Annex 1. Use of GPS trackers and logs

Contents

1. GPS tracker utilization

This section analyzes utilization of GPS trackers among the 39 households who accepted to wear the device on the 4-week monitoring period. Detailed information about the purpose and protocols followed in assigning the devices can be found in the October 2016 Research Pilot Report.

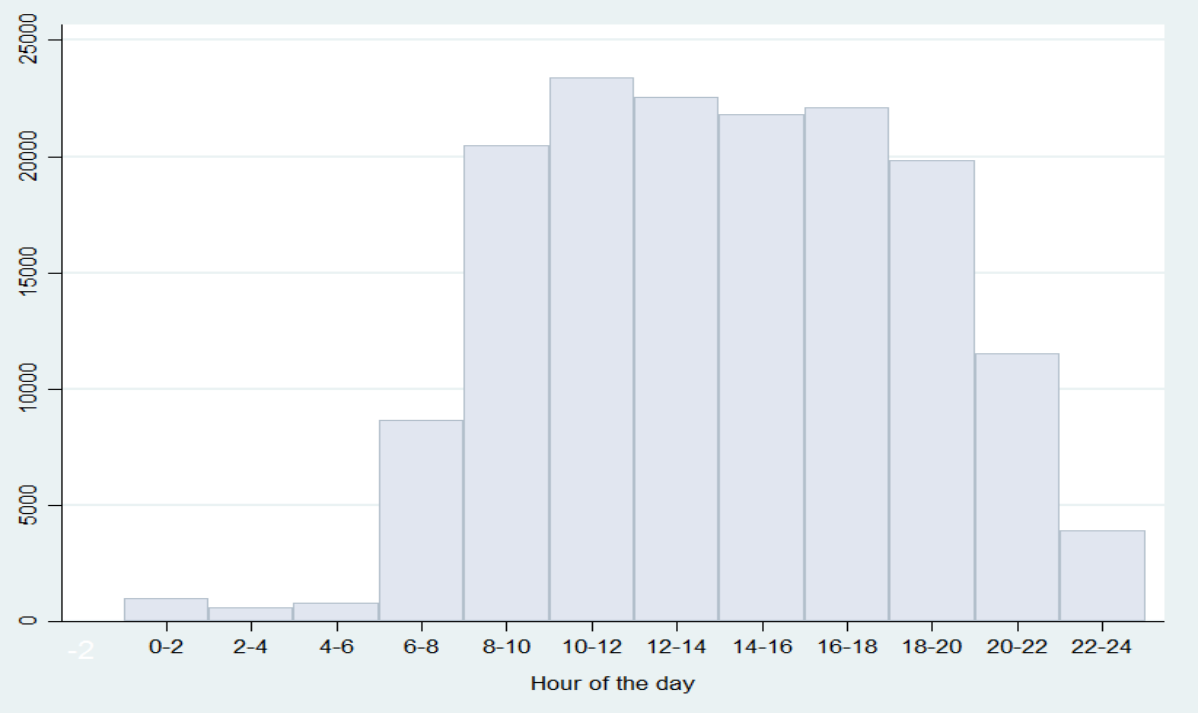
Before digging into the analysis, some **premises** are in order:

a. The households wore trackers voluntarily and without any incentive. Therefore, we should treat the following data on utilization as referring to individuals who accepted to wear the tracker. It is important to recall that a 10% share of eligible households outright refused to wear the loggers. Should the trackers be used at a large scale, it could be verified that the socio-demographic characteristics of people who refuse to wear them are not significantly different from the rest.

b. The pilot was conducted in the summer, when children do not go to school. It is difficult to assess to what extent this may have influenced tracker use among children. Parents may be more reticent to allow children to be tracked when they are skipping school (especially to work in the fields). Should the trackers be used at a large scale with children, it would be important to conduct a pilot during school time to observe whether children and parent behaviors towards the trackers may be different.

How is utilization of GPS trackers measured?

Figure 1. GPS tracker usage by hour intervals. Y axis represents the sum of waypoints for all individuals, throughout the tracking period (1-28 August 2017).



Once activated and in motion, the device logs GPS waypoints[1] at regular intervals of 2.5 minutes. If the device is not in motion (i.e. the person is not wearing it), it enters sleep mode and stop logging waypoints. As soon as it detects any movements, the device automatically activates and restart recording GPS data. Of course, logging only occurs when

[1] A waypoint is a pair of GPS coordinates (longitude, latitude) identifying a point on the earth. Each waypoint is associated to information on the time, date and speed at which it was recorded. The combination of these elements constitutes what we here call a “datapoint”.

the device successfully detects satellite signals. Individuals were asked to wear trackers at all time except when sleeping, showering or when there is a risk of damaging the device (e.g. wearing it in the rain).

Against this backdrop, we use two complementary methods for measuring tracker use:

a. The number of waypoints logged by individuals throughout the tracking period, which gives an overall idea of aggregate usage.
b. The time (hours and minutes) of *continuous* utilization of trackers in a day. This way of measuring takes into account consecutive waypoints that are logged at less than 5 minutes difference one another. In other words, if the elapsed time between two datapoints is higher than 5 minutes those two waypoints are discarded and so is the related using time. Unlike the first measure, this metrics aims at giving a sense of whether individuals wore trackers continuously during an average day.

Figure 1 shows tracker utilization by time slot – the Y axis measures the count of waypoints across all individuals, throughout the tracking period. Peak usage is between 8am and 20pm. In compliance with the instructions given to participants, usage at early morning and during the night drops significantly.

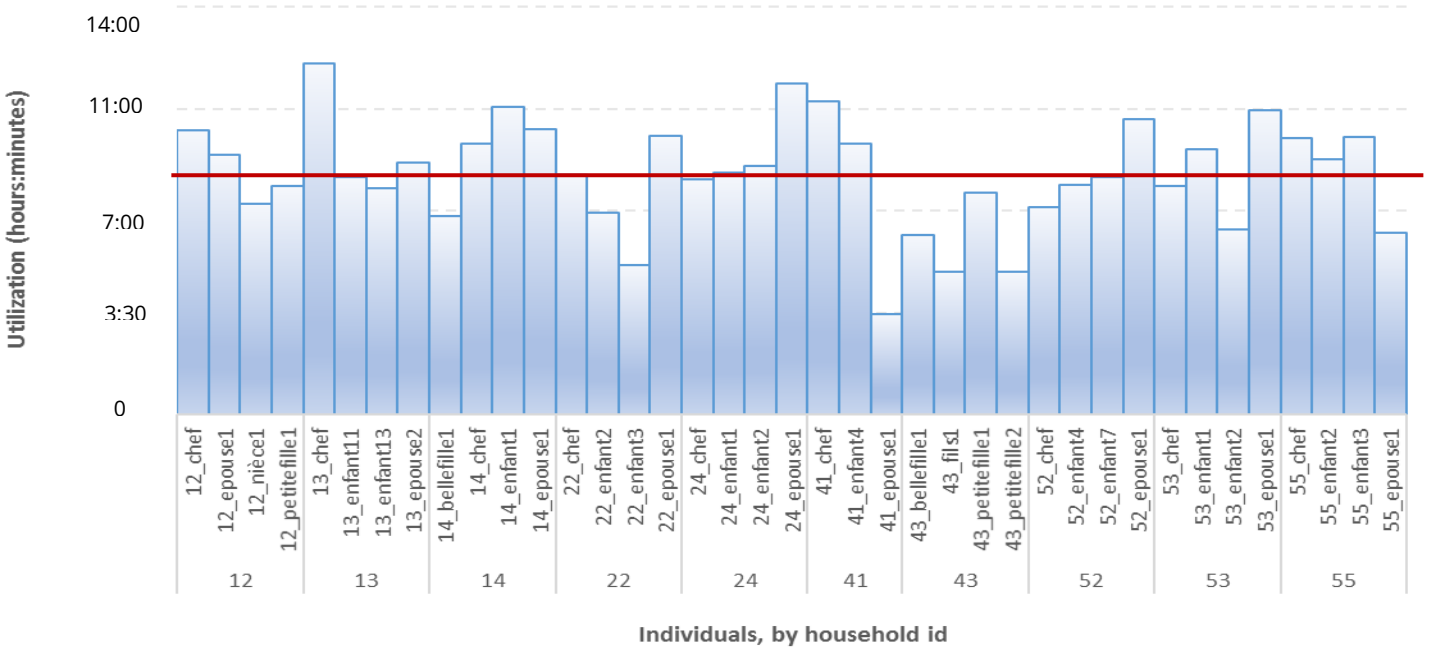
This section is structured as follows: first, it looks at how utilization is distributed across individuals (section 8.1); then across and within households (8.2); and it finally analyzes how usage has varied over-time (8.3).

Across-individual utilization

The average number of waypoints per individual throughout the tracking period is 4,015, or 143.4 per individual per day. In terms of variability, the standard deviation across individuals stands at 1,591. With a coefficient of variation of 0.39, **variability in tracker use can be considered as moderate.**

In terms of continuous tracking, **individuals wore GPS trackers for an average time of 8 hours 28 minutes each day.** Because of the definition of continuous use, this is an encouraging indication. Standard deviation across all individuals is of almost 2 hours, signaling that **in terms of continuous utilization, variation is more important**. Figure 2 offers a more visual representation of the distribution of tracker use across individuals, in terms of usage time.

Figure 2. Distribution of tracker utilization across individuals, by household code. Y axis reports no. of waypoints logged throughout the tracking period (1-28 August 2016). The horizontal red line represents the mean of waypoints (4,015).



Finally, it is worth exploring utilization *across age groups*. **Adults were more disciplined in wearing the trackers**: on average, they wore trackers for a daily use time of 8 hours and 51 minutes (across the tracking period), whilst children stand at 8 hours 3 minutes.

Similarly, adults score higher in terms of number of waypoints logged – adults have an average of 4,473 waypoints per person, children score 3,533.

This preliminary finding suggests that, despite the child-friendly tracker supports, children may need additional assistance, regular reminders and incentives to maximize use throughout the tracking period.

Within- and cross-household utilization

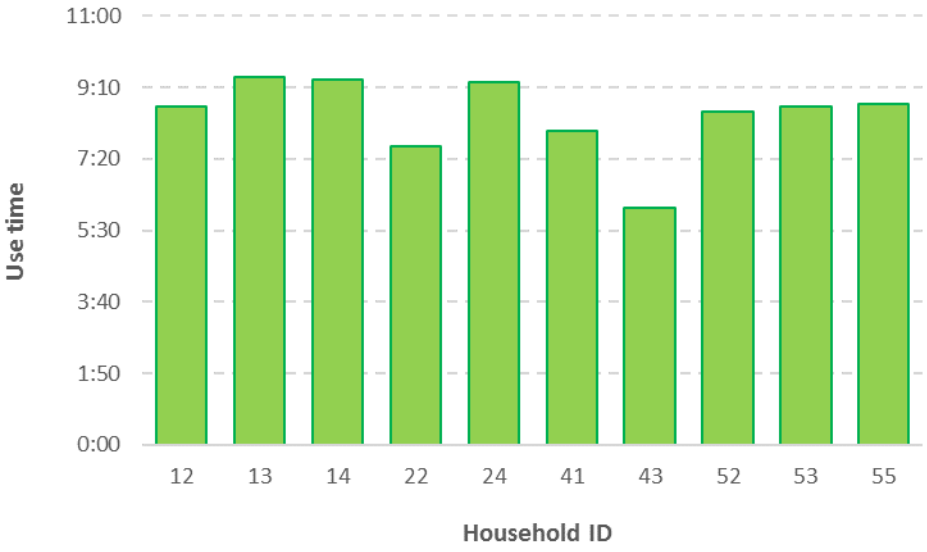


Figure 3 offers indications about how tracker use is distributed *across households*. Household # 13, the one that used trackers more systematically of all, scored 9 hours and 25 minutes per day across the tracking period. Household # 43, the least-disciplined in wearing trackers, totaled approximately 6 hours per day.

Figure 3. Average utilization across households, throughout tracking period, as measured by number of waypoints logged.

The cross-household standard deviation is of 1 hour of tracker use per day.

Figure 4 Within-household average utilization, standard deviation and coefficient of variation. The coefficient of variation is plotted against the secondary axis on the right-hand side of the chart.

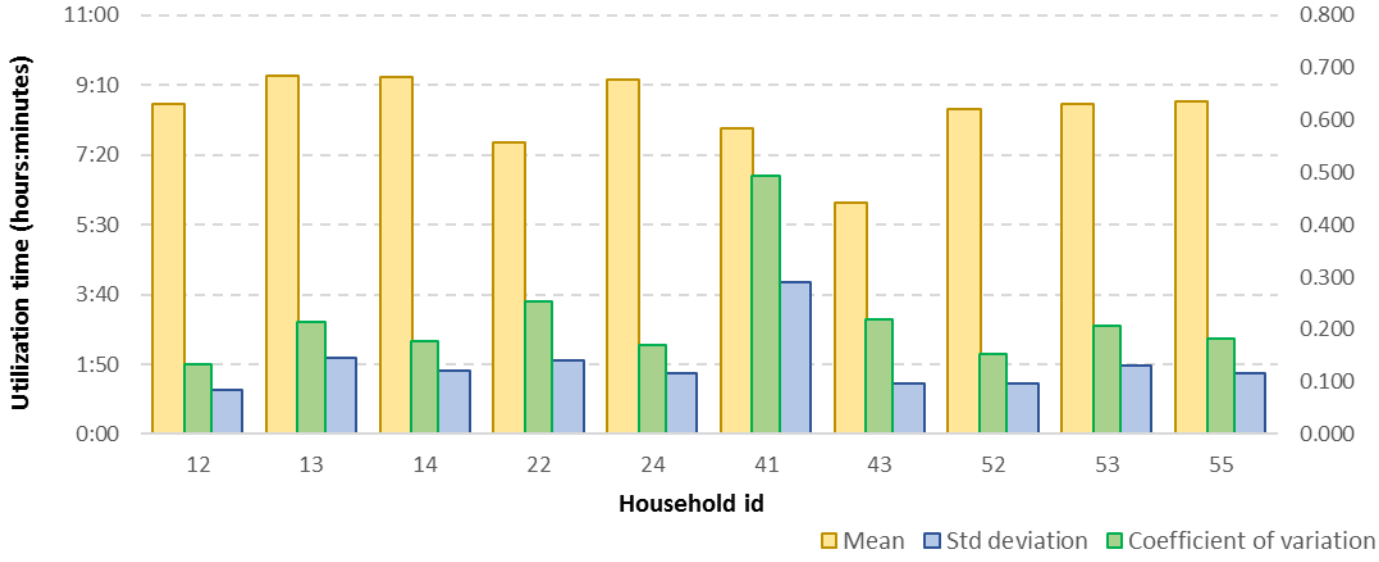


Figure 4 complements this information, by representing within-household average GPS utilization and variability, as measured by within-household standard deviation and coefficient of variation. Within-household standard deviation is higher than across-household standard deviation (1 hour 50 minutes vs. 1 hour).

The coefficient of variation, which is the ratio of standard deviation and mean, ranges from 0.13 to 0.49.

Utilization trends over-time

One aspect that appears important to be tested is whether utilization rates have remained constant or have instead dropped over-time, in order to test for user's fatigue after a certain number of weeks of utilization, or, conversely, for users becoming accustomed to wearing the trackers. The following two graphs shed some suggestive evidence over these two hypotheses.

Figure 5. Utilization over-time, by age group.

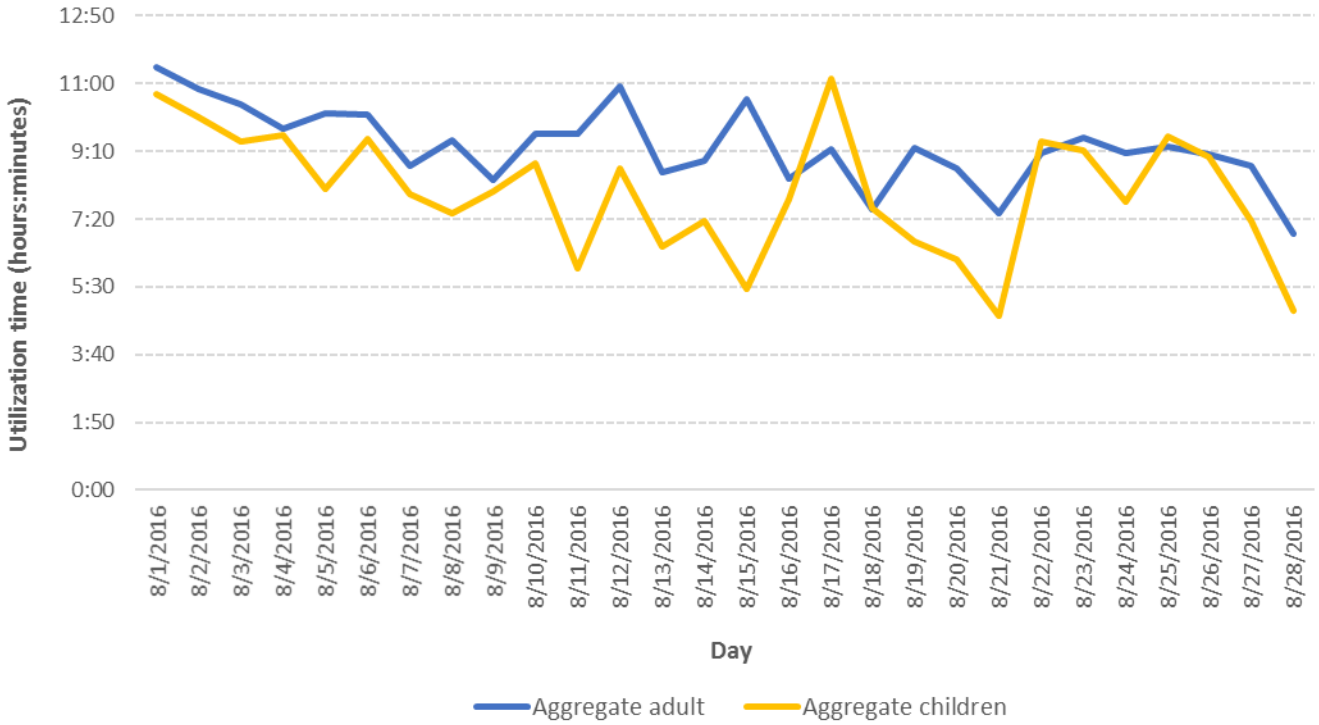


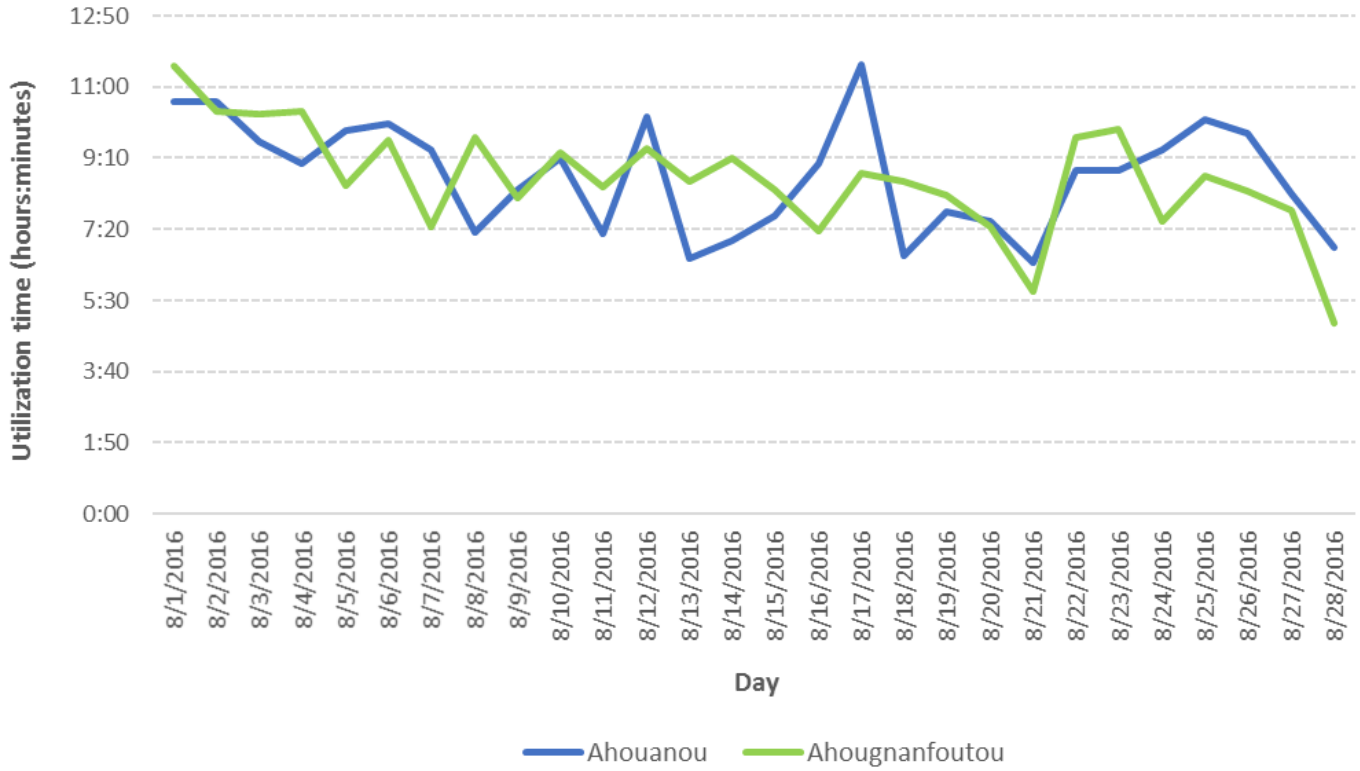
Figure 5 shows how utilization has evolved over the 4 weeks of tracking, across adults and children. **Overall, a decrease in use can be detected, both among adults and children, over-time.**

It can also be observed that the trend follows a rather irregular pattern, with frequent peaks and lows. In addition, because there seems to be a certain correlation in utilization between adults and children (the correlation coefficient stands at 0.74 when using no. of waypoints, and at 0.56 when using time), these peaks and lows may not be just random, but due to some specific activities or periodic events (such as the anticipation of a visit from the community agent) that affect tracker use. Comparing tracker data with activity logs may shed further light onto the sources of this trend.

Figure 6 plots utilization of the devices over-time, this time by village. **A progressive decrease in usage has occurred in both villages.** Moderate correlation in utilization rates across villages can be detected.

To sum up, utilization of the GPS devices has slightly dropped over the course of the 4 weeks of tracking, suggesting that the user's fatigue hypothesis may prevail. Children, in addition, appear to have consistently used the trackers relatively less than adults, pointing towards the need of providing extra support to younger users. Finally, correlation in use across age groups (adults v. children) and villages indicates that there may be some periodic activities and/or events that consistently affect use of trackers.

Figure 6 Utilization over-time, by village.



Summary of initial findings and lessons learnt

Key initial findings can be summarized as follows:

- Data shows satisfying utilization rates in the time slots during which individuals were asked to wear trackers.
- Individuals wore GPS trackers for an average time of 8 hours 28 minutes each day.
- Variability in tracker utilization exists, especially with measures of utilization emphasizing continuity in wearing the device. Over the tracking period, the dispersion around the mean across individuals almost reached 2 hours.
- Adults have been more disciplined than children in wearing trackers.
- Tracker use has decreased *over-time*, in both villages and across age groups (adults and children).
- Over-time trends also follow a rather irregular pattern, with peaks and lows. Interestingly, this pattern appears to be synced across age groups and, to a lesser extent, across villages.

Overall, data provides encouraging indications as to individuals' openness about wearing trackers. The main challenge will be to ensure utilization more regularly throughout the monitoring period. Community agents were surely of help in this respect, but more child-tailored support may be needed.

Some **practical recommendations** to achieve that purpose may be to:

- Consider some form of incentive to increase utilization, for instance a small prize for the top-5 children who wore trackers most regularly.
- Involve teachers in monitoring utilization – at least for children who go to school (more regularly).
- Continue offering child-friendly support, such as those piloted, including armband with cartoon heroes and football characters (especially for boys). Must be adapted to children's gender too.
- Replicate the experience with community agents, who have been useful not only in monitoring utilization on an ongoing basis but also to build confidence between the researchers and the host-communities.

Box 1. Mapping of GPS data points – some practical examples

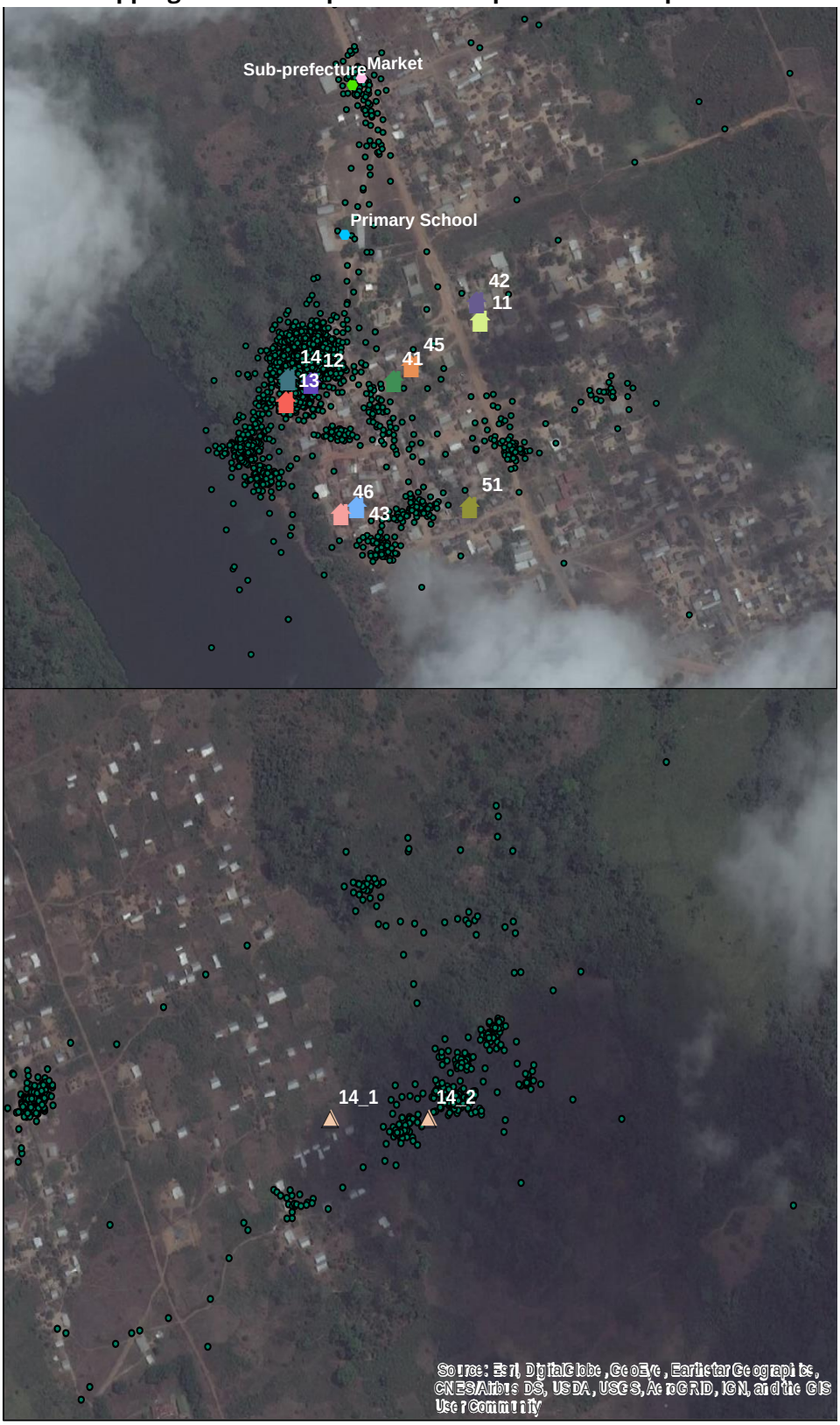


Figure on top. Example of mapping of tracker data, against key locations of interest. The tracker data, visualized as green dots, refers to one individual; the map also shows some locations of interest such as the primary school, the market and the sub-prefecture, as well as all neighboring houses. Houses are denoted with a colored house symbol and labelled with the respective household code.

Figure on the bottom. Tracker data and plots. The map shows tracker data (green dots) against two plots, symbolized as pyramids and labelled with the household code and the plot number. As it can be seen from the image, plot # 14_2 seems to be accurate as there seems to be some density of waypoints around its perimeter; however, the same does not hold true for plot # 14_1. This may be due to error measurement or to the fact the individual has not work on this specific plot during the tracking period.

The matching of GPS data of locations of interest, the paths taken by individuals, activity log data and survey data – which allows the analysis that is presented in section 9 of the main report – has been done through STATA, a data analysis and statistical package. Ad hoc STATA .do-file [2] have been written and can be made available upon request.

[2] Do-files contain an orderly list of commands to be performed by STATA, based on one or more datasets of interest. Using do-files allows to make data analysis reproducible by anyone who owns the dataset, in the interest of research transparency.

2. Activity log utilization

In principle, IPA asked individuals to fill in activity logs on a daily basis. Community agents' role, in addition, was to ensure this regularity. However, it was anticipated that actual utilization may not be as regular as envisaged.

This section explores activity logs utilization across individuals, gender-age groups and over-time. It replicates the same exercise done for utilization rates of GPS trackers.

How is utilization measured?

The approach chosen to measure activity log utilization is to consider that an individual effectively used the log if at least one activity was ticked in correspondence to each of the three sections of the day in which the log is divided (i.e. morning, afternoon and evening). This would give indications on whether the individual has taken the time to log its activities *throughout* the day.

The utilization rate, as per our definition, is likely to under-estimate real utilization: not all domestic or leisure activities can be listed in the journal. For instance, if the individual has rested all morning without carrying out any task, this would appear as though the person has not filled in the log in the morning. For this reason, this approach should be seen as **a very conservative way of measuring utilization**; figures may understate actual utilization.

Results

Table 1. Activity logs utilization rate, aggregate and by gender-age group. N=39. Period: 1-28 August 2016.

Gender-age group	Utilization rate
Adult men	67%
Adult women	57%
Total adults	62%
Boys	39%
Girls	54%
Total children	47%
Men	53%
Women	56%
Total	54%

The average utilization rate across the period has been 54%. The apparently modest take up can be explained by how utilization is defined, as stated above. As a matter of fact, if we drop the condition that at least one activity must be ticked in the evening (when less productive and domestic tasks are undertaken), the utilization rate rises from 54% to over 80% (across all individuals and for the whole tracking period). That said, the 54% figure **may raise concerns about the regularity at which activity logs were filled in throughout a typical day**.

As shown in Table 1, **boys (below or equal 15 years old) were by far the weakest performers**, whilst adult men were the most regular. Utilization among girls (below or equal 15 years old) was in line with the aggregate average.

Women used on average the logs more than men – although this result is mostly driven by boys' low track record.

Analyzing utilization rates *over-time* also highlights interesting patterns (see Figure 7 and 8):

- **Utilization appears to have decreased over time**, both across gender groups (men and women) and across age groups (children and adults) – a trend that was observed for trackers as well;
- The correlation among children and adult and between men and women is modest (correlation coefficient stands at 0.32);
- For adults and children there was a low in usage in correspondence to day 4 and 5 respectively;
- Across all groups, **utilization was quite bumpy**, suggesting highs and lows in use. This was another trend that was observed in tracker use.

Figure 7. Activity logs utilization rate over time and by age group. N=39.

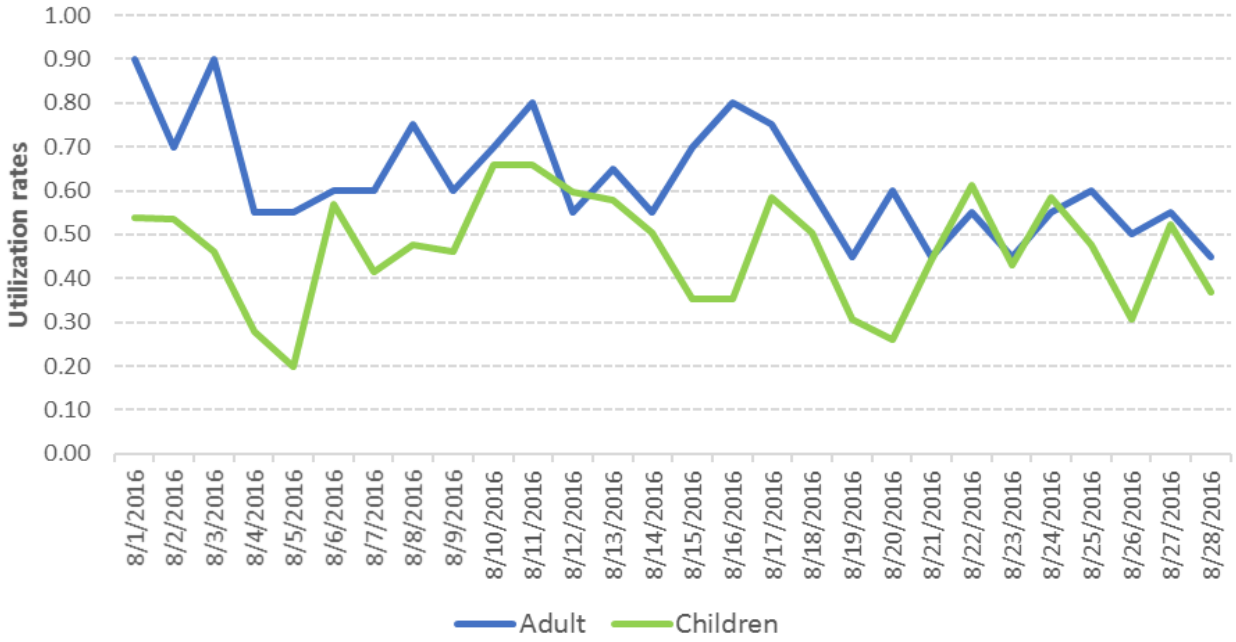


Figure 8. Activity logs utilization rate over time and by gender. N=39.