). The village selected near An Phu District (village 3) is located furthest north in the Mekong Delta in an area that borders Cambodia and

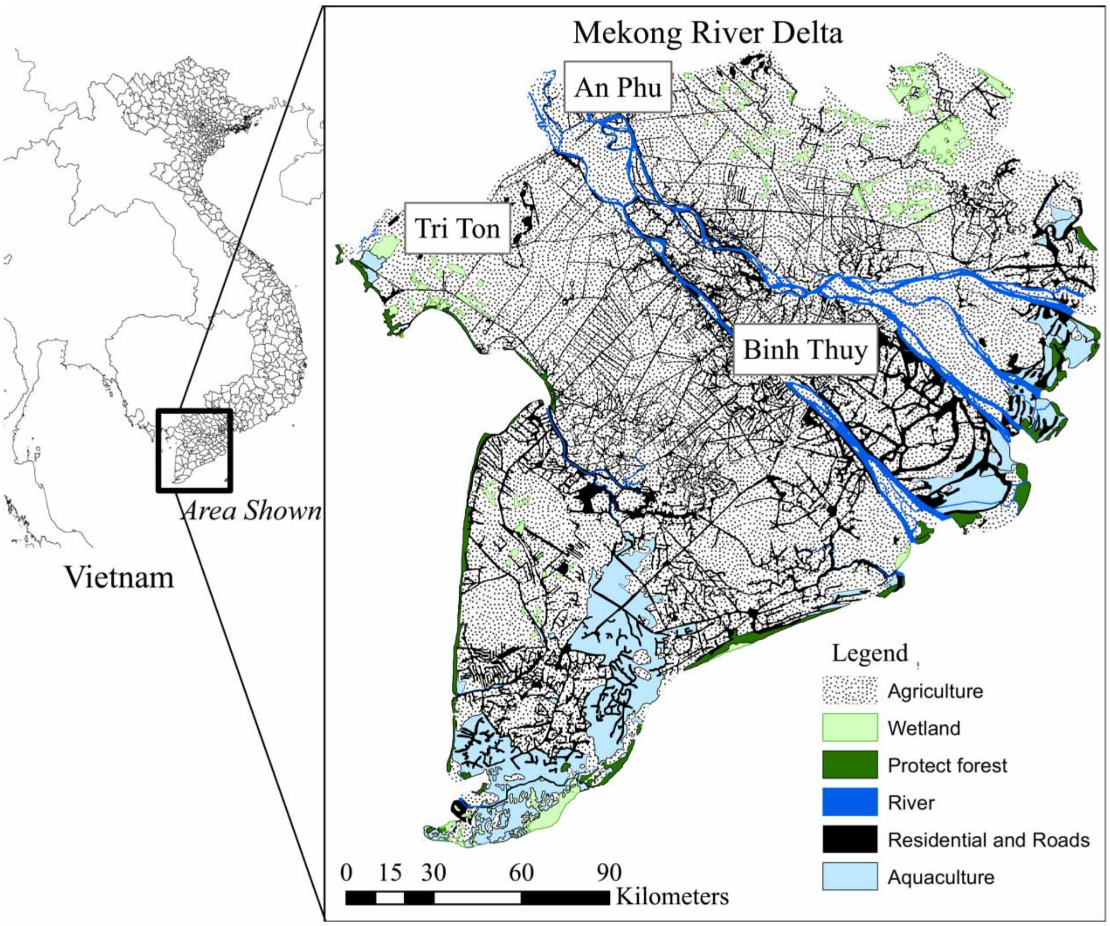

Figure 1 | Vietnamese Mekong River Delta; land use and site locations.

Table 1 | Select descriptions of villages

Provincial town	Village number	Approximate village population	Vulnerability to flooding[a]	Vulnerability to SLR[b]
Tri Ton	1	2,000	Medium	Medium
Binh Thuy	2	17,000	Low	High
An Phu	3	11,000	High	Low

[a]Approximated based on average flood depth, average flood duration, climate predictions, and major flood events. See text below.
[b]According to Wassmann et al. (2004).

experiences highly seasonal flooding. The village selected near Tri Ton District, while also northern, is closer to the Gulf of Thailand (village 1). Finally, the village near Binh Thuy District is the furthest south and most urban of the three areas (village 2). As shown in Figure 1(a), the Vietnamese portion of the Mekong Delta is dominated by agricultural and aquaculture land use. To protect the anonymity of respondents, specific village names have not been included. Another unique characteristic of this study site is that in the VMD many people still live in traditional stilt houses. These houses are still common particularly in the An Phu and Tri Ton Districts of this study site. The use of stilt houses has been prevalent for generations due to the flood tolerance these designs provide (Nguyen et al. 2011). Additionally, other studies have shown that stilt houses provide protection from mosquitos and other disease vector animals (Laderman 1975; Charlwood et al. 2003). Stilt houses provide flood avoidance, which is particularly relevant when floods arrive quickly.

Each village had a vulnerability to sea level rise assigned to it based on the results of the predictive model by Wassmann et al. (2004), which used historic and simulated hydrologic gauge data and two different sea level rise scenarios. Wassmann et al. (2004) defined three zones of vulnerability relating to sea level rise and one village from each zone was selected (Table 1). Although all three villages are susceptible to flooding during a moderate flooding event, they are exposed to different levels of risk, classified by vulnerability to flooding. Vulnerability to flooding was classified for each village using multiple sources of data including flood depth and duration from 1985 to 2010 to evaluate the current status of flooding in each village (Mekong River Commission 2010, 2014), a hydrodynamic model and the flood vulnerability index method that evaluated risk for future flooding (Dinh et al. 2012), and a study evaluating susceptibility to future major climactic events (Chaudhry & Ruysschaert 2008).

Agricultural land surrounds each of the three villages selected for this study, with village 2 being the most peri-urban of the three. Due to the large degree of heterogeneity in water and sanitation installation programs throughout the region, type of water and sanitation facility, as defined by the UN definition of improved water and sanitation, was used to compare households instead of specific implementing agency or organization.

Data collection and management

Qualitative and quantitative research methods were applied as part of a larger study, approved under Institutional Review Board approval, aimed at broadly conceptualizing household vulnerability, as it relates to water resources now and in the future. Surveys were conducted with a structured questionnaire utilizing random sampling within each selected community between February and April 2014. Field observations were also undertaken during this study. This approach aided the examination of everyday experiences and challenges faced by the interviewed households relative to water accessibility. During an initial site visit to each community, interviews with local personnel informed the design of the structured questionnaire and sampling frame. Local administrative personnel provided an aerial map of all households within the village and each household was assigned a number using a random number generator. The first 100 households on the randomly generated list were approached and utilized additional households from the list were included if one or more households declined to participate in the survey. Of the initial 300, two households declined to participate. The survey included questions relating to water and sanitation facilities and was carried out in Vietnamese with students from An Giang University serving as enumerators. In addition to asking usage, health, and hygiene questions, the survey enumerators observed and recorded details regarding the facility quality at each household. Prior to survey deployment the enumerators were trained in both English and Vietnamese during a 1-day workshop by members of the research team in collaboration with the Research Center for Rural Development of An Giang University.

Table 2 describes the various household characteristics included in this study. These characteristics represent socio-economic information including the size of the household, number of children in the household, age of respondent, employment, and education level. Study variables were chosen based on previous studies related to water and sanitation including economic resources (Fry *et al.* 2008) and variables relating to ownership of goods and education (Günther & Fink 2010). Since the MDGs and SDGs specifically target and track childhood mortality, this survey included recording the number of children under 18, as well as the number of children under the age of 5. Additionally, records of who manages the water in each household were collected to provide insight into the gender roles of water managers and if this influences the likelihood of household water access since previous studies have recognized the importance of women in water and sanitation development (Ray 2007; Fisher 2008). In this case, the term 'water manager' was used to describe the person in the household responsible for ensuring water was available, managing household water storage (where appropriate), and paying water fees (where appropriate). In one household surveyed these responsibilities were divided, in which case the primary description related to who is responsible for ensuring water was available, was used. As a part of the enumerator observation of household building materials, stilted households were identified and recorded using the category household floor material (wood). Additionally, to measure

Table 2 | Independent variables gathered through household survey

Variable name	Variable description	Measure
Village	Village of respondent	Categorical (e.g., village 1, village 2, village 3)
Household size	Number of people in household	Continuous
Children in household (<18 yr)	Number of children under 18	Continuous
Children under 5 yr	Number of children under 5	Continuous
Age	Age of respondent	Continuous
Agricultural employment	Primary income generator is agricultural in nature (e.g., harvesting, planting, fishing)	1 if agricultural employment, otherwise 0
Education level	Highest level of diploma achieved by respondent	Categorical (5 levels)
Local government	Distance to local government office	Continuous
Local market	Distance to local market	Continuous
Food security	Respondent identified experience in food shortage over the past year	1 if experienced food shortage, otherwise 0
Water manager	Respondent identified water manager for household	1 if female, otherwise 0
Water committee	Respondent identified the presence of a community water committee	1 if yes, otherwise 0
House size	Respondent identified house size (ha)	Continuous
Farm size	Respondent identified farm size (ha)	Continuous
Household floor material	Enumerator observation of household floor material	Categorical (3 levels)
Household wall material	Enumerator observation of household wall material	Categorical (4 levels)
Household roof material	Enumerator observation of household roof material	Categorical (3 levels)
Livestock	Respondent identified ownership of livestock	1 if yes, otherwise 0
Child education	Respondent identified if some or all of their children are currently in school	Categorical (6 levels)
Difficult to buy water	Respondent identified if there were any times during the year that were difficult to collect or buy drinking water	1 if yes, otherwise 0

the distance to local government and local markets, GPS locations were gathered by the enumerator at each study site.

Data analyses

Survey responses were coded using R statistical software. The categorical responses were dummy coded to allow interpretation through regression modeling. Utilizing logistic regression, a model was fit for each of the response variables to test the strength of relationships between access to water and sanitation (yes or no) and the other household characteristics. For each data subset, both stepwise regression and analysis of variance (ANOVA) were applied to determine the most appropriate model fit for the data. Three different regression analyses were applied to examine the effects of variables (from Table 2) on households with access and without access to improved water and sanitation. The three regression models analyzed: (1) all households with access to improved water, (2) all households with access to basic sanitation, and (3) households who had access to neither improved water nor sanitation facilities.

RESULTS

Household access and model selection

Of the households surveyed, roughly 73% ($n = 220$ water; $n = 221$ sanitation) had access to improved water or sanitation facilities. Although the access percentages were nearly identical between water and sanitation, only 58.3% ($n = 175$) of households had access to both basic sanitation and improved water while 11% ($n = 34$) had access to neither. The types of facilities each household had also varied among participants. As shown in Table 3, the most common 'improved' technologies for sanitation and drinking water included flush/pour toilets and piped facilities, respectively. Three households identified bottled water as their primary source for drinking water, which can be categorized as either improved or unimproved depending on the secondary source used by the household. In all three cases, the secondary source was unimproved and therefore was categorized as unimproved for all three households. The piped-water systems recorded were generally small community-level systems.

Table 3 | Type of primary water and sanitation facilities among households

		N	Category
	Type of sanitation facility		
Sanitation	Flush/Flush pour	129	Improved
	Ventilated pit latrine	35	Improved
	Simple pit with cement slab	57	Improved
	Open pit	16	Unimproved
	Latrine over ditch	16	Unimproved
	No facility, brush, bag	47	Unimproved
	Source of drinking water		
Drinking water	Piped water	179	Improved
	Rainwater	13	Improved
	Borehole/well in yard	16	Improved
	Borehole/well shared	12	Improved
	Bottled water with unimproved	3	Unimproved
	River/canal water	77	Unimproved

To determine the most appropriate logistic regression model for each response variable, both stepwise regression and ANOVA were applied. The Akiake information criteria (AIC) and cross-validation error rates allow for comparisons between each group of models to aid in model selection (Arlot & Celisse 2010). As Table 4 suggests, the models fitted by stepwise selection outperformed the models selected by ANOVA procedure and therefore the former were chosen for further analysis in all three cases.

Household characteristics

Household characteristics that demonstrated significant relationships between survey responses and access to water or sanitation included the distance to a government

Table 4 | Summary of AIC and cross-validation rates

Model	AIC	Cross-validation error
Sanitation (stepwise)	297.1	16.21%
Sanitation (ANOVA)	298.2	16.32%
Water (stepwise)	281.2	14.75%
Water (ANOVA)	285.3	15.04%
Neither sanitation nor water (stepwise)	152.6	7.48%
Neither sanitation nor water (ANOVA)	162.2	7.55%

office (for all three models) and distance to a local market (for water model) (Table 5). The negative coefficient estimates for distance to local government indicate that the further away the household was from the government center, the smaller their chances of having improved water or sanitation. Conversely, these results suggested that the further a household was from a market, the greater the odds of having access to an improved water source. The only other variable related to predicting access in all three models that was present and statistically significant was floor material. These results indicate that in all three cases, traditional stilt houses with wooden floors were statistically less likely to have access to improved water or sanitation.

When the households without access to either water or sanitation were examined, the stepwise model indicated that three variables were statistically significant predictors of access: distance to local government, stilted houses with wooden floors, and if the water manager was male or female. For the water model, families that had female water managers were more likely to have access to improved drinking water but this relationship was not present in the sanitation model. Figure 2 disaggregates the results related to gender roles in the household management of water. As shown in Figure 2(a), 80% of households indicated that either the mother or the daughter was responsible for managing the household water supply. This percentage varies among households with access to improved drinking water (Figure 2(b)) and without access to improved drinking water (Figure 2(c)). Stilted houses with wooden floors compromised 25% ($n = 74$) of all households surveyed. As indicated in Table 3, 73% ($n = 220$ water; $n = 221$ sanitation) of households had access to improved water or to basic sanitation. Of stilted households, however, 43% ($n = 32$) had access to improved water and 55% ($n = 41$) had access to basic sanitation. Throughout the sampling frame, 11% ($n = 34$) of all households and 35% ($n = 26$) of stilted household did not have access to improved water or basic sanitation. Farm

Table 5 | Model coefficients for three stepwise models

	Water		Sanitation		Neither	
Variable	**Estimate**	**Pr (>|z|)**	**Estimate**	**Pr (>|z|)**	**Estimate**	**Pr (>|z|)**
Children under 5	−0.72	0.00**	–	–	–	–
Difficult to buy	–	–	–	–	1.02	0.13
Local government	−0.08	0.08*	−0.13	0.00**	−0.22	0.00**
Local market	0.13	0.01**	–	–	–	–
Farm size	−0.32	0.00**	–	–	–	–
Floor material – wood (stilted)	−1.26	0.01**	−1.14	0.03**	−2.98	0.00**
Floor material – earth	0.77	0.45	−0.88	0.15	−1.22	0.19
Food security	–	–	−0.80	0.22	–	–
House size	23.17	0.06*	–	–	–	–
Household number of people	–	–	0.17	0.08*	–	–
Sanitation access	0.60	0.11	–	–	–	–
Water access	–	–	0.74	0.04**	–	–
Water manager	1.08	0.00**	–	–	0.99	0.06*
Water committee	–	–	–	–	−0.45	0.44
Wall material – concrete	−1.12	0.10	0.55	0.35	–	–
Wall material – wood	−1.62	0.02**	−0.58	0.31	–	–
Village 2	–	–	1.22	0.02**	–	–
Village 3	–	–	−0.53	0.25	–	–

*Significant at 0.10.
**Significant at 0.05.

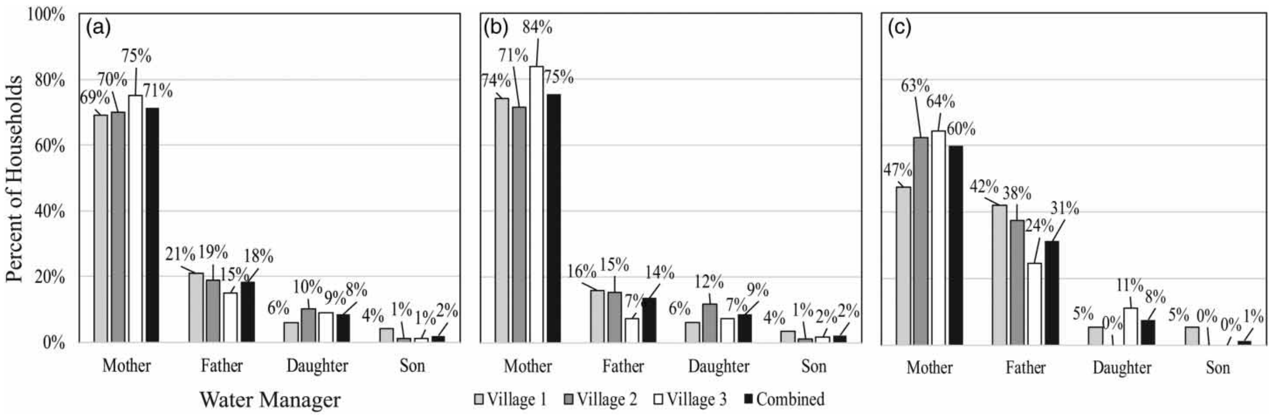

Figure 2 | Percent and role of household water managers in each village ((a) $n = 300$); percent and role of household water managers in households with improved water ((b) $n = 220$); percent and role of household water managers in households without improved water ((c) $n = 80$).

and house size also appeared to be significant for the water access model. There were a number of initial variables that proved to be unrelated to the stepwise model for any of the three models described. The village the household was located in was only a related variable within the sanitation model and indicated that village was significant and village 2 was more likely to have access to basic sanitation compared to village 1.

DISCUSSION

Reported access, combined access, and the SDGs

In this study, all three communities had lower access to improved water than reported average levels for the country of Vietnam. While this could have been due to sampling bias, the design of the quasi-random sampling as described should have prevented such selection bias and indeed other sample attributes were representative of the community as a whole (for example, basic sanitation). In addition to highlighting the lower levels of improved water access, this analysis revealed that the combined estimate of access, meaning access to both improved water and sanitation, totaled only 58.3%, much lower than nationally reported statistics on either metric separately. These observations indicate that this region of Vietnam has substantial progress to make to achieve the SDGs' more ambitious targets of achieving universal access to both water and sanitation by 2030. Alongside universal access, the SDG targets include strengthened definitions of improved access and safely managed water and sanitation and hygiene (United Nations 2017). Although this study collected data categorized through definitions of the MDGs related to improved water and basic sanitation, if the more ambitious SDG definitions were applied, these results would show even lower levels of access. With respect to reporting procedures, multiple case studies and monitoring and evaluation surveys have questioned the accuracy of the nationally reported access to improved water and sanitation statistics (Zawahri et al. 2011; Onda et al. 2012; Bartram et al. 2014). Recent work by Roche et al. (2017) used the Demographic Household Survey to estimate national and regional access for water and sanitation in a number of countries and found that the fraction of the population using both improved water and sanitation is substantially lower than separate figures and the urban–rural inequality is greater for combined SDG coverage than combined MDG coverage. Strengthening the national reporting procedures is a first step in accurately achieving the 2030 SDGs. Recent literature has proposed various ways to more accurately measure progress and success (Bartram et al. 2014; Pullan et al. 2014; Giné-Garriga et al. 2017). Giné-Garriga et al. (2017) argued for an approach that focuses on measurable descriptors of availability, safety, acceptability, accessibility, and affordability, while others (e.g., Pullan et al. 2014) have highlighted the necessity for improved geospatial disaggregation of survey monitoring data to target greater knowledge about hidden inequalities.

Challenges in flood-prone areas and other variations between models

The results presented herein indicate that traditional stilted households with wooden floors had significantly lower odds of access to water or sanitation. While these houses are well suited to manage water when annual flooding occurs (Nguyen et al. 2011), these findings suggest that they appear to limit the ability of households to implement and install water and sanitation facilities. The design and sustainability of implementing improved sanitation facilities on stilt houses is more complex than designing with non-raised buildings. These housing techniques are not only common in flood regions throughout Vietnam but are also prevalent in many countries in the region. SDG 13 was developed to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters through integration of various measures into national policies, strategies, and planning. Future research to determine how these strengthened resilience planning efforts align with other SDGs could provide additional insight into these results.

In WASH, due to the role women and girls play in household water provisioning including collection and management, they are disproportionately affected by a lack of access to adequate WASH (Ray 2007; Tilley et al. 2013; Caruso et al. 2015). Gender disparities in multiple areas prompted the global community to target improving gender equality and empowering women in both the MDGs (goal 3) and the SDGs (goal 5). The results of the regression analyses that were included in this study indicate that households with female water managers, including mothers or daughters, were more likely to have access to improved drinking water than those with male water managers, yet this indicator relationship was not present in the sanitation model or the model which analyzed households without access to either water or sanitation. This provides an initial window into the relationship that gender may play in accessing water and sanitation throughout the Mekong River Delta. Further information could be identified by more robust gender-segregated data on not only household characteristics but also system-level management structures and decision-making for WASH throughout the region and country.

Additionally, reports from the JMP have pointed to disparities between urban coverage and rural coverage, indicating that living further away from an urban area decreases the likelihood of coverage (UNICEF & World Health Organization 2013, 2016). This study did not measure the distance of households to an urban area as defined by the JMP; however, it provides a comparison regarding the potential for geospatial disaggregation and measurable descriptors. In this study, households were less likely to have access to water or sanitation if they were located further from the local government office. With respect to market access, the distance to market proved to be significant for the water model only and showed that households closer to the market were less likely to have access to improved water. These results point to additional complexity that may exist when considering the urban–rural divide.

Limitations and future research direction

Although this study presents observational data, which therefore have limited ability to articulate the causal relationships between outcomes and indicators, it provides a case for discussing several implications and challenges associated with achieving the 2030 SDGs. The results of this study associated socio-economic factors with households having access to improved water and sanitation, and further, may be able to predict a family's sanitation or improved water access using these socio-economic factors. While this paper developed a model with acceptable AIC and cross-validation rates for this case study analysis, to use this model for its predictive capabilities outside of these three communities, the next step would be to study other communities with the same protocol in order to validate the model findings elsewhere. The results indicated that in these three VMD communities, distance to the local government office was a statistically significant proxy indicator for access to improved water and basic sanitation in all three models. While these results represent information relevant to these three communities, future research testing hypotheses based on geospatially disaggregated data or measurable descriptors have the potential to strengthen practitioners' ability to identify households with and without access. In doing so, this information has the potential to help government and non-governmental organizations identify households without access without completing time-consuming and expensive field surveys if they had access to either certain demographic and socio-economic information or were able to compute geospatial information about the region of study. With regard to the geospatial information, it remains unclear why the distance to market was not significant for two of the three models and thus would benefit from further study. Although the specific model results of this case study may only be directly relevant to communities with similar qualities as those featured in this article, this research provides an outline of how development practitioners may deploy quasi-random social surveys sampling procedures and statistical analyses to develop proxy indicators for identifying populations without access to water and sanitation in the future. This type of work, when combined with country level data, may provide the ability for governments and non-governmental organizations to identify communities and regions in greater need of development assistance.

CONCLUSIONS

Achievements in providing access to improved water and basic sanitation have been hailed, and rightly so, as a major success in the MDGs. To achieve the ambitious Sustainable Development Goal targets of universal access to water and sanitation by 2030, substantial progress must be made to identify and target households with unequal access to these basic human rights. This case study provided a snapshot into access to water and sanitation facilities in the Vietnam Mekong Delta. It was observed that in all three communities surveyed, households had lower access to improved water and basic sanitation than nationally reported statistics. When viewed together, the combined MDG coverage was even lower than access of water or sanitation separately, showcasing the work that lies ahead as the global community works to implement the SDGs. The results of this paper also highlighted that in the case of the VMD, traditional stilt houses and design present complex challenges for implementing water and sanitation related SDGs. Experience and common sense approaches have driven building design to mitigate flooding, yet others have pointed to a general lack of scientific experimental data underpinning building design recommendations (Roberts 2008). By analyzing access to improved water and sanitation coverage simultaneously, this research also investigated factors that affect one intervention and not the other. As the global community moves towards implementing the SDGs, it is imperative to continue bringing water and sanitation interventions to people worldwide. This study indicates that the factors influencing sanitation do not mirror those influencing drinking water and perhaps ought to be considered separately. Although water and sanitation are intricately entwined, these results suggest that more tailored approaches by the international community will be necessary to continue development success in the coming decades. In addition to providing a survey of access in the VMD, these results have the theoretical potential to help target how to provide access to households within the region that still do not have access to water and sanitation facilities.

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