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PUBLISHER

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VERSION

VoR (Version of Record)

PUBLISHER STATEMENT

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REPOSITORY RECORD

Barakzai, S. Shiriin, and T. Bongertman. 2019. "Identifying the Water Supply Service Levels of the Poorest Quintile in Rural Laos: Applying PCA for Programme M and E". figshare. <https://hdl.handle.net/2134/31017>.

37th WEDC International Conference, Hanoi, Vietnam, 2014

**SUSTAINABLE WATER AND SANITATION SERVICES
FOR ALL IN A FAST CHANGING WORLD**

**Identifying the water supply service levels of the poorest
quintile in rural Laos: applying PCA for programme M&E**

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BRIEFING PAPER 2011

This paper presents the findings from SNV (Netherlands Development Organisation) Laos of the Functionality of Rural Water Supply (FRWS) programme baseline conducted in 2013 in Atsaphone and Phin districts of Savannakhet province. The baseline applied Principal Components Analysis (PCA) to identify the poorest households enabling analysis of household service levels disaggregated by wealth quintile as well as other demographic characteristics. The paper explains why PCA was adopted, practicalities of applying it in the field, and lessons learnt from the process. The resulting baseline findings allow identification of the aspects of rural water supply (RWS) functionality which affect the poorest households enabling SNV to design its programme to meet the needs of the most vulnerable.

Targeting the water supply needs of the rural poor

MDG 7 provided the motivation for significant improvements to be made in rural water supply coverage in many countries. Ongoing post-2015 discussions have highlighted the need to improve service levels as well as eliminate inequalities, currently aiming for universal household drinking water by 2030.

Motivated by the Sustainable Development Goals focus on addressing Equity and Non-Discrimination (END) in service levels between different groups, reliable and consistent identification of the most vulnerable households (HHs) is an essential part of the Functionality of Rural Water Supply (FRWS) programme's approach.

SNV's FRWS programme aims to address the problem of non-functional rural water supplies in our programme countries. RWS functionality levels are not readily available in many countries, and definitions of functionality differ, but it is estimated that only 20-40% of current coverage actually provides users with functional water services (Improve International 2013).

Use of the JMP Improved/ Unimproved classifications alone is acknowledged as no longer adequate to capture the full scope of functionality and various efforts have been made to identify the critical factors affecting RWS service levels and to define criteria for basic levels of service. SNV Asia's FRWS programme has adopted four indicators: Quality, Quantity, Accessibility and Reliability (QQAR), to assess the service levels received by HHs, where the lowest level of service for these four individual indicators is taken to be the Overall service level for the HH.

How to identify the poor

It is important that "wealth" is understood broadly in social and economic terms and not just income. Identification of the poor at programme level has previously used existing national identification systems, such as Cambodia's national ID-Poor system, or programme specific methods such as participatory wealth/poverty assessment which takes account of the local context via input from local people.

Neither of these approaches are appropriate due to the scale of SNV's multi-country programmes and the need to assess impact on the poorest between countries. Therefore in 2013 SNV decided to adopt the socio-economic scoring approach used by the DHS for our Asia WASH programmes. The DHS's Principal Components Analysis (PCA) approach was selected because:

- It uses asset-based wealth ranking rather than income which is more appropriate for rural HHs;
- It is an internationally recognised and established method developed by the Demographic and Health Survey (DHS) and is also used in Multiple Indicator Cluster Surveys (MICS);
- The MICS/ DHS have been developed for individual countries with context specific variable/ asset lists available in English and the local language, and are updated regularly in all SNV programme countries.

What is Principal Components Analysis (PCA)?

The purpose of PCA is to reduce the sample data set by developing a new set of variables, smaller than the original data set, whilst retaining the most significant characteristics of the sample. It assumes that households respond differently to the survey questions due to their socio-economic status. PCA applies standard statistical transformations to the response distributions for each question to produce normal (bell-shaped) distributions. It identifies the variables which have the greatest variations in response, the Principal Components, which provide the greatest opportunity to disaggregate between the sampled households, e.g. if every HH has a bicycle then we cannot differentiate between households based on ownership of bicycles. PCA assigns a weighting to each of the variables depending on the extent of response variation. It then sums the overall weighted scores for each HH using only the identified Principal Components. The HHs can then be sorted by their resulting socio-economic scores (SES) and split into five groups or quintiles, each containing 20% of the total number of HHs, with Quintile1 being the group with the lowest scores.

Applying PCA in practice

In practice, applying PCA required us to access the current MICS/ DHS survey tool and statistical software analysis syntax, usually held by the national statistics bureau and UNICEF country offices. Interrogation of the syntax enables identification of the survey tool questions which are needed for PCA. For Laos there are seven core ‘components’ or groups of questions on which the PCA is based (see Table 1).

Table 1. Laos 2012 MICS PCA variables	
“Variable” group	Questions included
Water and sanitation	Main source of water for: drinking, other uses. Nature of HH sanitation
Rooms used for sleeping	No. of rooms used for sleeping
Household construction	Main construction material for floor, roof, walls
Cooking fuel	Main type of cooking fuel used; electricity, LPG, gas etc.
Household assets	Assets owned by HH such as electricity, clock, radio etc.
Household member assets	Assets owned by individual household members such as watch, bike, cart etc
Livelihood assets	HH ownership of agricultural land or livestock

Since the syntax for PCA analysis is already developed for the national MICS, we only needed to engage a statistician who was able to apply the PCA to the HH survey data in order to calculate the socio economic scores. However, as the FRWS programme aims to influence the responses to the “water and sanitation” questions, we undertook the PCA ignoring these variables to avoid future interdependency problems.

Survey methodology

The Laos FRWS baseline was conducted in the wet season of 2013 in Atspahone and Phin districts of Savannakhet province. Approximately 370 HHs were sampled in each district which had populations of 8840 and 8640 HHs respectively, to provide statistical accuracy to 5%.

Assessing functionality of rural water supply service levels

The SNV Laos FRWS programme uses the service level matrix shown in Table 2 to determine the service level of each HH. A HH’s service level is assessed based on a series of sub-questions in the HH survey tool for each of the four QQAR indicators. The HH’s service level for each indicator is based on the average

service level over the wet and dry seasons and for up to three water supplies. The HH's Overall FRWS service level is the lowest of their four QQAR service levels.

LoS (score)	Quality		Quantity (l/p/d)	Accessibility (mins/ p/d)		Reliability (months/yr)	Overall LoS
High (5)	HH perception of quality	Improved RWS	>100	<30mins	Within HH compound	12	The lowest score of each HH's four individual indicators
Intermediate (4)			50-100		<100m	10-11	
Basic (as national standards) (3)			20-49		100-1000m	8-9	
Substandard (2)		Unimproved RWS	5-20	31-60 mins	>1000m	5-7	
No service (1)			≤5	>60 mins		0-4	

Baseline findings

PCA results

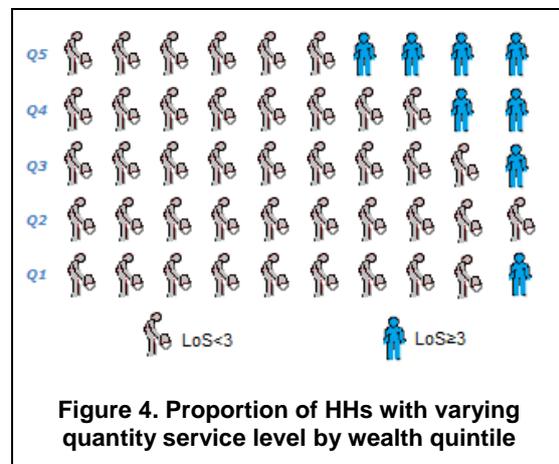
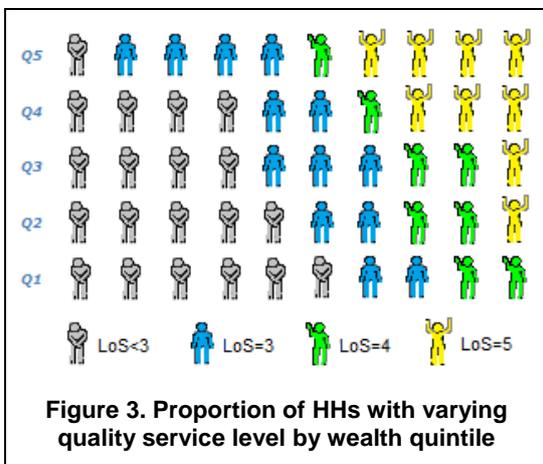
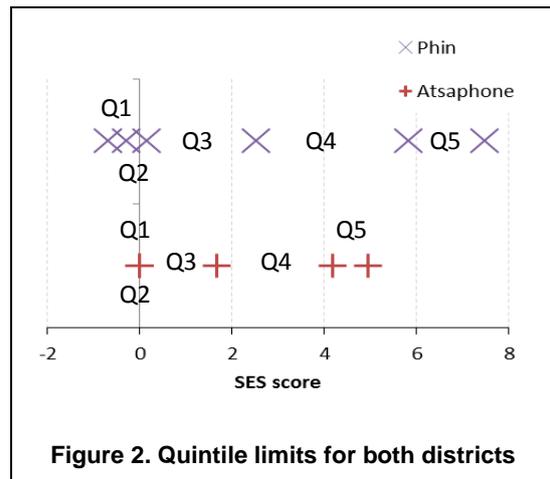
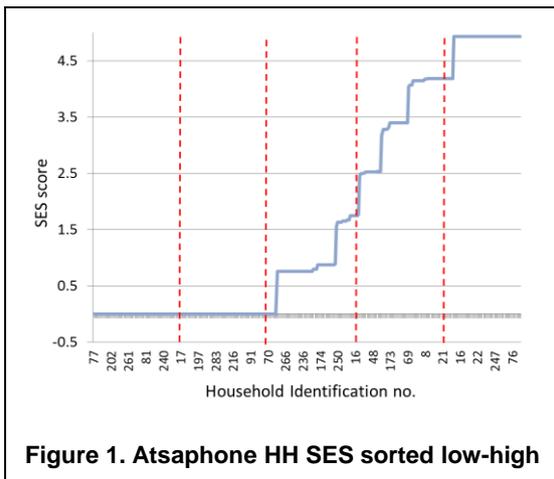
The PCA analysis identified the variables noted in Table 3 as principal components for the two districts. We see that owning a satellite dish had the highest weighting in Atsaphone whilst in Phin wealth was most strongly associated with owning a TV. Cooking with wood was strongly correlated with poverty in Phin.

Variable group	Floor material	Cooking fuel		HH assets								HH member assets
Variable response option	Cement	Charcoal	Wood	Electricity	Fan	TV	CD/VCR Player	Water pump	Satellite dish	Mobile/non-mobile telephone	Refrigerator	Motorcycle /Scooter
Atsaphone				0.875	0.868	0.757		0.791	0.894		0.750	
Phin	0.301	0.670	-0.682	0.890	0.849	0.902	0.592	0.762	0.897	0.399	0.802	0.427

When we apply these weightings to calculate the HH SES and plot the HHs sorted by their SES we get a distribution for Atsaphone as shown in Figure 1. From this plot we can identify the SES limits for each quintile, splitting the total number of HHs into five equal groups. Plotting the SES limits for each quintile for the two districts side by side (Figure 2) we can see that the range of scores in Atsaphone (0 to 4.935) is narrower than in Phin (-0.682 to 7.491), suggesting less social inequality.

Inequality in FRWS Levels of Service (LoS) by wealth quintile

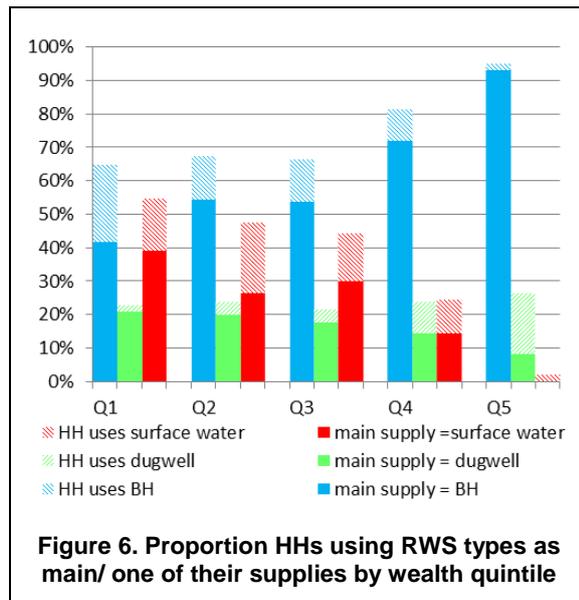
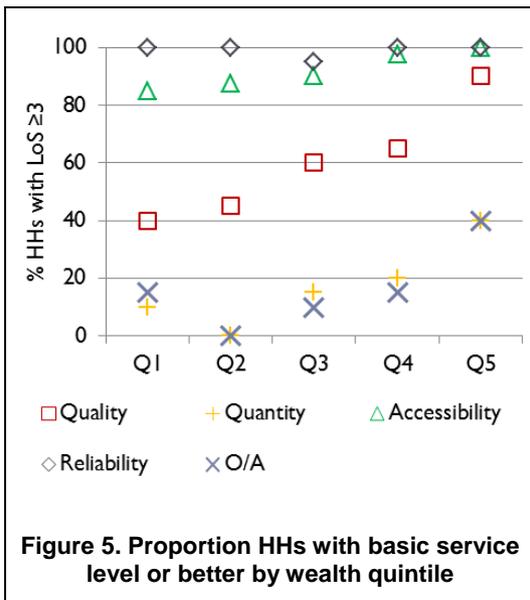
- Quality LoS: 73% of Atsaphone, but only 49% of Phin HHs have a Basic Quality service level or better. In both districts, being in a higher wealth quintile correlated with a better service level, with Q5 HHs more than twice as likely to have a Level of Service (LoS) of Basic or better (Figure 3) than Q1 HHs.
- Quantity LoS: No HHs in Atsaphone had a Quantity LoS of 5, regardless of wealth quintile, and only 17 percent met or exceeded the Basic service level. (Figure 4).



- **Accessibility LoS:** In both districts, the majority of Q1, 2 and 3 HHs reached the Basic service level, whilst the majority of Q4 HHs in Atsaphone and Phin were likely to have LoS 4 and LoS 5 respectively. Although the Accessibility service levels were higher than our Basic level, based on Laos national standards, even for lower quintiles. There are still 8 percent of HHs who did not meet the Basic level, equivalent to over 800 HHs in the whole of Atsaphone and over 700 HHs in Phin district.
- **Reliability LoS:** Both districts had very high Reliability service levels regardless of wealth quintile with over 90 percent meeting the Basic LoS. This is due to the decision to average the service levels of all the supplies used by each HH, masking lower individual RWS reliability service levels.
- **Overall LoS:** When looking at the Overall FRWS levels of service we found that the HH results were strongly affected by the low Quantity service levels, and that the majority of sampled HHs do not meet the Basic LoS. In both Atsaphone and Phin a correlation between LoS and wealth ranking was seen.

An alternative way to visualise the inequalities in service levels is shown in Figure 5. We can clearly see that, whilst Reliability LoS is both high and about the same for all quintiles, the LoS for the other three FRWS indicators is correlated to wealth quintile. Figure 5 enables us to identify the aspects of RWS functionality which have the potential to benefit the Q1 and Q2 HHs the most, i.e. Quality and Quantity.

Figure 6 presents the proportion of HHs which used each of the three main RWS types and of these how many named it as their main water supply. We see that only two thirds of Q1 HHs who used a borehole also named it as their main supply, compared to almost all of the Q5 HHs who used a borehole. Conversely over two thirds of the 55 percent of Q1 HHs who used surface water named it as their main supply compared to none of the 2 percent of Q5 HHs who used surface water. Similarly whilst almost the same proportion of HHs in each quintile used dugwells, they were named as the main supply by nearly all the Q1 HHs compared to only a quarter of Q5 HHs. This shows the reliance on low-tech RWS types by poorer HHs.



Inequalities in FRWS Service levels by other demographic indicators

Table 3 presents some outline demographic data for the sampled HHs in each district.

Data set	District Characteristic	Atsaphone	Phin
Basic demographic data	Gender	50:50 male: female 3% female headed HHs	50:50 male: female 2% female headed HHs
	Religion	99% Buddhist	57% animist, 39% Buddhist
	Ethnicity	72% Laos	68% Khmu
Lao PDR MICS/ DHS questions	Connectivity	100% road access 44% electricity	99% road access 46% electricity
	Disabled family members	2% HHs	4% HHs

The LoS results were also disaggregated by these indicators to identify inequalities in service level. There was very little evidence of inequality by gender of HH members, and the number of female-headed HHs was too low to be able to draw reliable conclusions about patterns in their functionality service levels.

Results by religion were mixed with no noticeable trend for quality, quantity or reliability. Accessibility levels of service varied in Phin, with Buddhist HHs more likely to have higher levels of service. There are no obvious reasons for this observation.

With regards to ethnicity, in both districts the minority ethnicity were more likely to have a higher Quality LoS, whilst in Phin the minority ethnicity was also more likely to have a better Quantity LoS. There were no clear trends between ethnicity and Accessibility or Reliability LoS.

The Government of Lao PDR places high priority on connecting rural villages by road, however the majority of our sampled HHs are connected by road and we were not able to use this to disaggregate results. Therefore HH access to electricity was used as a proxy for connectivity and correlated strongly with improved LoS for all the QQAR indicators.

HHs were asked if they had any disabled members or people with special needs. Table 3 shows that the proportion of HHs with disabled members is similar in both districts and comparable to the national estimate of the disabled population of 3.19% for rural areas. In both districts and for all QQAR indicators, presence of a disabled family member correlated with a higher level of service, though the reasons for this are not known and this conclusion is based on a small number of HHs.

Influence of findings on FRWS programme design

From the findings presented above we can see that PCA brings another dimension to the disaggregation of the FRWS baseline results which will enable SNV to design the FRWS programme to prioritise the needs of the poorest HHs. Their greater reliance on low-tech RWS poses a challenge to WASH programmes which focus on improving sustainability of boreholes or gravity fed supplies. The findings have required us to rethink how we can improve the service levels that HHs receive from dug wells and surface water, whilst also trying to increase use of boreholes.

We also found that poor HHs in our sample districts are most effuse affected by low quantity and quality service levels. Further analysis of the results found that more than half the HHs believed that they did in fact use enough water, though they fell below our Basic service level. Similarly about half of the HHs who used an Unimproved supply believed their water supply was good quality sometimes, most of the time or all of the time. This leads us to the conclusion that formative research is required to address beliefs about the health risks of borehole water and preferences for surface water, in order to develop context specific behaviour change strategies.

Bearing the above in mind we also identified that the value of water supplies needs to be addressed such that HHs are willing to invest in higher service levels, before developing any RWS service models, private or otherwise.

This ability to present our baseline data focusing on the RWS situations of the poor provides an opportunity to advocate on their behalf for increased investment on these specific issues with government and donors.

Lessons learnt from applying PCA

Understanding how PCA enables comparison of results across geographical boundaries and also over the duration of a programme was central to the decision to test its application to SNV's FRWS programme and ultimately adapt it for use in all future SNV Asia WASH programmes.

Key lessons learnt include:

- Use of the current MICS/ DHS survey tool and its respective PCA syntax for each country is critical.
- Identifying locally available statistical human resources to reliably conduct the PCA is ideal
- A consistent approach to defining the quintiles and their SES cut-off levels needs to be agreed
- Interrogating the resulting SES distributions and identified principal components to see if they align with expectations based on experience of the specific locations and communities is advisable

In theory the HH survey tool could be shortened to only include the questions for the variables identified as the principal components for the programme area, allowing us to reduce the interview duration. However at present, recognising the risk of relying on 'black box' number crunching without real understanding of the complex statistical analysis being undertaken, SNV is in the process of trying to develop a simplified proxy for PCA which enables clearer understanding by our staff and WASH partners. This process is currently underway drawing from the lessons learnt from the three 2013 baseline surveys which applied PCA.

Acknowledgements

The authors would like to thank the SNV Laos FRWS team for contributing to the ongoing review and design of the Asia FRWS programme, testing the methods and sharing their lessons learnt. We further thank the national and local government agencies responsible for water in the respective countries as well as local WASH stakeholders who tested and undertook the baseline surveys.

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