Spatial Patterns of Sanitation in Rural Vietnam: An Application of Small Area Estimation

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Nguyen Viet Cuong

Abstract
Diarrhea is one of the main causes for mortality of under-five children (Boschi-Pinto et al., 2008), and this disease can be attributed to deficient hygiene, sanitation and water supply (Bartram and Cairncross, 2010). Information on spatial patterns of sanitation is very important for sanitation support programs. In this study, we estimate and construct spatial maps of the proportion of households using sanitary latrines in rural Vietnam using a small area estimation method. It shows that there is a great spatial variation in the sanitary latrine rate. Within the same rural districts, the proportion of households using sanitary latrines varies largely across communes.

Keywords: Sanitary latrine, poverty mapping, small area estimation, Vietnam.
1. Introduction

Although, the worldwide under-five child mortality rate dropped significantly over time, the mortality was still estimated at 43 deaths per thousand live births per year in 2015 (The Inter-agency Group for Child Mortality Estimation, 2015). Global deaths from diarrhea of under-five children were estimated to account for 19% of total child deaths (Boschi-Pinto et al., 2008) and this massive disease burden is attributed to deficient hygiene, sanitation and water supply (Bartram and Cairncross, 2010). Yet, there are still a large proportion of people who do not have access to it. According to an estimate from World Bank (2015), 33% of the world population did not have access to improved latrines in 2015. Most countries have implemented programs to promote the access to hygienic or sanitary latrines.

An important question in all targeted programs is how to identify beneficiaries. More detailed information on beneficiaries increases the effectiveness of targeted programs (e.g. Bigman and Fofack (2000) and Elbers et al. (2007). Information on sanitary latrines is available in most household surveys, but household surveys are sampled and not representative at small areas. On the other hand, population censuses cover the whole population but most of them do not contain data on sanitary latrines. Elbers et al. (2002, 2003) develop a small area estimation method to combine a household survey and a population census in order to estimate poverty and inequality at small areas.¹

In this study, we will combine the 2011 Rural Agriculture and Fishery Census (RAFC) and the 2011 Viet Nam Multiple Indicator Cluster Survey (MICS) to estimate the sanitary latrine rate at small areas including districts and communes using the method of Elbers et al. (2002, 2003). Vietnam is a country with great success in poverty reduction. However, around 42.8% of households do not have access to sanitary latrines (according to the 2011 MICS). The proportion of households without sanitary latrine is much higher in rural households, at 56.5%, and ethnic minorities, at 76.6%.

There is a great geographical variation in living standards in Vietnam. Households who are living in delta are much better off than households in regions of Northern Mountain and Central Highlands. Access to sanitary latrines can also vary substantially across geographical areas. To provide supports on sanitary latrines, it is very important to have information on households’ access to sanitary latrines at small areas such as districts and communes. Vietnam has a large number of large-scale household surveys and censuses.

¹ In Vietnam, this method is applied to estimate the poverty and inequality at small areas in e.g., Minot et al. (2003), Nguyen (2012), Lanjouw et al. (2017), and Bui and Nguyen (2017). The method has been applied in around 40 countries in the world to predict the poverty (Bedi et al. 2007).
Yet, most surveys and censuses do not have detailed information on latrine types. Possibly, only the Viet Nam Multiple Indicator Cluster Surveys (MICS) are large-scale and nationally representative surveys which contain detailed information on latrines to define sanitary latrines according to MOH’s definition. Although the 2011 MICS contains data on sanitary latrines, it does not have a large sample to generate the estimates at the small areas such as communes and districts. In this study, using the method of Elbers et al. (2002, 2003) we will combine the 2011 MICS with the 2011 RAFC to estimate the proportion of households with sanitary latrines at the commune, district and province levels.

The remaining of the report is structures into 3 sections. Section 2 presents the data sets used in this study. Sections 3 and 4 present the estimation method and empirical results, respectively. Finally section 5 concludes.

2. Data set

This study will rely on two data sets. The first data set is the Rural Agriculture and Fishery Census (RAFC) in 2011. The RAFC were carried out by the GSO in July 2011. The censuses covered all households in rural areas. The censuses contain data on individuals and households including basic demography, employment and housing, and agricultural activities. There are also commune-level data on socio-economic conditions, agricultural production, infrastructure and transportation, education, health, and social affairs of all the rural communes throughout the country. There are 16,194,218 households covered in the census. More information on the 2011 RAFC can be found in MPI (2011).

The Viet Nam Multiple Indicator Cluster Survey (MICS 2011) was conducted from December 2010 to January 2011 by the General Statistics Office of Viet Nam (GSO) with financial and technical support from United Nations Children’s Fund (UNICEF) and the United Nations Population Fund (UNFPA) in Viet Nam. MICS 2011 contains detailed data on characteristics of children and women in Viet Nam. The 2011 MICS also contains data on household living standard including assets, durables, and housing conditions. The survey is representative at the urban/rural areas and regions. The number of households sampled in the 2011 MICS is 11,617 households. In this study, we use the rural sample, which covered 6,507 households (GSO, 2011).

The 2011 MICS contains data on types of latrine used by households. Table 1 presents the latrine type in the 2011 MICS for the full sampled and rural sampled households (without sampling weight). Based on the MOH’s definition, sanitary latrines include four types: Flush to piped sewer system; Flush to septic tank; Flush to pit (latrine); Ventilated Improved Pit latrine (VIP) (the first four latrine types in Table 1). When
sampling weight is applied, the proportion of households with sanitary latrines in rural areas is 43.46%.

Table 1: Type of latrine in the 2011 MICS

<table>
<thead>
<tr>
<th>Type of toilet facility</th>
<th>Code in MICS</th>
<th>All sample</th>
<th>Rural sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Observations</td>
<td>Percent</td>
</tr>
<tr>
<td><strong>Sanitary latrines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush to piped sewer system</td>
<td>11</td>
<td>204</td>
<td>1.68</td>
</tr>
<tr>
<td>Flush to septic tank</td>
<td>12</td>
<td>6,308</td>
<td>51.3</td>
</tr>
<tr>
<td>Flush to pit (latrine)</td>
<td>13</td>
<td>519</td>
<td>3.78</td>
</tr>
<tr>
<td>Ventilated Improved Pit latrine (VIP)</td>
<td>21</td>
<td>56</td>
<td>0.49</td>
</tr>
<tr>
<td><strong>Other latrines</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush to somewhere else</td>
<td>14</td>
<td>58</td>
<td>0.48</td>
</tr>
<tr>
<td>Flush to unknown place / Not sure / DK</td>
<td>15</td>
<td>25</td>
<td>0.22</td>
</tr>
<tr>
<td>Pit latrine with slab</td>
<td>22</td>
<td>1,045</td>
<td>9.73</td>
</tr>
<tr>
<td>Pit latrine without slab / Open pit</td>
<td>23</td>
<td>545</td>
<td>4.13</td>
</tr>
<tr>
<td>Composting toilet</td>
<td>31</td>
<td>1,069</td>
<td>9.78</td>
</tr>
<tr>
<td>Bucket</td>
<td>41</td>
<td>16</td>
<td>0.12</td>
</tr>
<tr>
<td>Hanging toilet, Hanging latrine</td>
<td>51</td>
<td>885</td>
<td>9.78</td>
</tr>
<tr>
<td>No facility, Bush, Field</td>
<td>95</td>
<td>837</td>
<td>5.96</td>
</tr>
<tr>
<td>Other</td>
<td>96</td>
<td>43</td>
<td>0.37</td>
</tr>
<tr>
<td>Missing</td>
<td>99</td>
<td>4</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>11,614</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

3. Estimation method

The Elbers et al. (2002, 2003) method can be described by three steps as follows. In the first step, we select common variables of the 2011 RAFC and the 2011 MICS. The common variables include household composition, land, water and housing conditions, and durables. Commune variables that are computed from the 2011 RAFC are also merged to the 2011 MICS. For example, we can calculate the average crop size at the commune level from the 2011 MICS and include this variable in the 2011 MICS to estimate the model of sanitary latrine.

In the second step, we regress the sanitary latrine on the selected common variables using data from the 2011 MICS. More specifically, we estimate the following model:

\[ Y_{ic} = \alpha + X_{ic} \beta + \varepsilon_{ic}, \]  

(1)
where $Y_{ic}$ is a dummy variable indicating whether household $i$ in cluster $c$ has access to a sanitary latrine, $X_{ic}$ the vector of the common variables, $\alpha$ and $\beta$ are regression coefficients, $\varepsilon_{ic}$ is error terms. The subscript $ic$ refers household $i$ living in cluster $c$. The sanitary latrine is defined according to the definition of MOH (see Table 1).

In the third step, we use the predicted model to estimate the access to sanitary latrine for households in the 2011 RAFC:

$$
\hat{Y}_{ic} = \hat{\alpha} + X_{ic}^{\text{Census}} \hat{\beta} + \hat{\varepsilon}_{ic},
$$

where $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\varepsilon}_{ic}$ denote the estimates for $\alpha$, $\beta$, and $\varepsilon_{ic}$. The predicted $\hat{Y}_{ic}$ are used to compute the proportion of households having access to sanitary latrines at the commune, district and provincial levels. The point estimates as well as the standard errors of the satisfaction level are calculated by Monte-Carlo simulations. In each simulation, a set of values $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\varepsilon}_{ic}$ are drawn from their estimated distributions, and an estimate of the proportion of households having access to sanitary latrines at the commune, district and provincial level are obtained. After $k$ simulations, we can get the average and standard deviation over the $k$ different simulated values of the proportion of households having access to sanitary latrines.

It should be noted that there is a question on whether households used a flush latrine in the 2011 RAFC. However, there is no information on other types of latrines. A flush latrine is considered as a sanitary latrine. It means that we only need to estimate the probability of having a sanitary latrine for households without a flush latrine. If we estimate the sanitary latrine model for households without a flush latrine, it can lead to the selection bias. Thus, we employ the idea of switching models: instead of estimating model (1), we will estimate the following model:

$$
Y_{ic} = Z + (1-Z)(\alpha + X_{ic}\beta + \varepsilon_{ic}),
$$

where $Z$ is a dummy variable indicating whether a household has flush toilet. If a household has a flush toilet ($Z$ equals 0), then the household’s latrine is defined as a sanitary latrine, and variable $Y$ equals one. If a household does not a flush toilet ($Z$ equals zero), then model
(3) will be used to estimate the probability of having a sanitary latrine. Equation (3) can be expressed as follows:

\[ Y_{ic} = \alpha + (1 - \alpha)Z + (ZX_{ic} - X_{ic})\beta + (1 - Z)\epsilon_{ic}, \]  

(4)

In this study, we will estimate model (4) using the 2011 MICS and apply the estimated model to the 2011 RAFC to predict the proportion of households with a sanitary latrine at the commune and district level.

4. Estimation results

Tables A.1 to A.6 present the estimation of models of sanitary latrine. Each model is estimated for each region. Table 2 compares the regional estimates based directly on data from the 2011 MICS and those from the small area estimation. Both estimates are quite close. It provides an evidence of the reliable estimates from the small area estimation method. The estimates from the small area estimation have smaller standard errors than those based on MICS. By regions, Northern Mountains has the lowest proportion of sanitary latrines, while South East has the highest proportion of sanitary latrines.

Table 2: The proportion of households having sanitary latrines by regions (in percent)

<table>
<thead>
<tr>
<th>Regions</th>
<th>Number of households</th>
<th>% households with sanitary latrine: estimate from the 2011 MICS</th>
<th>% households with sanitary latrine: estimate from the small area estimation method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Estimate</td>
<td>Standard error</td>
</tr>
<tr>
<td>Northern Mountain</td>
<td>2224291</td>
<td>22.25</td>
<td>2.87</td>
</tr>
<tr>
<td>Red River Delta</td>
<td>3842133</td>
<td>58.04</td>
<td>3.32</td>
</tr>
<tr>
<td>Central Coast</td>
<td>3656308</td>
<td>40.45</td>
<td>4.09</td>
</tr>
<tr>
<td>Central Highland</td>
<td>862680</td>
<td>39.61</td>
<td>4.08</td>
</tr>
<tr>
<td>South East</td>
<td>1429570</td>
<td>79.95</td>
<td>3.27</td>
</tr>
<tr>
<td>Mekong River Delta</td>
<td>3324644</td>
<td>34.87</td>
<td>3.44</td>
</tr>
</tbody>
</table>

Source: estimation from the 2011 RAFC and the 2011 MICS

Table 3 presents the proportion of sanitary latrines by provinces. Rural households Cao Bang and Tuyen Quang are those with the lowest access to sanitary latrines. Da Nang is the city with the highest proportion of households with access to sanitary latrines, followed by Ho Chi Minh city, Dong Nai and Binh Duong.

Table 3: The proportion of households having sanitary latrines by provinces (in percent)
<table>
<thead>
<tr>
<th>Province code</th>
<th>Province name</th>
<th>Number of households</th>
<th>% households with sanitary latrine</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Northern Mountain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Ha Giang</td>
<td>127363</td>
<td>15.49</td>
<td>1.58</td>
</tr>
<tr>
<td>4</td>
<td>Cao Bang</td>
<td>89801</td>
<td>13.15</td>
<td>1.63</td>
</tr>
<tr>
<td>6</td>
<td>Bac Kan</td>
<td>58838</td>
<td>18.27</td>
<td>1.60</td>
</tr>
<tr>
<td>8</td>
<td>Tuyen Quang</td>
<td>158733</td>
<td>13.74</td>
<td>3.74</td>
</tr>
<tr>
<td>10</td>
<td>Lao Cai</td>
<td>103252</td>
<td>19.55</td>
<td>1.75</td>
</tr>
<tr>
<td>11</td>
<td>Dien Bien</td>
<td>86069</td>
<td>18.70</td>
<td>2.22</td>
</tr>
<tr>
<td>12</td>
<td>Lai Chau</td>
<td>62270</td>
<td>16.31</td>
<td>1.95</td>
</tr>
<tr>
<td>14</td>
<td>Son La</td>
<td>201982</td>
<td>17.55</td>
<td>1.40</td>
</tr>
<tr>
<td>15</td>
<td>Yen Bai</td>
<td>145824</td>
<td>19.53</td>
<td>1.95</td>
</tr>
<tr>
<td>17</td>
<td>Hoa Binh</td>
<td>162112</td>
<td>20.24</td>
<td>1.53</td>
</tr>
<tr>
<td>19</td>
<td>Thai Nguyen</td>
<td>223755</td>
<td>28.13</td>
<td>1.74</td>
</tr>
<tr>
<td>20</td>
<td>Lang Son</td>
<td>137758</td>
<td>16.82</td>
<td>1.47</td>
</tr>
<tr>
<td>24</td>
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<td>374004</td>
<td>23.55</td>
<td>1.54</td>
</tr>
<tr>
<td>25</td>
<td>Phu Tho</td>
<td>292530</td>
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<td>1.52</td>
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<tr>
<td><strong>Red River Delta</strong></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>1</td>
<td>Ha Noi</td>
<td>942634</td>
<td>73.82</td>
<td>1.49</td>
</tr>
<tr>
<td>22</td>
<td>Quang Ninh</td>
<td>139108</td>
<td>43.63</td>
<td>2.02</td>
</tr>
<tr>
<td>26</td>
<td>Vinh Phuc</td>
<td>198603</td>
<td>44.23</td>
<td>2.25</td>
</tr>
<tr>
<td>27</td>
<td>Bac Ninh</td>
<td>219062</td>
<td>67.44</td>
<td>2.08</td>
</tr>
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<td>30</td>
<td>Hai Duong</td>
<td>401853</td>
<td>53.93</td>
<td>1.58</td>
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<td>282746</td>
<td>59.84</td>
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<td>Hung Yên</td>
<td>283615</td>
<td>62.27</td>
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<td>498287</td>
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<td>Ha Nam</td>
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<td>52.30</td>
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</tr>
<tr>
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<td>Thanh Hoa</td>
<td>783353</td>
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<td>Province code</td>
<td>Province name</td>
<td>Number of households</td>
<td>% households with sanitary latrine</td>
<td>Std. Err.</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------</td>
<td>----------------------</td>
<td>------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
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Finally, Figures 1 to 3 present the proportion of rural households with access to sanitary latrines at the province, district and commune level. Provinces in Northern Mountains have very low rates of sanitary latrines. In Mekong River Delta, several provinces such as Kiên Giang, Trà Vinh, Bắc Lệ and Soc Trang also have low sanitary latrine rates. Figure 2 shows that within a province (the province borders are presented by solid line), there is variation in the hygienic latrines across districts. In some provinces in Central Highlands with middle rates of sanitary latrine, there are districts with very low sanitary latrine rates (below 10%). Similarly, there is a large variation in the percentage of sanitary latrines across communes in the same districts (Figure 3).
Figure 1: The proportion of households with sanitary latrines by provinces
Figure 2: The proportion of households with sanitary latrines by districts
Figure 3: The proportion of households with sanitary latrines by communes
5. Conclusion

Vietnam is a country which have been successfully in poverty reduction. However, there is still a large proportion of households who do not access to sanitary latrines, especially in rural areas. To provide sanitation support programs, it is very important to have more detailed information on location of households who lack the access to sanitary latrines. In this study, I combine the 2011 Rural Agriculture and Fishery Census (RAFC) and the 2011 Viet Nam Multiple Indicator Cluster Survey (MICS) to estimate the sanitary latrine rate at small areas including districts and communes in rural Vietnam.

The results show a strong spatial variation in the sanitary latrine rate in Vietnam. Most provinces in Northern Mountain region have very low rates of sanitary latrines. This region is also the poorest one in Vietnam. Although Mekong River Delta has higher income than Central Highlands, it has a lower proportion of households using sanitary latrines than Central Highlands. It implies that information on not only monetary poverty but also nonmonetary dimensions such as sanitation is important for poverty targeting. In addition, sanitation data at more disaggregated areas is more informative for targeting of the support programs. In some provinces with middle rates of sanitary latrine, there are districts and communes with a very low sanitary latrine rate.
References


### Appendix

Table A.1. Regression of sanitary latrine in North Mountain

| Explanatory variables                                      | Coefficient | Std. Err. | t     | Prob>|t|
|------------------------------------------------------------|-------------|-----------|-------|------|
| _intercept_                                                | 0.1942      | 0.0757    | 2.5638| 0.0105|
| Commune proportion of households having buffalo            | 0.1841      | 0.0588    | 3.1927| 0.0018|
| Commune proportion of households having chicken            | -0.3120     | 0.0878    | -3.5544| 0.0004|
| Household having Household having computer                 | 0.3654      | 0.0452    | 8.0825| 0.0000|
| Commune proportion of households having computer           | 2.3034      | 0.4546    | 5.0674| 0.0000|
| Household having Household having fridge                    | 0.2022      | 0.0246    | 8.2196| 0.0000|
| Number of high schools in commune                          | 0.0842      | 0.0296    | 2.8433| 0.0045|
| Commune having market                                      | 0.0722      | 0.0239    | 3.0282| 0.0025|
| Household having mobile phone                              | 0.0601      | 0.0262    | 2.2964| 0.0218|
| Commune proportion of people working in service sector     | -1.1562     | 0.4266    | -2.7100| 0.0068|
| Tuyen Quang province                                       | -0.1140     | 0.0394    | -2.8938| 0.0039|
| Household having piped water                              | 0.2277      | 0.0537    | 4.2418| 0.0000|

R-squared: 0.2977
Number of observations: 1155
Rho: 0.015

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.2. Regression of sanitary latrine in Red River Delta

| Explanatory variables                                      | Coefficient | Std. Err. | t     | Prob>|t|
|------------------------------------------------------------|-------------|-----------|-------|------|
| _intercept_                                                | -0.3900     | 0.1631    | -2.3907| 0.0170|
| Household having buffalo and cows                         | -0.1239     | 0.0483    | -2.5638| 0.0105|
| Household having chicken                                  | -0.0795     | 0.0266    | -2.9880| 0.0029|
| Household having computer                                 | 0.1200      | 0.0413    | 2.9035| 0.0038|
| Commune proportion of households having computer          | -0.9949     | 0.3118    | -3.1907| 0.0015|
| Commune proportion of households having clean (not-piped) water| 0.1122      | 0.0485    | 2.3127| 0.0209|
| Household having fridge                                   | 0.2629      | 0.0286    | 9.1831| 0.0000|
| Number of high schools in commune                         | 0.0598      | 0.0261    | 2.2965| 0.0218|
| Commune proportion of households having livestock          | -0.4471     | 0.1032    | -4.3311| 0.0000|
| Household having mobile phone                             | 0.1352      | 0.0332    | 4.0698| 0.0001|
| Commune proportion of households having motorbike         | 1.0363      | 0.1813    | 5.7173| 0.0000|
| Household having desk telephone                           | 0.0743      | 0.0271    | 2.7420| 0.0062|
| Commune proportion of households having desk telephone    | 0.6848      | 0.1406    | 4.8717| 0.0000|
| Nam Dinh province                                          | 0.1488      | 0.0416    | 3.5783| 0.0004|
| Ninh Binh province                                         | 0.2161      | 0.0578    | 3.7383| 0.0002|
| Household having unclean water                            | -0.1086     | 0.0269    | -4.0338| 0.0001|

R-squared: 0.294
Number of observations: 1161
Table A.3. Regression of sanitary latrine in Central Coast

| Explanatory variables                                   | Coefficient | Std. Err. | t     | |Prob|>t |
|----------------------------------------------------------|-------------|-----------|-------|---|---|
| _intercept_                                              | -0.7523     | 0.1225    | -6.1415 | 0.0000 |
| Household having buffalo and cows                        | -0.1783     | 0.0265    | -6.7255 | 0.0000 |
| Household having television                             | 0.1127      | 0.0408    | 2.7635 | 0.0058 |
| Household having computer                               | 0.1848      | 0.0449    | 4.1205 | 0.0000 |
| Commune proportion of households having flush latrine    | 0.8591      | 0.0757    | 11.3532 | 0.0000 |
| Household having fridge                                  | 0.1863      | 0.0301    | 6.1965 | 0.0000 |
| Commune having irrigation system                         | 0.1020      | 0.0345    | 2.9617 | 0.0031 |
| Commune proportion of Kinh households                    | 0.2159      | 0.0700    | 3.0837 | 0.0021 |
| Household having mobile phone                            | 0.1340      | 0.0275    | 4.8687 | 0.0000 |
| Commune proportion of agricultural workers                | 0.3324      | 0.0964    | 3.4489 | 0.0006 |
| Commune having secondary school                          | 0.2315      | 0.0458    | 5.0522 | 0.0000 |
| Household having desk telephone                          | 0.1191      | 0.0246    | 4.8389 | 0.0000 |
| Thua Thien Hue city                                      | -0.2798     | 0.0768    | -3.6438 | 0.0003 |
| Commune having water program                             | 0.0794      | 0.0347    | 2.2873 | 0.0224 |
| R-squared                                                | 0.386       |           |       |   |
| Number of observations                                   | 1160        |           |       |   |
| Rho                                                      | 0.055       |           |       |   |

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.4. Regression of sanitary latrine in Central Highland

| Explanatory variables                                   | Coefficient | Std. Err. | t     | |Prob|>t |
|----------------------------------------------------------|-------------|-----------|-------|---|---|
| _intercept_                                              | 0.4187      | 0.2415    | 1.7335 | 0.0833 |
| Household having Household having computer               | 0.1656      | 0.0428    | 3.8725 | 0.0001 |
| Commune proportion of households having crop             | -0.5902     | 0.2406    | -2.4529 | 0.0143 |
| Commune having cultural house                            | 0.1428      | 0.0271    | 5.2624 | 0.0000 |
| Household having Household having fridge                 | 0.2254      | 0.0293    | 7.0714 | 0.0000 |
| Commune proportion of households with garbage place      | 1.3668      | 0.1699    | 8.0463 | 0.0000 |
| Commune having kindergarten                              | 0.0987      | 0.0152    | 6.5061 | 0.0000 |
| Household is Kinh majority                               | 0.1924      | 0.0279    | 6.8841 | 0.0000 |
| Household having mobile phone                            | 0.1591      | 0.0326    | 4.8868 | 0.0000 |
| Number of lenders in commune                              | -0.2198     | 0.0575    | -3.8205 | 0.0001 |
| Proportion of lands with certificate in commune           | 0.0027      | 0.0006    | 4.5029 | 0.0000 |
| Road village in communes                                 | -0.0225     | 0.0027    | -8.2022 | 0.0000 |
| Dak Nong province                                         | 0.1132      | 0.0430    | 2.6314 | 0.0086 |
| R-squared                                                | 0.3678      |           |       |   |
| Number of observations                                   | 1168        |           |       |   |
| Rho                                                      | 0.055       |           |       |   |

Source: estimation from the 2011 RAFC and the 2011 MICS
Table A.5. Regression of sanitary latrine in South East

| Explanatory variables                                      | Coefficient | Std. Err. | t    | Prob>|t |
|------------------------------------------------------------|-------------|-----------|------|------|
| _intercept_                                                | -0.5373     | 0.3917    | -1.3716 | 0.1706 |
| Commune proportion of households having buffalo            | -0.9426     | 0.5034    | -1.8725 | 0.0615 |
| Commune proportion of households with electricity          | 0.8852      | 0.4163    | 2.1263 | 0.0338 |
| Household having electric fan                              | 0.1958      | 0.0932    | 2.1011 | 0.0360 |
| Household having fridge                                    | 0.2039      | 0.0292    | 6.9743 | 0.0000 |
| Commune proportion of households using gas for cooking     | 0.2404      | 0.0920    | 2.6128 | 0.0092 |
| Commune having irrigation system                           | -0.0981     | 0.0297    | -3.3037 | 0.0010  |
| Household having mobile phone                              | 0.0854      | 0.0445    | 1.9199 | 0.0553 |
| Commune proportion of households receiving microcredit     | -0.0035     | 0.0011    | -3.2964 | 0.0010  |
| Household having desk telephone                            | 0.0565      | 0.0285    | 1.9864 | 0.0474 |
| Dong Nai province                                          | 0.0844      | 0.0312    | 2.7053 | 0.0070 |

R-squared: 0.2529
Number of observations: 771
Rho: 0.016

Source: estimation from the 2011 RAFC and the 2011 MICS

Table A.6. Regression of sanitary latrine in Mekong River Delta

| Explanatory variables                                                                 | Coefficient | Std. Err. | t    | Prob>|t |
|---------------------------------------------------------------------------------------|-------------|-----------|------|------|
| _intercept_                                                                          | -0.2760     | 0.0581    | -4.7496 | 0.0000 |
| Commune proportion of households having bathroom                                      | 0.4003      | 0.0839    | 4.7686 | 0.0000 |
| Household having computer                                                             | 0.2526      | 0.0476    | 5.3051 | 0.0000 |
| Commune proportion of households having flush latrine                                 | 0.8578      | 0.1255    | 6.8366 | 0.0000 |
| Commune proportion of households having clean (not-piped) water                       | 0.2307      | 0.0346    | 6.6604 | 0.0000 |
| Household having electric fan                                                         | 0.1247      | 0.0360    | 3.4674 | 0.0005 |
| Household having fridge                                                               | 0.2685      | 0.0280    | 9.5769 | 0.0000 |
| Household size                                                                       | -0.0193     | 0.0074    | -2.5964 | 0.0105  |
| Household having desk telephone                                                      | 0.0615      | 0.0255    | 2.4099 | 0.0161 |
| Household having clean water (non-piped)                                             | -0.1015     | 0.0248    | -4.0928 | 0.0000 |

R-squared: 0.3196
Number of observations: 1152
Rho: 0.085

Source: estimation from the 2011 RAFC and the 2011 MICS