Powering Education Project
Phase II

Final Report

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1. Introduction

The hidden crisis of energy poverty currently affects more than 1.2 billion people worldwide – 93 million of these are school-age children living in the rural areas of Sub-Saharan Africa.

Powering Education is one of the first attempts to draw a link between access to energy and access to education. By coupling the diffusion of solar lamps with rigorous impact assessment studies, the project explores whether the availability of clean energy sources affects students' performance as well as household economics and social development.

The first one-year project – **Powering Education Phase I** – was jointly developed and implemented in rural Kenya with **GIVEWATTS**, a non-governmental organization that offers renewable energy solutions to off-grid communities in developing countries, and **Enel Foundation**, a non-profit organization promoted and fully supported by Enel Group. Launched in cooperation with the **World Economic Forum** Global Shapers Hubs of Rome and Nairobi, the project has been awarded first prize and the acceleration grant of the 'Shaping a Better Future Challenge' by **The Coca-Cola Company**.

The second phase of the project – **Powering Education Phase II** – extended the target of the analysis in terms of number of schools and covered a broader research scope that for the first time includes the household context in addition to the education dimension. Along with the grant from The Coca-Cola Company and the renewed collaboration with Enel Foundation, this second phase has been supported by **Enel Green Power** and by the **Private Enterprise Development in Low-Income Countries (PEDL)**, a research initiative of the **Centre for Economic Policy Research (CEPR)** and the **Department For International Development (DFID)**.

Powering Education represents the main project so far of Powering Impact, an initiative designed and developed in cooperation with GIVEWATTS. By leveraging the power of data, analytics and technology to tackle pressing social issues, Powering Impact aims at delivering innovative solutions to key stakeholders across business, governments, and civil society.

2. Powering Education Phase I

Powering Education Phase I was rolled out between September 2013 and September 2014 and consisted of a 12-month study exploring the linkage between access to clean energy sources and education. It was based on a Randomized Controlled Trial (RCT) model designed and managed by the project's Research Team.

2.1 Description

Powering Education Phase I entailed the distribution of approximately **300 solar lamps to 300 students** located in **12 schools** in rural and off-grid communities in Kenya. By replacing dangerous, expensive and heavily polluting kerosene lamps, solar lamps enable children to study longer and their families to save money. The distribution of the lamps sets the context for a structured assessment of their impact on the students' performance. The Research Team carried out a total of four surveys throughout the project's life cycle, and was able to closely monitor improvements in students' performance as well as broader effects of the replacement of kerosene lanterns with solar lamps.

2.2. Results

Results showed that, on average, a student that does not own a solar lamp performs significantly better if s/he is in a class where most students own lamps (**positive spillover**). The project also revealed that students owning a lamp tend to spend more time studying at home, with an average increase in study time of 17%. Besides, results of the analysis conducted at household level showed that families whose kids had been given a solar lamp have been able to reduce their expenses, cutting their weekly lighting bills by 10-15%. Follow-up research conducted on the ground by our Team showed that families allotted a significant portion of their increased savings to other household needs, such as better sanitation facilities.

Figure 2.1 Powering Education I, Results.

3. Second Phase

Powering Education Phase II focuses on the link between access to light and educational outcomes. This is a follow-up project that builds on Hassan and Lucchino (2014) who showed a positive intention to treat and spillover effects of solar lamps on grades. The current project scales up the original one by extending the sample size and changing the randomisation structure.

Furthermore, this project aims to provide new evidence on the important question of whether interventions such as access to light, which relax constraints in relation to the number of productive hours available, can stimulate the emergence of currently pent-up productive potential, particularly of women. In doing so, it also speaks to the broader question of whether access to lighting can help initiate similar, if much more modest, **socio-economic transformations** as those that come along with large scale electrification.

The constraint on **productive hours** is particularly relevant to women, who overwhelmingly carry the burden of having to fit housework into the time available to them (World Bank, 2012). Ironically, an important fraction of daylight hours are often devoted to collecting firewood or sourcing kerosene to ensure some basic level of lighting during the hours of dark, thereby further reducing the time available for other uses.

Similarly, necessary but less productive activities typically relegated to women, such as cooking or cleaning the house, may crowd-out more remunerative uses of this limited time remaining.

Therefore, we dedicated considerable attention to **time use** (and indirectly labour supply and employment) effects. Specifically, we tried to identify whether there were changes in the allocation of activities across the times of day. To the extent that the productivity or effectiveness of a task depends on the time of day it is carried out, '**task-shifting**' may have economic consequences even in the absence of changes in total time use.

Figure 3.1 Kisii County, Kenya. Survey operations.

4. Project Context

The project aims to understand and quantify the impact determined by access to modern forms of lighting compared to traditional fuels (such as kerosene), or indeed no lighting at all.
This requires identifying a target area exhibiting both low penetration of the electricity grid and limited presence of off-grid energy providers.

We identified the **Kisii County** located in South-Western Kenya as a candidate region for the project.

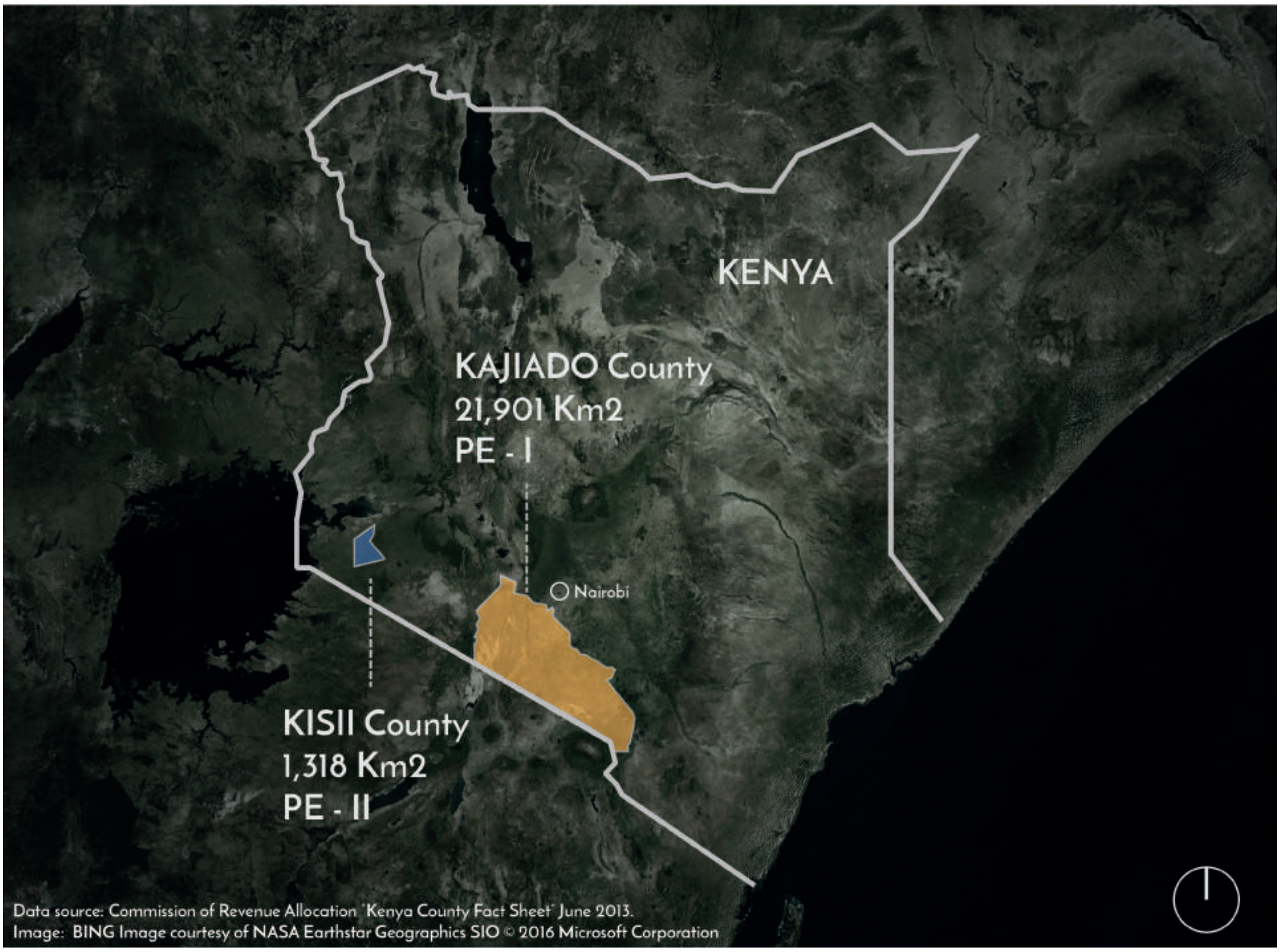

Figure 4.1 Kisii County, Kenya. Location.

Compared with **Kajiado County** (the location of Powering Education Phase I), **Kisii County** has a larger total population and a substantially higher population density (874, 3 people/Km2), with a direct impact on the electrification processes. Moreover, the new area is undergoing a remarkable development process especially in the agriculture sector and in the growth of local micro-businesses, representing a very interesting environment from a research standpoint.

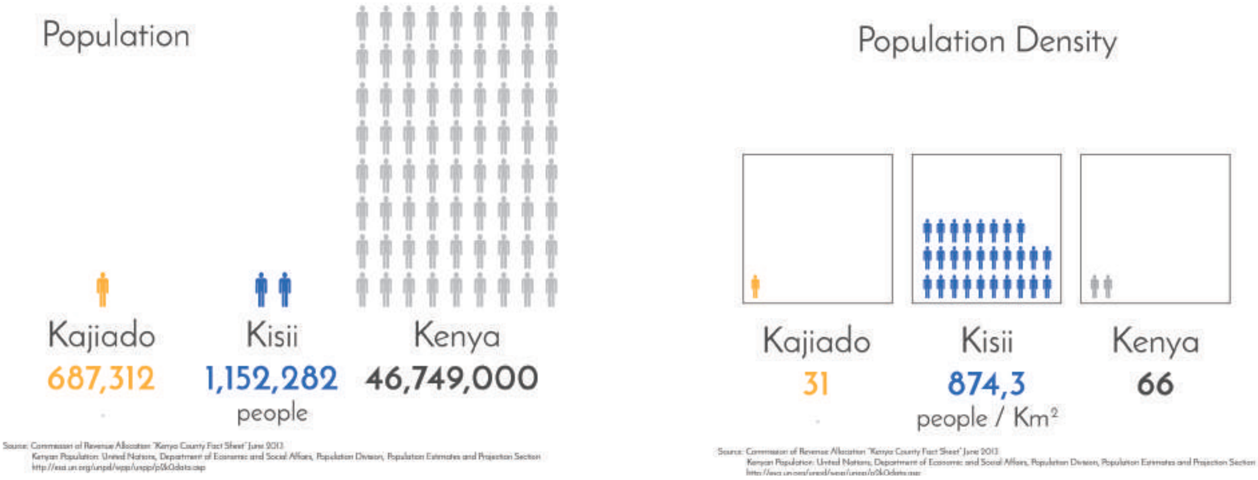

Figure 4.2 Kisii County, Population and population density data.

Figure 4.3 Kisii County, Kenya. Landscape.

More specifically, the county has a low electrification rate and it represents an optimal location to assess energy and education related issues on multiple levels, from small lighting systems up to home systems and mini-grids.

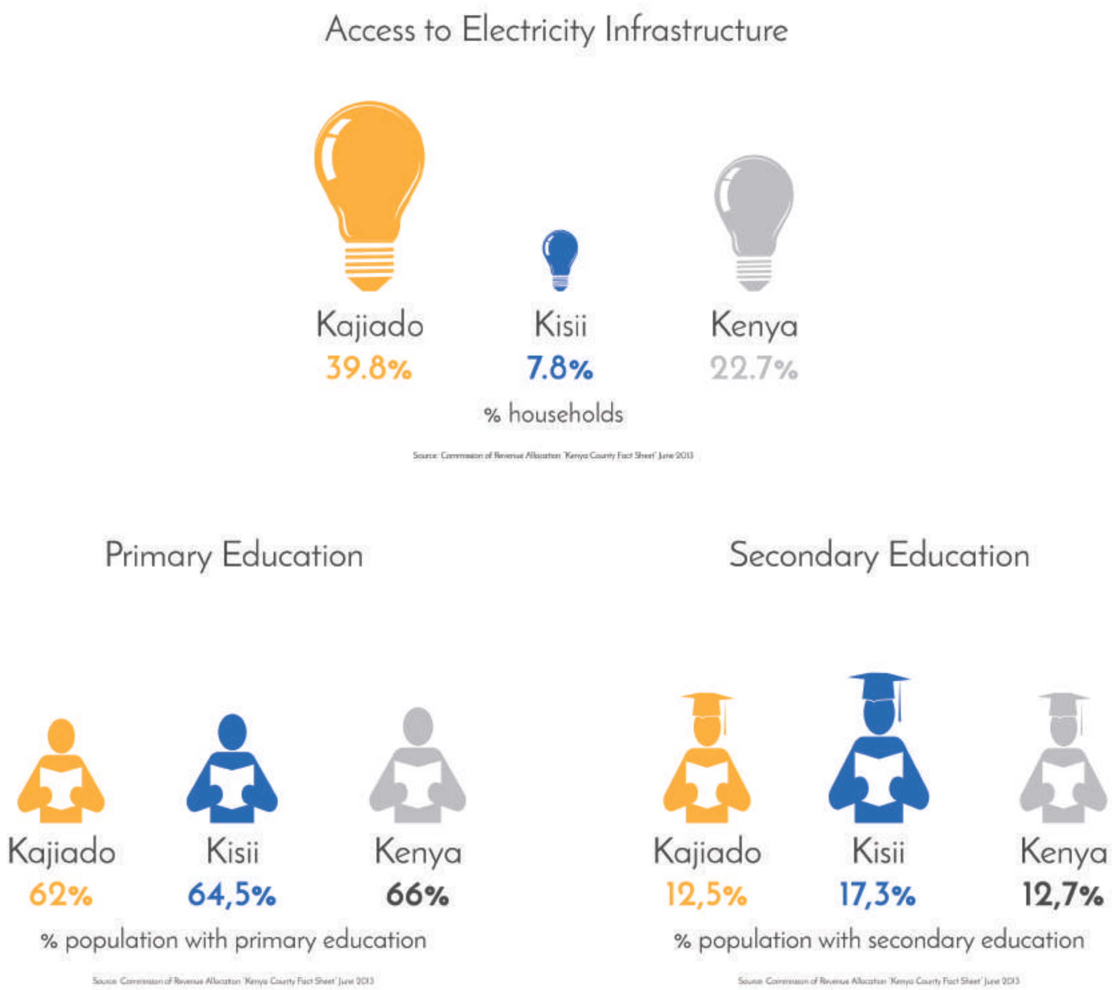

Figure 4.3 Kisii County, energy access and education data.

The Kisii county is divided into 5 districts, and within 3 of these (Gucha, Gucha South and Masaba) more than 95% of the population is reported as lacking access to electricity in the Kenya Population and Housing Census 2009. We complement this information with satellite night light data, which offers a more up-to-date snapshot of energy access in the region as well as accurate measurement of light intensity for areas as small as 1 square kilometre.

We identify **Gucha South** as the district with the lowest current levels of electricity assess. A striking feature of the project area is also its geographical and socio-economic homogeneity.

5. School Selection and Randomization

In the target region, we identified **85 target schools**.
As a first step, 84 out of the 85 schools selected in our sample agreed to sign an Engagement Letter expressing their willingness to participate, regardless of their future treatment assignment.
We used satellite night data to restrict our sample of schools to those in areas without access to light. Specifically, we dropped 3 out of 85 schools located within a 1 square kilometre grid unit with a light intensity score higher than zero (i.e. the lowest level).
We used pupil grades on national examinations from previous years to proxy for the quality of schools, and we successfully matched these data to 74 out of the 85 target schools using the Kenya National Examinations Council (KNEC) unique identifier.
Finally, we calculated distances from the school to the closest road and to population centres as proxies for access to markets and overall levels of economic activity.
The above data collection and school filtering resulted in 72 eligible schools with full data out of the original 85 schools invited to participate in the project.
We used this dataset to conduct our cluster level randomisation.
Importantly however, power calculations suggested that including more than 60 schools did not deliver gains in statistical precision justifying the additional cost. Therefore, we ultimately decided to work with a random subset of **60 schools** out of the 72 schools with complete data.

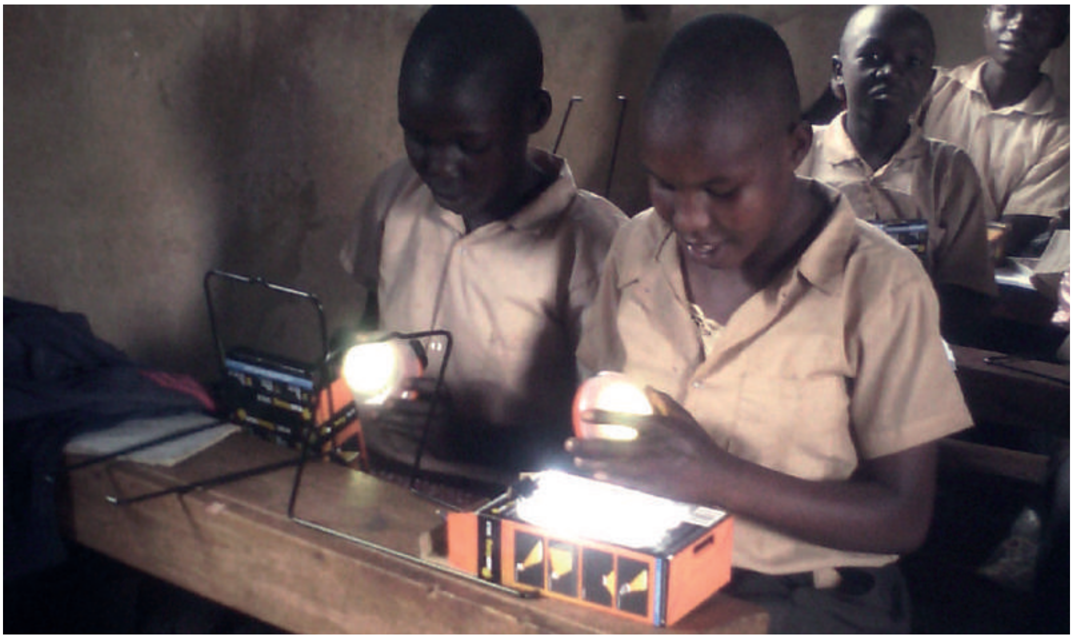

Figure 5.1 School in Kisii County, lamps distribution.

5.1 Randomization Approach

The experiment was based on a **hybrid of school-level and individual-level randomization**, reflecting recent innovation in the randomization literature (Baird et al 2014).
Based on this randomised design, the treatment was randomised across schools, such that we assigned some schools to a pure control group, some to a pure treatment group and some to a mixed combination of treated and control students, with three groups defined as follows:
#1 - Students of the first group of schools all received a lamp and constituted a "treatment group at full saturation".
#2 - Students of the second group of schools did not receive the lamp at all, and constituted the "pure control group".
#3 - Half of students in the third group of schools received a lamp and the other half did not. These constituted, respectively, the "treatment and control groups at partial saturation".

This scheme allowed to **measure both the effect of the solar lamps** on those pupils who received one, **as well as the spillover effect** on those who did not but whose classmates did.

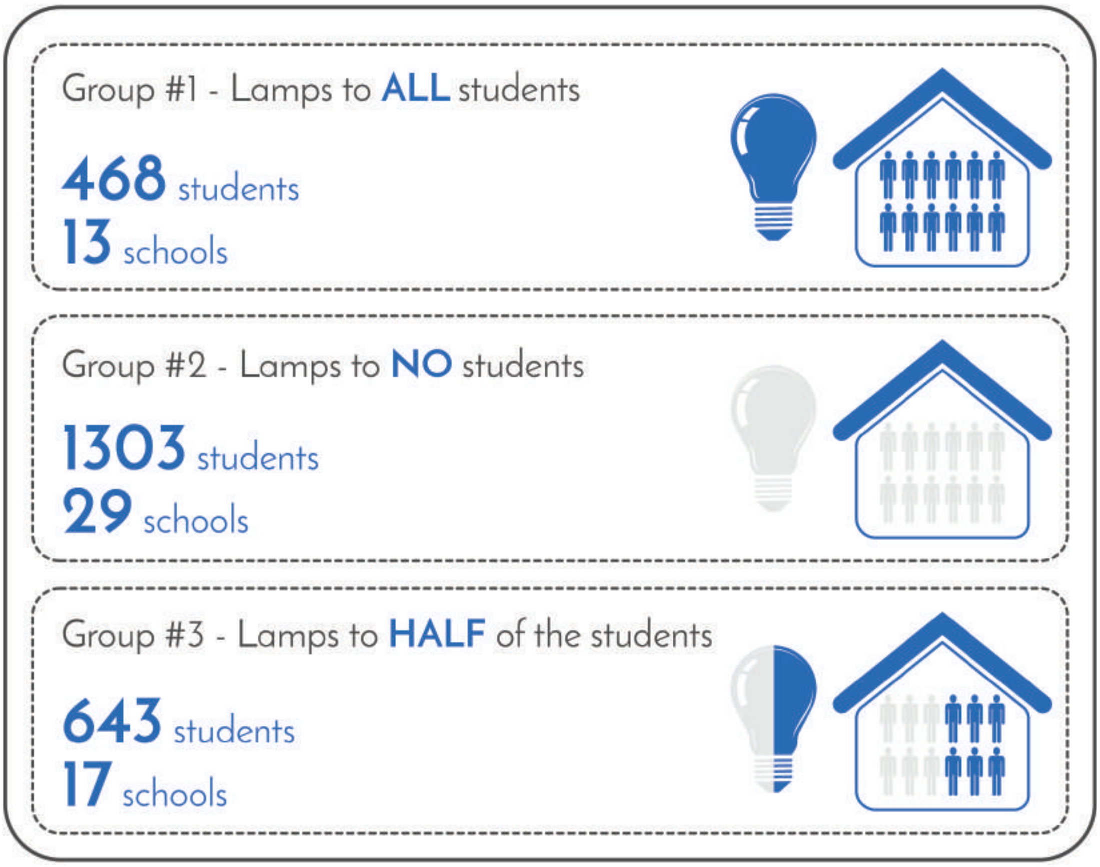

Figure 5.2 Randomized Controlled Trial

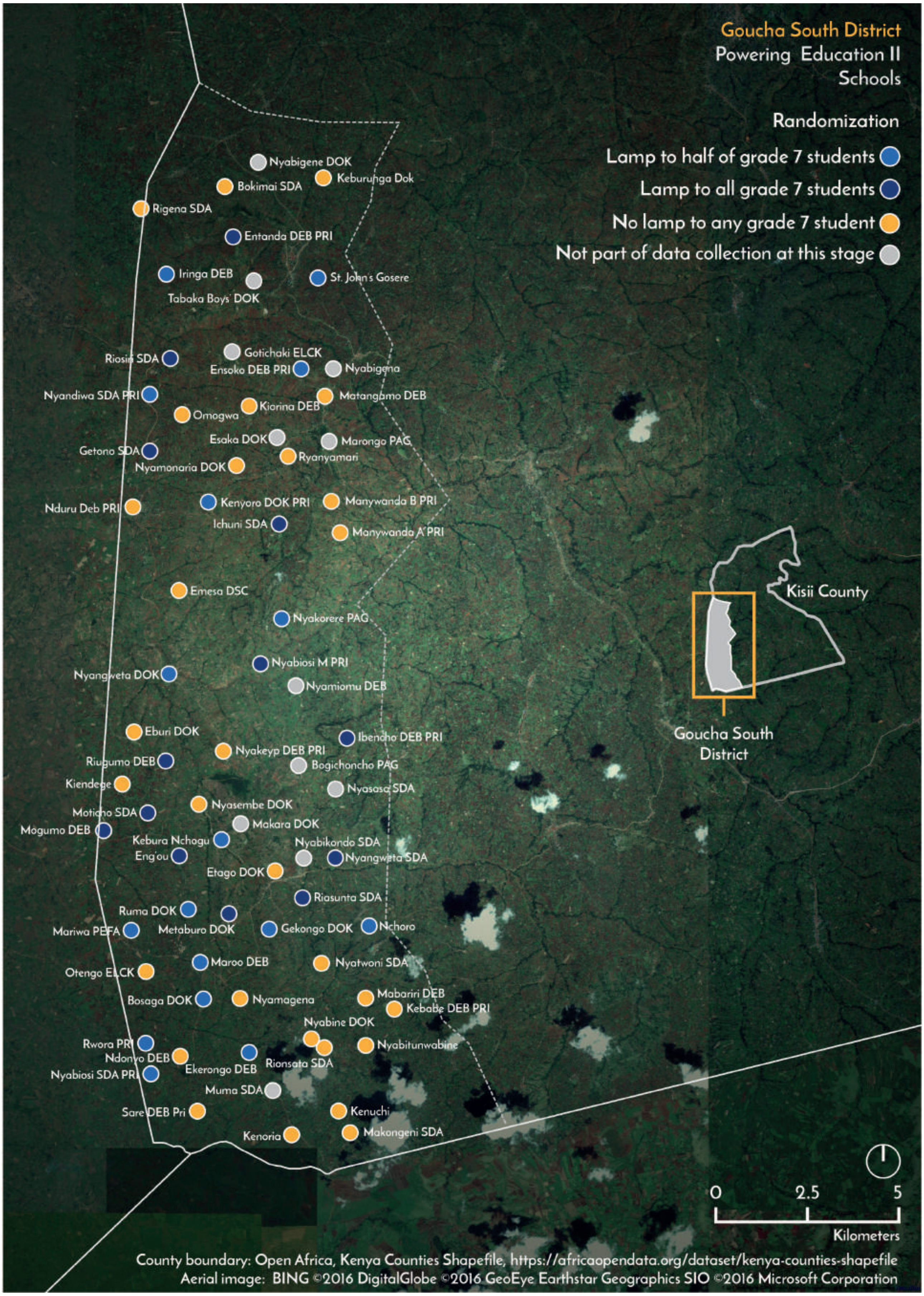

Figure 5.3 Kisii County - PE II Schools Randomization

6. Operations

The sampling frame was the population of **2,229 7th grade students** across the **60 schools** in the Gucha South district in Kenya.

Drawing on this frame, we carried out three **data collection** efforts relevant to this report:

- A **paper-based collection of mobile phone numbers** targeting the parents of all 2,229 students. This operation identified 1,292 unique phone numbers relating to 1,375 students.
- A **tablet-assisted face-to-face survey** targeting a 55% random sample of 1,181 students selected from the 2,159 we had full baseline data for. The sampling was stratified by school, treatment assignment, gender and high and low baseline math grades. This operation was conducted in January 2016 and reached 876 students (a response rate of 74%).
- A **geographical mapping** of the homesteads targeting all 2,229 students, which was able to successfully identify the homes of 1775 (80%) of the students. The mapping was conducted in February 2016, recording residential locations at May 2015.

Drawing on the sample of **806 parents** who offered their contact details, we carried out two main data collection operations:

- A single wave of **computer assisted telephone survey** targeting all 1,292 unique mobile numbers, which was able to obtain full responses for 806 adults (a 62% response rate). This operation was conducted during November and December 2015
- A repeated experiential sampling time use survey of the the 1,292 unique mobile numbers using **interactive voice response calls**, conducted at random times of day over the 17 Tuesdays or Thursdays over the period between the 4th February 2016 and 31st March 2016 inclusive. The calls successfully got through to the respondent in 55% of cases, and 23% of these respondents completed at least part of the survey. A total of 2,817 person-time observations were collected. The average number of entries per person was 2.18

Figure 6.1 PE II Students

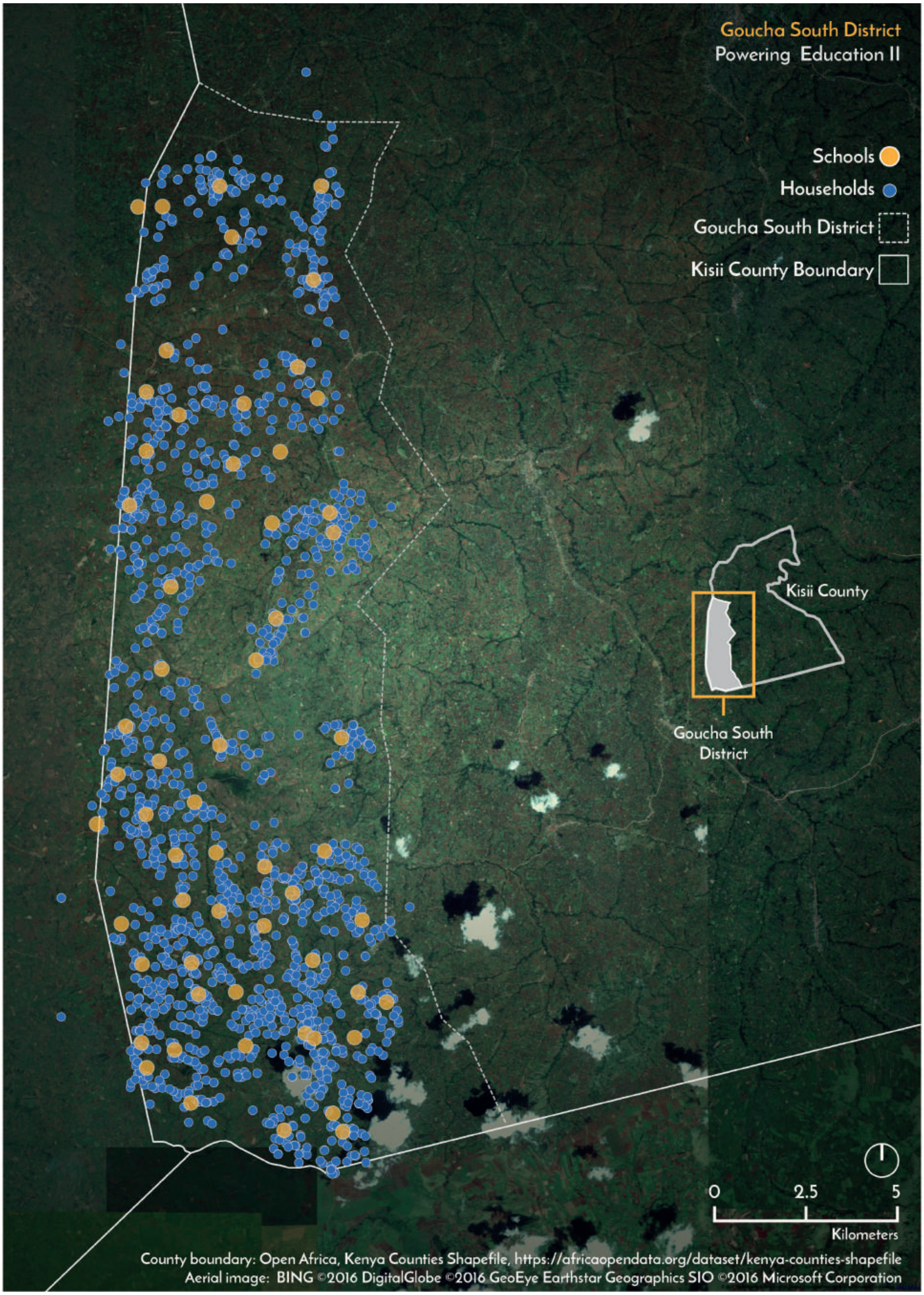

Figure 5.4 Kisii County - PE II Schools and Households positions based on PE II team geographical mapping data

We also conducted a **field visit in November 2015** aimed at gaining a qualitative understanding of the project context and refining our theory of change ahead of the preparation of the survey instruments and operations. This was also an occasion to run some cognitive testing of survey questions. During the fieldwork, we interviewed 13 families, 6 from the control group and 7 from the treatment group. We interviewed 4 fathers, 7 mothers, 2 step-parents, and had an impromptu focus group with a group of mothers (some of whom where project participants) while they were selling vegetables on the side of the road.

Figure 6.2 PE II surveyor interviewing a student

The team distributed a total number of **784 lamps (Sun King™ Solo from Greenlight Planet)** in May 2015. Individual students in schools at the partial treatment saturation were randomly assigned to receive lamps using a public lottery, stratified by gender.
Very high compliance was observed throughout the entire project.
In more than 94% of cases, the solar charge of the lamp was sufficient for the activities they wanted to use it for. In terms of lamps' appropriation, in more than 90% of cases the lamp stayed at home during the night; in four cases it stayed at school; in three cases at some other students' house; and for the remaining 10% of cases in some other unreported location.
Finally, 98% of respondents used the lamp mostly for studying; whereas, 38% of respondents declared to use the lamp also for working at home.

6.1 Project Program

The project spans over 18 months, from December 2014 through June 2016, as indicated in the project program.

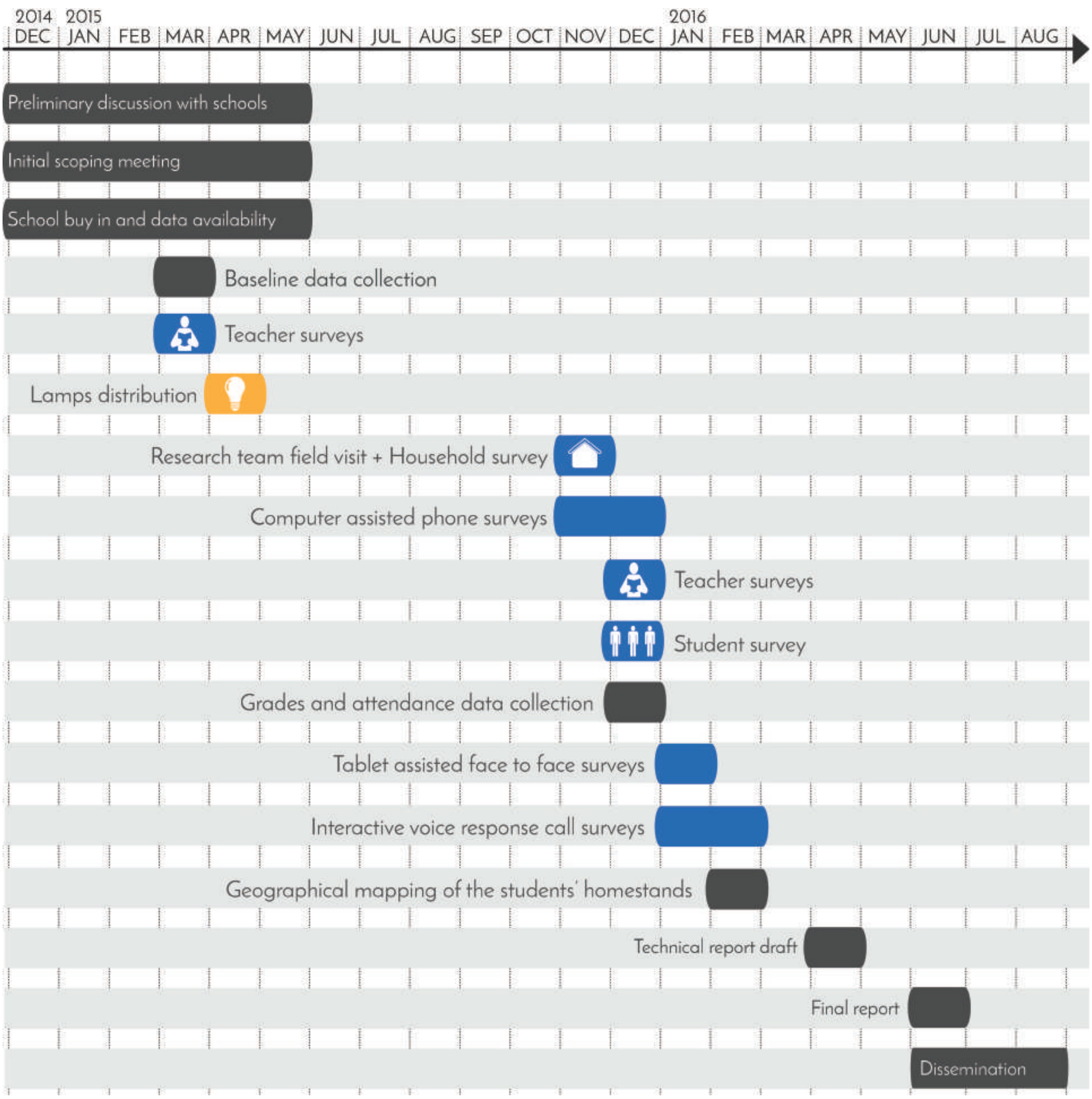

Figure 6.3 Powering Education Phase II program.

7. Results

7.1 Effects on Education

The results of this study confirrm the positive effect that lamps have on education that were highlighted also in Hassan and Lucchino (2014). It is very important that such result is confirmed also in a different setting compared to the initial study. This certainly increases the external validity of the impact of solar lighting on education. **Our overall assessment is that the two studies confirm that solar lamps can be an effective and significant tool to improve educational outcomes of pupils in off-grid areas**. However, solar lamps should not be seen as substitute for electrification, but as a short-term practical solution to limit the drawbacks on human capital accumulation coming from the lack of electricity.

7.1.1 Grades

Overall, we find a positive and significant treatment effect, such that students with the lamp see their grades in mathematics increase by about four points.
We also find a positive spillover effect of about 2 points on the grades of students that did not receive the lamp, but were in a class where 50% of pupils did. However, this spillover effect although positive is not statistically significant.

Figure 7.1 Powering Education II surveyor reviewing students' grades

The lack of significant spillover evidence contrasts with our previous findings in Hassan and Lucchino (2014). This should not necessarily be seen as an inconsistency, as the geographical and cultural settings of the two experiments are different. Indeed, these heterogenous results shed some light on the external validity of spillover effects and what is needed to make them materialize. In this setting most students (about 59% of respondents) study alone. Of the remaining 41%, only 36% of these study with treated students. So only about 15% of our overall sample can be subject to contamination through lamp sharing and only half of those are in classes with mixed treatment status. Moreover, in this experiment, schools may have been less likely to intervene in how the lamps were to be used. In most of the cases, lamps stay at home during the night, and only in four cases stayed at school. Finally, teachers did not get involved in the organisation of afternoon study groups, whereas in Kajiado it was more common to organise study sessions after the end of classes. In this context, the space for interaction between treated and control students seem limited; indeed fieldwork experience revealed that students walk straight home after the classes, which was not the case in Kajiado.

From a policy point of view, all this suggests that in order to enhance the effectiveness of solar lamps on educational outcomes in a cost-effective way by exploiting spillover effects, it is pivotal to involve schools for the organisation of post-lectures study groups and the creation of interaction opportunities between treated and control students.

7.1.2 Time allocation and family usage

The lamp has a positive and significant treatment effect on study time, such that treated pupils study about 35 minutes per day more than students in the pure control group. Moreover, treatment also leads to a significant reduction of time spent on chores.

More specifically, we find that the lamp has effects on study time at home rather than at school. This is consistent with the lack of evidence on spillovers, given evidence in Hassan and Lucchino (2014) indicates studying at school is the major source of spillovers. Moreover, we find spillover effects on study time at home on non-treated students.

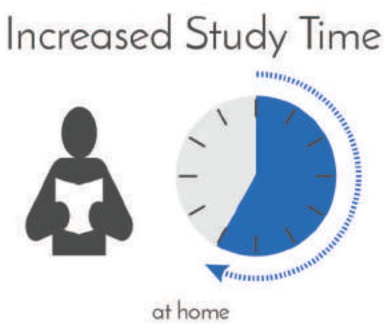

Figure 7.2 Results: time allocation

If we look at study time in different periods of the day we find that treated students increase their study time both in the morning and in the evenings where the effect is stronger. Nevertheless, for non-treated students in mixed classes, study time increases significantly only in the mornings. This is not surprising given that control students do not have access to the lamps' illumination in the evenings. It is possible that there is a competition effect on control students who decide to devote more study time in the mornings to compensate for the fact that they did not receive the lamp.

7.2 Effects on Households Activities

Economic development and structural change are long processes involving the evolution and mutation of all aspects of the economy and society. Existing work shows that large scale electrification has an important part to play in this transformation. However, considering a quarter of humanity lives in areas where off-grid solutions such as solar lamps or home systems are the only options allowing some form of energy access, there is very little research into whether, albeit commensurate to their much smaller size, these can trigger similar mechanisms of socio-economic transformation.
To our knowledge, this project is one of very few recent works tackling this issue, and the only one that finds evidence that small scale lighting solutions can help stimulate the very first steps in the direction of economic transformation.

7.2.1 Diversification & Task Shifting

By exploiting experimental variation in the ownership of solar lamps, we identify treatment effects leading to a diversification in household livelihoods from agricultural to non-farm economic activities.

Image credits: PureSolution/Shutterstock and Enraged/Shutterstock
Figure 7.3 Task Shifting from agricultural to non-farm economic activities.

Our time use data allows us to explore any treatment effects on the timing of different activities. These treatment effects are visualised in Figure 7.4.
Each panel displays the estimated treatment effect (blue line) and 90% confidence interval (light blue shaded area) across all hours of the day.

The panels in the top row of Figure 7.4 display the treatment effects across the broad time aggregates, with the panels below each representing their component parts. The horizontal line runs at zero, and the vertical lines represent approximate sunrise and sunset times.

Specifically, we see that productive work gives way to leisure (primarily rest) in the morning, but the reverse occurs during the evenings as men in treated households increase their involvement in non-farm work and in social engagements.

The Figure also provides further evidence that lamps influence wake-up and sleep times: we find stronger evidence indicating that treated household delay going to sleep, both for men and women.

These results support some important points.

Firstly, the evidence of `task shifting', especially when moving from one side of sunset to the other strongly substantiates the belief that the differences we identify between treated and control households are driven by access to light, and ultimately by the treatment.

Secondly, `task shifting' is economically important even in the absence of changes to aggregate time allocations if the productivity of a task depends on the timing when this is carried out.

Social engagements are a case in point. These include socially and economically relevant activities such as listening to the radio or paying a visit to members of the community.

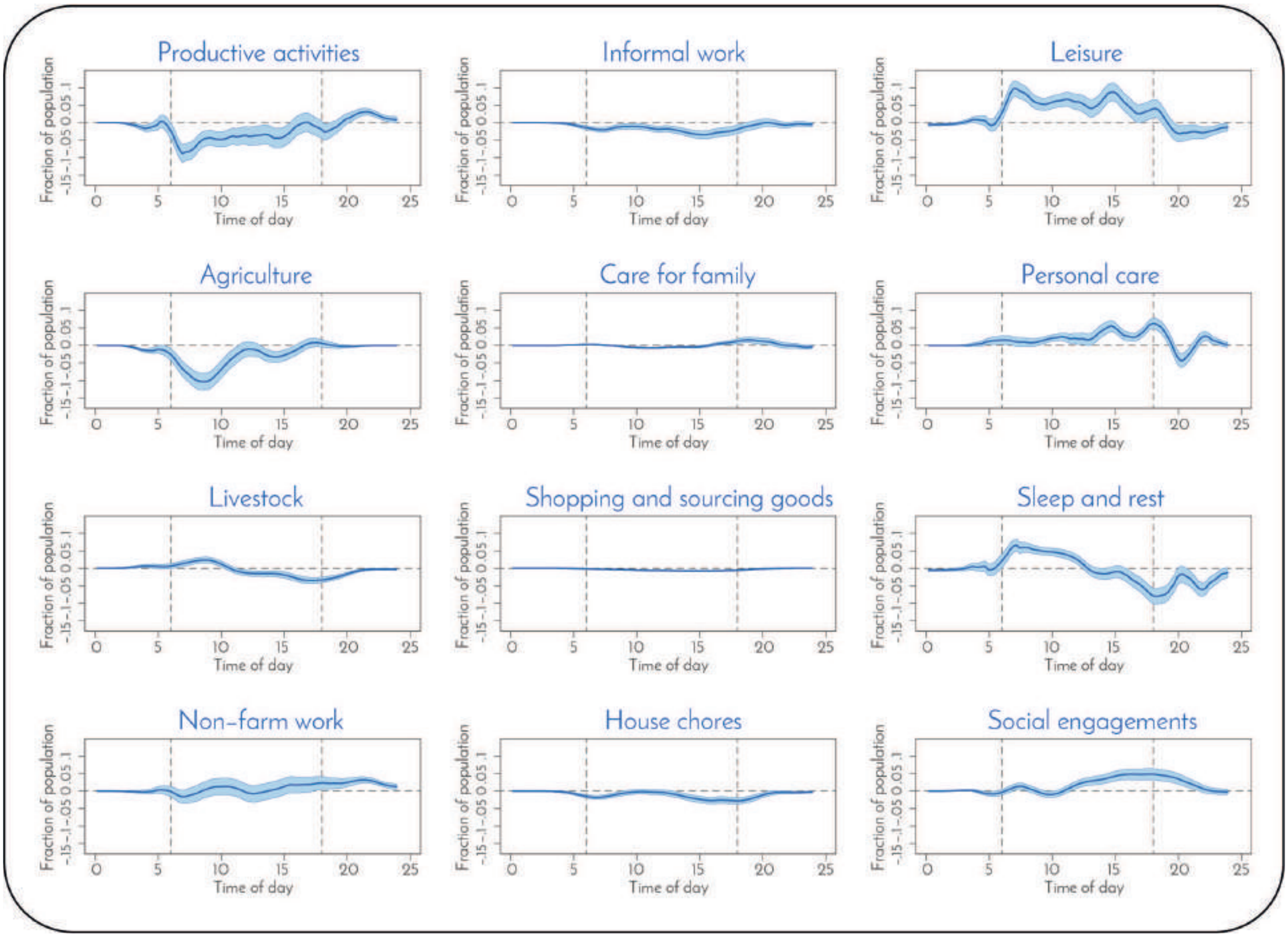

Figure 7.4 Results: diversification of activities

7.2.2 Income Streams

We find strong evidence of an economically large shift in incomes from farm to non-farm activities, of around 290 Kenyan Shillings (USD $2.90) per week, equivalent to 20% of the mean household income in our sample.

At the same time, we do not detect any change in total income.

The treatment effect on total household income and total equalised household income are generally positive, but not statistically significant.

This raises the question as to why families might be induced toward this shift if it leaves them no better off. One explanation could relate to the diversification of risks across income streams. Alternatively, it could be that the process of transformation in economic activities is still ongoing and is not fully developed at only 7 months from treatment.

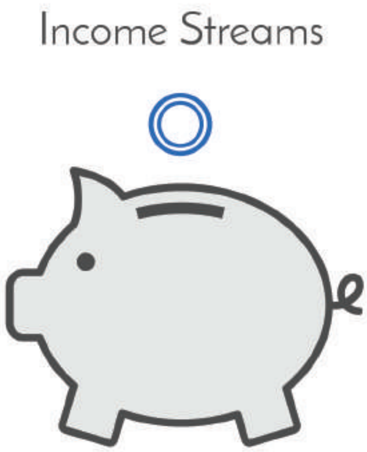

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Figure 7.5 Results: income streams

8. References

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