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## Junior Farmer Field Schools, Agricultural Knowledge and Spillover Effects: Quasi-experimental Evidence from Northern Uganda

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## Summary

We analyse the impact of a junior farmer field school project in Northern Uganda on students' agricultural knowledge and practices. We also test for the presence of intergenerational learning spillover within households. We use differences-in-differences estimators with ex-ante matching. We find that the program had positive effects on students' agricultural knowledge and adoption of good practices and that it produced some spillover effects in terms of improvements of household agricultural knowledge and food security. Overall, our results point to the importance of adapting the basic principles of farmer field schools to children.

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**JEL Classification:** O13, O22, O55, C93

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# Junior Farmer Field Schools, Agricultural Knowledge and Spillover Effects: Quasi-experimental Evidence from Northern Uganda*

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**Abstract**

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## 1. Introduction

Low agricultural productivity and rural poverty in developing countries may be caused by market incompleteness such as credit constraints, imperfect financial and insurance markets, weak property rights or lack of agricultural knowledge regarding new technologies, products and methods (among others, Rosenzweig and Wolpin 1993; Van der Ban and Hawkins 1996; Croppenstedt, Demeke and Meschi 2003; Kazianga and Udry 2006; Conning and Udry 2007; Goldstein and Udry 2008).

Several countries have tried to tackle informational constraints through agricultural extension services, with the goal of helping farmers to improve their agricultural productivity. Such initiatives generally provides knowledge in agronomic techniques and skills to rural communities in a participatory manner.

One of the most widespread capacity building approach within agricultural extension programs are Farmer Field Schools (FFSs). FFSs are a participatory method of learning, technology adaptation and dissemination. In practice, FFSs are community-based adult-education practices aimed at transferring agricultural knowledge, improving skills and empowering farmers through learning-by-doing. FFSs were implemented first in Indonesia in 1989, and they are now applied in many Sub-Saharan countries (Braun *et al.* 2006).

Given the large popularity of FFSs, a number of studies have tried to assess their impact on different outcomes such as agricultural knowledge, technology adoption, agricultural production, food security and poverty alleviation. Although randomized controlled trials on the effect of FFSs have not been conducted so far, some studies have tried to account for selection into program participation. The findings of this literature are mixed, with some studies showing no significant programs' impact, and other papers finding positive effects in terms of improved agricultural knowledge, technology, production and on food security.[1]

The same principles of FFSs can be adapted to different specific topics or groups of beneficiaries, for instance to children through junior farmer field schools (JFFSs).[2] JFFSs aim to improve short and long-term livelihood, food security and well-being of both children and their households. Expected benefits include increased agricultural knowledge and skills and improved food security. In addition, a process of inter-generational knowledge transmission from children to their household's adults may also occur. The transfer of agricultural knowledge can change the agricultural practices of the recipients' units, while agricultural production and household food security can develop. In view of these spillovers from children to their households, the potential beneficial effects of JFFS programs are enhanced.

JFFSs have been developed and implemented in Mozambique, Zimbabwe, Kenya, Swaziland and Namibia since November 2003 (FAO 2007). However, contrary to FFSs for adults, the literature on the effect of JFFS is still very scarce and, to the best of our knowledge, a quantitative evaluation of their impact has never been performed[3].

In this paper, we analyse the impact of a JFFS project implemented in Northern Uganda by the international NGO AVSI in the 2011-2013 period. Using a quasi-experimental approach,

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[1] An extensive review of impact evaluation studies on adult FFSs is in Waddington *et al.* (2014). Key recent contributions on the effects of FFS are Gotland *et al.* (2004); Feder, Murgai and Quizon (2004); Tripp, Wijeeratne and Piyadasa (2005), Van den Berg and Jiggins (2007), Rejesus *et al.* (2012), Davis *et al.* (2012), Todo and Takahashi (2013) and Larsen and Lilleor (2014).

[2] Other types of FFS programs are business or marketing FFS, that are expected to develop additional skills with the aim of improving farmer livelihoods or to promote different types of farming, for instance through farmer livestock schools (Waddington *et al.* 2014).

[3] Djeddah, Mavanga and Hendrickx (2006) present anecdotal evidence on the implementation of a pilot program in Mozambique targeting orphans and vulnerable children between 12 and 18 years living in communities highly impacted by HIV/AIDS. The project contributed to boosting school enrolment and it attracted children that were not included in the project to undertake agricultural activities. FAO implemented a JFFS in refugee camps within the host community in Kakuma and Dadaab (Kenya), providing the targeted young people some good knowledge on agriculture and life skills. However, according to the evaluation report, the project seemed to be too short to make a significant difference (FAO 2010a).

we measure the direct effects of JFFS on students' agricultural knowledge and practices. We also look at the extent to which the project spills over to students' households' agricultural knowledge and practices. As far as we know, this is the first paper analysing the direct and spillover effects of a JFFS project using a quasi-experimental methodology[4].

Northern Uganda was afflicted by nearly twenty years of continuous conflict in the 1987-2007 period. At the end of the conflict, in 2007, the Government of The Republic of Uganda formulated and launched the Peace, Recovery and Development Plan (PRDP), a comprehensive development framework. Since then, the overall situation in Northern Uganda improved substantially. However, much still remained to be done to restore the disrupted economic and social fabric and to ensure food security, particularly in some districts.

Currently, agriculture is the main livelihood and income source for the Ugandan population. Agriculture employs three quarters of the labour force and accounts for one quarter of Uganda's GDP. Smallholders account for 96 percent of farmers and 75 percent of agricultural produce. However, they underperform substantially, contributing to food insecurity among smallholder farming families. Agricultural knowledge is still quite poor, and the production techniques are those of subsistence farming (World Food Programme 2015).

In Uganda, the universal primary education *curriculum* includes agriculture, but it has important gaps, like the lack of proper agriculture training for teachers, adequate agricultural teaching materials for primary schools and the lack of integration between practical and academic education. Moreover, as a consequence of living in the internally displaced camps for a couple of decades, children and their families were forced to a diet that did not necessarily correspond to their traditional one, because local food could not be produced

[4] Nakasone and Torero (2016) is the only paper analysing spillover effects from students to parents, although in a completely different context. They implemented a field experiment in a rural high school in the northern highlands of Peru where they showed agricultural extension videos to students in the school's computer lab. They find that the information provided to the teenagers increased parents' knowledge and adoption of agricultural practices.

during the insurgency and food products were mainly imported or provided by the donor community. This heavily affected food consumption patterns in favour of products that were not grown locally. Hence, children and their families often lack proper knowledge of food preparation and conservation and they are often unaware of the importance of a diet containing good and varied nutrients. Then, re-gaining agricultural education is crucial for the development of the area.

In view of this, drawing from FAO's experience and lessons on JFFSs, in 2011 the NGO AVSI adopted the JFFS approach within the project *Agriculture for all* (*AFA*). The primary objective of the project was to increase agricultural knowledge and food security in primary school children, teachers, local leaders and district officials, and to advocate for the inclusion of practical agricultural education in the existing primary school *curriculum*. According to the project, agricultural knowledge had to be fostered through the active involvement of the children in the school gardens through JFFSs.

In this paper, we analyse the impact of *AFA* using quantitative counterfactual analysis. More specifically, we try to assess its impact on students' agricultural knowledge and practices. Moreover, we assume that children are induced to transmit their newly acquired knowledge to their parents and guardians, for the new knowledge to be applied at household level (inter-generational spillover effects). Although the transmission of information from one subject to another is not necessarily automatic and may require costly efforts, children and their household members are related by strong ties and physical proximity. Therefore, a process of information exchange is likely to occur. In view of this, we analyse the spillover effects of the project at household level investigating its impact on agricultural knowledge, practices and production and on household food security and nutrition.

The empirical analysis is based on household-level panel data. The data were collected in the pre-program and post-program periods in ten treated and ten control schools in two districts of Northern Uganda (Gulu and Kitgum). We also use a second source of data containing results of a test on agricultural knowledge administered to treated and control students before and after the program by the project's staff.

Our estimation strategy combines two approaches: propensity score matching (PSM) and differences-in-differences (DID). Indeed, PSM alone cannot account for unobserved characteristics that might explain both the treatment and the outcomes. Hence, our approach relies on differences-in-differences comparisons of treated subjects with matched samples of non-treated individuals. The use of matching techniques helps ensure similarity between the treated and control samples. Moreover, if treated and non-treated subjects differ along both observable and unobservable characteristics, estimation that joins ex ante matching on observable characteristics and fixed-effects to account for time invariant unobserved factors produces more reliable estimates than matching alone (Smith and Todd 2005). As robustness checks, we use different matching algorithms.

We find that the program had positive effects on the students' level of agricultural knowledge and practices. Moreover, we find evidence that this knowledge is spilling over to other members of the household in terms of more agricultural knowledge and improvements of food security and nutrition. However, we find no impact on the propensity to introduce new agricultural good practices and on household agricultural production.

Given that relatively large number of hypotheses that we are testing, we applied the Bonferroni correction for multiple hypotheses. Despite the correction is extremely conservative, most of our results are robust to it. Moreover, while we could not test directly the common trend assumption, at the core of identification in the DID framework, because we have data on just one period before and after the treatment, we use a number of placebo tests to validate the assumption.

The remainder of the paper is organised as follows: the next section presents a description of the project under evaluation; Section III describes the sampling procedure and the data; Section IV explains the empirical strategy; econometric results are discussed in Section V while concluding remarks are provided in the last section.

## 2. The project

At the end of October 2011, within the framework of the Peace, Recovery and Development Plan (PRDP), the international NGO AVSI[5] launched the project *Agriculture for all* (*AFA*) using funding from a group of Italian Foundations (*Fondazioni 4 Africa*).

The *AFA* project is based on three pillars: *i*) experimental learning field, *ii*) teaching of special agriculture topics and good agricultural practices, *iii*) life skills.

According to the first pillar, the school gardens should be realized and used as a place for experimental learning where children are exposed to the complexity of proper gardening and where they can learn basics of food security and nutrition.

The second pillar of the project requires that field learning goes along with the teaching of special topics and good agricultural practices, such as integrated pest management and intercropping. It includes traditional and modern practices for the entire cycle of agricultural activities (preparation, sowing, transplanting, weeding, irrigation, pest control, etc.).

Finally, each module includes a life skills component (third pillar), for children to make the 'magic link' between how they take care of their fields and how they take care of themselves. For instance, when undertaking initial agricultural planning, children should also learn to plan and explore their own aspirations; when learning how to protect their crops from pests and

[5] AVSI is an international non-governmental organization founded in Italy in 1972; it has been active in Uganda since 1984, maintaining a constant presence in the Northern regions even during periods of high insecurity. Throughout the years, several donors have funded AVSI projects in the health and HIV/AIDS, water and sanitation, education, protection, mine action, and food security and livelihood sectors.

disease, they should also learn how to protect themselves from threats such as HIV, violence etc.[6]

The project was implemented in ten primary schools in the North-Uganda districts of Kitgum and Gulu. In each of the selected schools, children attended weekly learning sessions, including practical and theoretical classes, which were given by AVSI staff together with the school agriculture teachers. These latter benefitted from refresher courses on agricultural techniques and on life skills to better accompany children's learning process.

A general work plan for each school was defined upon opening of the school garden. It detailed the activities, resources and the people responsible for the whole duration of the program. The plan, detailed by week, provided children and teachers with a clear schedule of the work to do in the garden, and in particular of the fieldwork and special topics of the program. Moreover, children and their teachers could select some crops to be grown in the school gardens among those cultivated in the area throughout the year.

The project provided some equipment and tools to each JFFS. More specifically, each school received a start-up kit composed of 2 wheelbarrows, 10 hoes, 5 pangas, 5 watering cans, 5 basins, 2 sprayers, 1 tape measure, 2 spades, 2 measuring strings, 5 slashers, 5 jerrycans, 4 rakes and 4 axes.

Training courses based on the AVSI and FAO JFFS manuals (FAO 2010b) for the head teachers, the agriculture teachers and the local chiefs were organized upon opening of the school gardens. Finally, throughout the project, meetings at district levels were organized to advocate for the integration of the JFFS approach in the existing agricultural *curriculum*.

In order to ensure the involvement and participation of local authorities and communities in the JFFS approach, the project also planned other specific activities, like open days, community events and JFFS days. Allowances were provided to agricultural teachers, district

[6] In this study, we do not evaluate the impact of the program's third pillar.

officials, head teachers, local authorities and community animators to facilitate the training of children.

The schools' selection was made in the last months of 2011, while the selection of students within schools, the mobilization of schools and of other local institutions was made at the beginning of 2012. The project's initiatives started between April and May 2012. The project had an initial duration of 12 months but, at the end of the first year, the program was extended for one more year and it ended in October 2013.

## 3. Sampling and data

A common challenge when evaluating the impact of development programs is related to non-random assignment of the treatment. Endogeneity bias due to non-random program placement arises when beneficiaries are purposively selected following criteria that may also correlate with the outcome of interest. Random assignment of beneficiaries to a treatment and a control group ensures unbiased impact assessments. However, in our case random assignment of schools could not be implemented.

Ten schools in the two districts of Gulu and Kitgum (five per district) received the program intervention (treated schools) and ten schools were chosen as control schools. The treated schools were identified among those that AVSI had been supporting in the past, in collaboration with the District Education Office. This criterion allowed AVSI to implement the project more easily, because good relationships with the schools' management were already in place. However, no previous program was related in any way to JFFS[7].

The control schools received neither external support nor other JFFS programs throughout the evaluation exercise. The sample of control schools was stratified at district and sub-county

[7] The previous interventions were mainly based on a more traditional approach, for instance construction of classrooms, staff housing and latrines or delivery of desks and books in schools with scanty or inadequate equipment.

level: both treatment and control schools were located in the two districts of Gulu and Kitgum. Moreover, three sub-counties were chosen in each district (Omiya Anyima, Lagoro and Namokora in Kitgum and Lakwana, Lalogi and Odek in Gulu) and, in each of these, at least one control and one treated school were selected[8]. Table A1 in the Appendix shows schools' sampling details. Stratification is often seen as a tool to mitigate selection bias.

A second potential source of selection is at the individual level, when participation to program activities is open. This is a major issue in the case of FFSs, where more motivated and entrepreneurial individuals are likely to self-select into the program, leading to a positive bias in the program's evaluation (Larsen and Lilleor 2014). In the *AFA* case, however, the choice to participate in the JFFS was not made by the children themselves: the program's participants were identified by AVSI together with the school management and the local authorities. The program targeted 30 students in each selected school as beneficiaries of the project. The targeted children were identified considering specific criteria, which included their degree of socio-economic vulnerability (they had to be orphans of one or two parents and they had to live in vulnerable conditions as assessed by the local stakeholders), school grade (primary school), and gender (to keep a proper gender balance). The same criteria were applied for the selection of students in control schools.

Such design does not threaten the internal validity of the exercise, but weakens its external validity on the effects of JFFSs on untargeted students at primary school. However, JFFS programs have normally been conceived to target vulnerable children in several contexts (FAO 2007).

The data used in this study are based on two sources: household surveys and project's records about students' level of agricultural knowledge. Survey data were collected in two points in time - before the treatment and nine months after the end of the program. The baseline

[8]The only exception is in Kitgum, where three treated and no control schools were selected in the sub-county Namokora.

questionnaire was administered in May 2012, while the majority of follow-up data were collected in August 2013.[9] Interviews were addressed to the student's guardian, defined as the member of the household who is responsible for the child, who takes care of him/her materially and emotionally and who lives in the same house with him/her. Our study sample includes 559 households (279 in the treatment and 280 in the control group) for which we have information both at the baseline and at the follow-up.

Baseline and follow-up questionnaires include seven sections aimed at collecting information on households and on students: demographic characteristics, assets and land, agricultural production in the two seasons preceding the surveys, agricultural knowledge and adoption of good practices, income and expenditures, food sources and consumption and perception of guardians relative to their children's agricultural knowledge.[10]

Questionnaires were translated in the local language (*luo*) and were administered by six independent enumerators.[11] One Survey Field Manager coordinated the survey process and one auditor checked the questionnaires handed in by enumerators.

The second source of data contains results of a test administered to treated and control students before and after the program by AVSI staff in schools. The test had the purpose to measure the students' knowledge of some aspects of agriculture covered during the educational sessions. Moreover, in order to evaluate the extent to which students were involved in agricultural activities, after performing the test students were asked how often they practiced agriculture, helped parents with agriculture, used fertilizer and cultivated their own piece of land.

[9]Around 14% of the interviews were done between September and October.

[10]The baseline and follow-up questionnaires are available upon request.

[11]A survey-training manual was prepared and distributed to enumerators. It is available upon request.

The baseline test was administered at the same time of the household survey, while the follow-up test for students took place in May-June 2014, around two years after the beginning of the interventions in schools.

Due to organizational and budget constraints, AVSI was unable to administer the test on the entire sample of students at the baseline and follow-up. More specifically, data are available for all ten treated schools and for four control schools. The reason for such imbalance lies in the fact that AVSI had stronger requirements from the donor for monitoring data in treated school and a limited budget for data collection in control schools. As a result, we have data on 306 students at the baseline, whose guardians were also surveyed at the baseline, of which 221 in 10 treated schools and 85 in 4 non-treated schools. At the follow-up, we are able to track 293 students, of which 223 from the 10 treated schools and 70 from 4 control schools (the same of the baseline). We end up with complete information at the baseline and follow-up for 211 units (162 in treated, 49 in control schools) that we use to compare outcomes. Attrition analysis for both sources of data is done in the next section.

### *3.1. Attrition analysis*

We have attrition on both data sources we are using. As far as the household survey is concerned, at the baseline eleven questionnaires (eight in the treatment and three in the control group) out of the six hundred expected were discarded because the quality of the information collected was not satisfactory. However, the limited number and the quite even distribution of the low-quality questionnaires across schools is unlikely to affect the results of our analysis.

In the follow-up survey, we were unable to track 30 students' guardians (thirteen in the treatment group and seventeen in the control group), corresponding to a 5% attrition rate. The main reasons include relocation of the household in too far off sub-counties and guardians' unavailability to be surveyed because they moved to too far off villages to farm. Attrition is not differential across treatment and control samples, as shown in Table 1. Diagram 1 shows the sample flow from the baseline to the final sample.

Diagram 1

As regards data on students' agricultural knowledge, they are available only for a sub-sample of students included in the study. As stated above, control schools are underrepresented, which leads to differential attrition. Moreover, the sample does not include all targeted students due to absence at time of the test (either at the baseline or at the endline) and some marginal mistakes in the identification of targeted students. Overall, the attrition is 82.5% and 41.9% in the control and treated sample, respectively. We check to what extent the sub-samples of students in treated and control school for whom we have complete information is representative of the respective samples. In order to do this, we look at the determinants of attrition (both baseline and follow-up), by using baseline household data. This is shown for the sub-sample of treated and control students in columns 1 and 2 of Table A2, respectively. We find that some sort of selective attrition seemed to occur in the treated sample, where attrition is more likely to occur for students whose households are male-headed, where agriculture is the main activity and for older student. Conversely, non-systematic attrition seems to occur in the control sample, where non-attriters represent adequately the overall control population with the only exception of more attrition for students whose household head is able to read and write. The non-random attrition in the treated group implies that, if we assume that older students and those living in households where agriculture is the main income generating activity are more receptive to the projects' initiatives, our estimates might be downward biased. We also compared the average characteristics of the treated and control samples for which we have data on students' agricultural knowledge and we find that the two samples are pretty well balanced (see Table A3 in the Appendix).

However, in view of such data limitations, we take results on agricultural knowledge based on these data with caution, and we test the project's impact on children's knowledge using information on guardians' perceptions, available for the whole sample, as well.

### *3.2. Descriptive statistics and sample balance*

Baseline summary statistics of the main characteristics of household heads, students, households and schools for the overall, treated and control samples are reported in Table 1. The table also shows mean differences between treatment and control groups and results of *t*-test for their statistical differences.[12] Around two thirds of heads are male and the same share lives in couples. Their average age is 47 years. Around 60% of household heads are able to read and write, while 21% have no schooling. The vast majority of household heads (89%) works in agriculture as main income generating activity.

Table 1

The average household size is seven. Around 70% of the households own a sack or kitchen garden and the average size of owned land is 7.5 acres (about 3 hectares), slightly higher in the treatment than in the control group. The average number of breadwinners (i.e. household members who earn some cash out of income generating activities) is 1.8 and it is higher in the treatment group. The survey contains detailed information regarding household assets. By

[12] Wild cluster bootstrapping was used given the small number of clusters in each group (Cameron et al., 2008 and Cameron and Miller, 2015).

aggregating this information, we computed a wealth index using principal component analysis (Filmer and Pritchett 2001)[13].

As regards students' characteristics, the sample includes an almost equal number of boys and girls and the average age is between 13 and 14 years. Students have been attending school for an average of 5.4 years.

Treated and control schools are similar in terms of the main characteristics (e.g. enrolment, number of students per teacher, number of books per student and class size).

Overall, although our setting does not involve randomization, figures in Table 1 show homogeneity along the main observable characteristics at the baseline: no relevant difference emerges between treatment and control groups both at the individual and at the school level.

### *3.3. Outcome measures*

We consider a number of outcome variables to measure *AFA*'s impact. In order to define such variables, we relied on the AVSI project documentation and on the FAO Monitoring and Evaluation Toolkit for Junior Farmer Field and Life Schools (FAO 2010b).

The major expected outcome of the program is its direct effect on participants in terms of increased agriculture knowledge, skills and practices. First, we analyse the project's impact on a set of outcomes using data on agricultural knowledge available only for the sub-sample of students included in the study. These outcomes are: student agricultural knowledge, which is evaluated through an index measuring the number of correct answers provided in the test

[13] The items considered to build the index are: roof material (grass, banana leaves, iron sheets), walls material (mud and poles, unburnt bricks, burnt bricks), floor material (rammed earth, bricks, cement or concrete), light source ( biomass, candle, paraffin, gas, electricity), toilet facility (bush, shared pit latrine, private pit latrine, flush toilet), number of rooms in the dwelling, hoes, ploughs, granaries, bikes, motorbikes, mobile phones, big-size animals (donkeys, horses, oxen, cattle), mid-size animals (goats, sheep, pigs), small-size animals (poultry, ducks, doves, pigeons), beds, tables and chairs, kitchen appliances (jerry cans, pots, pans, fans, stoves), energy sources (batteries, generators), other appliances (sewing machines, iron, wheelbarrow, kettle, radio, tv).

and ranging between zero and six[14], daily agricultural practice, regular help with agriculture provided by students to their household's members, use of fertilizer by students and cultivation by students of a piece of land of their own.

Next, we evaluate the project's impact on students' agricultural knowledge exploiting their guardians' perceptions. In this case, we are able to use the information collected on the whole sample. Specifically, the survey asked guardians whether they thought that the children learned concepts and practice about agriculture and whether the children worked in home gardens.

A second expected project's impact regards spillover effects in terms of increased household's agricultural knowledge and practices. More specifically, we expect that JFFS participants transmit their newly acquired agricultural knowledge to their household's members. Such transmission mechanism might in turn impact on household agricultural practices. In view of this, first we consider as potential outcomes the household's agricultural knowledge. We measure it through a series of questions assessing the knowledge of fertilizer preparation, ingredients of natural pesticides, soil ingredients, preparation and orientation of nursery bed for trees and vegetables, transplantation of vegetables, growing process of some vegetables and post-harvest techniques. In order to evaluate the overall agricultural knowledge, we build a synthetic score (ranging from 0 to 15) considering the answers to all the previous questions.

Next, we consider other outcomes related to household's adoption of specific agricultural practices, such as opening all available land for agriculture or cultivating a sack or kitchen garden. Moreover, we build an index by summing the number of adopted agricultural good practices among the following: crop rotation, row planting, broadcasting, mulching, zero

[14] In particular, the tests assessed knowledge of fertilizer-making, periods of rainy seasons, pests and diseases affecting agricultural products, agro-ecosystem analysis, soil composition, key factors for healthy plants' growth and drought coping strategies.

tillage, improved seeds, organic manure, inorganic fertilizer, fallowing and agroforestry. The index ranges between zero and ten. Finally, as a more direct test for information transmission effects, we estimate the project's impact on the probability that at least one agricultural practice has been learned from children in school.

The third set of outcomes is about spillover effects on household agricultural production. Data on production were collected, by product, for each household and for different agricultural seasons. More specifically, we collected information on four agricultural seasons, two of which are baseline ($2^{nd}$ season 2011 and $1^{st}$ season 2012) and two follow-up ($2^{nd}$ season 2012 and $1^{st}$ season 2013). The baseline questionnaire was administered in May 2012, in the middle of the first agricultural season. However, we think it is very unlikely that the intervention had any effect on this season, which is then considered as baseline season. The evaluation of JFFS is made by comparing the agricultural outcomes of similar seasons ($2^{nd}$ season 2012 vs $2^{nd}$ season 2011 and $1^{st}$ season 2013 vs $1^{st}$ season 2012).

We consider as outcomes the number of crops that were the subject matter of the students' training and that were subsequently adopted and the probability of adopting new crops. In order to evaluate more precisely the presence of spillover effects regarding agricultural production, we also consider the probability of introducing new crops due to the children's suggestions.

The final set of outcomes regards household food security and nutrition. Indeed, according to *AFA*'s first pillar, besides agricultural and gardening notions the school gardens should provide students with food security and nutrition basics. Hence, we expect results in terms of greater awareness of the importance of a good and diversified nutrition which may lead to improvements in household eating habits.

We elicited information on these aspects through the recall method, with questions referring to food practices on the day or in the week preceding the interview. Specifically, we asked respondents the number of meals consumed by adults and children on the day preceding the interview, which food items had been eaten during the previous week and the frequency of their consumption. Using this information, we computed two synthetic measures of the levels and diversity of food consumption: the Food Consumption Score (FCS) and the Household Dietary Diversity Score (HDDS). The FCS is constructed according to the World Food Programme guidelines (World Food Programme 2008), while the HDDS has been proposed in the framework of the Food and Nutrition Technical Assistance (Swindale and Bilinsky 2006).[15]

Finally, to assess the impact of *AFA* on food security, we considered as outcomes the number of food types which have been eaten at least once in the previous 7 days (out of a list of 22 Ugandan common items included in the questionnaire) and the probability that household's members eat different specific food items weekly (i.e. cereals and tubers, pulses, vegetables, fruit, meat and fish, milk, sugar and oil fats).

Baseline mean values of all outcome variables are reported in columns 1 (treated group) and 2 (control group) of Tables 2 to 6.

## 4. Empirical strategy

[15] The FCS is a composite score based on dietary diversity, food frequency, and relative nutritional importance of different food groups. Food items are grouped into 8 standard food groups with a maximum value of 7 days/week. The consumption frequency of each food group is multiplied by an assigned weight that is based on its nutrient content. Those values are then summed obtaining the Food Consumption Score (FCS). Food groups and relatively weight (w) are i. Cereals and Tubers (maize, rice, millet, sliced bread and buns, porridge, posho, cassava, potatoes), w=2; ii. Pulses (beans, peas, groundnuts), w=3; iii. Vegetables, w=1; iv. Fruits, w=1; v. Meat and fish, w=4; vi. Milk, w=4; vii. Sugar and sugar products (sodas and juices), w=0.5; viii. Oils, fats, butter, simsim, w=0.5. The HDDI corresponds to the number of different food groups (out of 12), consumed over the past 7 days. The HDDS food groups are constructed as follows: main staples are disaggregated into two groups (cereals, and roots and tubers), meat, fish and eggs group is disaggregated into its three subgroups; and there is a group for "other foods", such as condiments, coffee, or tea.

Although the sampling procedure at both school and student level should reduce the potential bias due to endogenous placement and sorting of participants, in order to rigorously identify the impact of the program our empirical strategy exploits the double variation in time and across treatment and control groups.

More specifically, the panel structure of our data allows using differences-in-differences estimators (DID) (Heckman, Ichimura and Todd 1997, 1998) to estimate the program's effects. Moreover, we use matching techniques to increase similarity between the two samples along observable characteristics. This method compares the change in the outcome variable in the treated group before and after the program, to the change in the same outcome in the matched control group.

The DID estimator relies on the assumption that, conditional on observed characteristics, the evolution of the outcome in treated and control groups would have been the same in the absence of the project (*common trend assumption)*. Put differently, any difference in the relevant outcome between treated and control individuals due to unobserved factors is fixed over time (Heckman *et al.* 1997). When longer time series are available, evidence for the common trend assumption is generally provided showing that outcomes in treatment and control groups move in parallel in untreated periods. However, given that we have data on just one period before and after the treatment, we use a number of placebo tests to validate the assumption by looking at outcomes that should not be affected by the project (e.g. household size, source of lighting, toilet facilities, electric appliances and kitchen items owned) and verifying that they moved in parallel in treatment and control groups before and after the treatment (see Table A4 in the Appendix).

Throughout our evaluation exercise, we thus assume that the difference between pre and post-treatment outcome between treatment and control group, conditional on pre-program observed characteristics, identifies the average effect of the program, the so-called ATT (average effect of the treatment on the treated).

We study the effect of *AFA* on outcome $Y$ of individual $i$ (being the student or the guardian) in school $s$ at time $t$, by estimating the following OLS regression (Heckman and Robb 1985):

$$Y_{ist} = \delta + \gamma T_s + \alpha t + \beta(T_s * t) + \rho x_{i0} + \varepsilon_{ist} \quad (1)$$

where $T_s$ is a dummy variable equal to one if student *i* or his/her guardian belongs to a school selected for treatment and zero for those in the control group, $t$ is equal to one for post-program observations and equal to zero for pre-program observations and $x_{i0}$ is a vector including head (gender, age, marital status, ability to read or write, level of schooling, agriculture as main activity, having a formal employment, received external support in the previous season), student (gender, age, number of years of schooling, class attended) and household (size, number of people earning, wealth index, land extension) characteristics, measured at the baseline. $\beta$ is the parameter of interest and gives the DID estimate of the average effect of *AFA* on outcome $Y_i$. $\delta$ is a constant term, $\gamma$ is the treatment group specific effect, which accounts for average permanent differences between treatment and control individuals, and $\alpha$ gives the time trend effect common to control and treatment group.

In order to better compare treatment and control groups, we repeat the exercise using propensity score matching. This method allows us to balance the two samples along several observable covariates and compare differences in the final outcome. We construct a propensity score (Rosenbaum and Rubin 1983) considering variables affecting both treatment and outcome, fixed over time, and found to be relevant in previous research. More specifically, the estimated propensity score includes head, student and household characteristics (vector $x_{i0}$ of equation 1)[16]. We use the kernel matching algorithm (Becker and Ichino 2002) and cluster standard errors at school level to consider the presence of correlated school-level shocks related to the way the program is implemented, for instance due to school-specific teachers' ability or degree of students' interaction (Bertrand, Duflo and Mullainathan 2004).

As robustness check, we also run the nearest neighbour bias corrected matching estimator (Abadie *et al.* 2004), the biweight kernel and the radius matching algorithm on the differences in time of outcomes.

## 5. Results

Estimation results regarding the project's effects on the children's agricultural knowledge and attitudes are presented in Tables 2 and 3. Spillover effects on households are shown in Tables 4 to 6. The reported coefficients correspond to the ATT ($\beta$ in equation [1]) of *AFA*.[17]

Notice that, given the relatively large number of hypothesis that we are testing, we applied the Bonferroni correction for multiple hypothesis. Despite the correction is extremely conservative, most of our results are robust to it.

### *5.1. Impact of JFFSs on students*

Table 2 shows the impact of the program on students' agricultural knowledge and practices, assessed using data collected from students. The first raw of the table shows estimates of the *AFA* project on agricultural knowledge. We see that the ATT is always positive, although not always significant, suggesting a positive project's impact. Moreover, results in Table 2 show that treated students seem to enhance their attitudes towards agriculture, as measured by their

[16] In all the exercises, we impose common support and sample balancing appears satisfactory: all variables in the propensity score are balanced across treatment and control in the five blocks in which the distribution is divided.

[17]We do not show other regressors' coefficients but they are available upon request.

probability of practicing agriculture daily or of providing regular agriculture-specific help to their parents. Especially in this latter case, the ATT is high and statistically significant.

On the contrary, the program was not found to affect the frequency of fertilizer use and the probability of students cultivating their own piece of land. However, the absence of impact in the latter case may be related to the fact that not all children have the opportunity to cultivate a piece of land of their own.

Table 2

The impact of the project on the children's agricultural knowledge and practices is evaluated also through their guardians' perception. In this case, we can exploit information on the full sample. Table 3 shows the ATT of the project on guardians' perception outcomes. It shows that the project significantly increased the guardians' perception that children learned concepts and practices about agriculture and that they were more involved in gardening activities at home. In this case, the positive impact of *AFA* emerges whatever the evaluation methodology.[18]

Table 3

Overall, based on these findings obtained using both objective and subjective information, we conclude that there is evidence of the effectiveness of *AFA* on students' agricultural knowledge and practices.

[18] The large difference between treated and control individuals in the average baseline values of the variable "Student learned concepts and practice about agriculture" based on guardians' perceptions may be related to the fact that the baseline survey was administered shortly after the starting initiatives of the project related to community events, open days and JFFS field days open to the children's parents. This might contribute to an increase in the baseline value for this variable among treated subjects and to a downward estimate of the ATT.

*5.2. Spillover effects of JFFSs*

As mentioned before, JFFS may potentially produce spillover effects to the children's households through an inter-generational information transmission mechanism. We try to assess the presence of such spillover effects considering different outcomes at household level.

First, if children participating in the JFFS transmit the concepts learned to their family members, we can expect that the households of the treated group will have a higher agricultural knowledge as compared to the control group.

The first line of Table 4 shows estimates of equation [1] considering the score describing the household level of agricultural knowledge. We find a positive ATT with all matching algorithms employed (only in the case of difference in difference without matching the coefficient is positive but not statistically significant), suggesting that a process of information transmission from students to other household members is in place.

Table 4

Spillover effects might also be related to the influence of the JFFS on the probability to adopt specific agricultural practices. Our results suggest that participation in JFFS increased the probability to open all land to agriculture, while we find no significant impact on the probability to cultivate a sack or kitchen garden.

As regards the program's impact on more specific agricultural good practices, Table 4 shows that, although ATT coefficients are always positive, they are not statistically significant. Finally, we find a positive ATT on the probability that at least one agricultural practice has been learned from children in school. This latter result confirms the presence of spillover effects, suggesting that children actually transmit the knowledge acquired through JFFSs to their household members.

Overall, regression analysis reveals that the project produced some spillover effects in terms of improvements of household agricultural knowledge and of the propensity to open all land to agriculture, while we find no impact on the propensity to introduce new agricultural good practices.

An additional potential spillover effect is on agricultural production: if children participating in the JFFS transmit the knowledge acquired to their household members, we can expect some change in household agricultural production due to the implementation of this improved knowledge as a supplementary project effect. However, in this case we find that whatever the outcome considered, the ATT coefficients are never statistically significant (see Table 5).

Based on these findings, it seems that the project did not produce spillover effects on household agricultural production, suggesting that the agricultural knowledge transmitted from the children to their household members did not translate, at least in the short run, in any change of agricultural production.

Table 5

A final important potential spillover effect of the project regards its impact on household food security and nutrition. Indeed, according to the project's first pillar, besides agricultural and gardening notions, the *AFA* project should provide students with food security and nutrition basics.

Table 6 displays ATT coefficients. Results show that treated households improved their overall diet diversification as measured by all the three indexes considered (FCS, HDDS and number of weekly food types), although the positive coefficients are not always statistically significant. Moreover, the targeted households seem to increase the animal protein content of their diet (fish and meat) and the consumption of cereals, tubers and sugar.

Table 6

## 6. Discussion and conclusions

We analysed the effect of a JFFS project implemented in Northern Uganda in the 2011-2013 period. We evaluated the project's impact on several outcomes, both related to the exposed children and to their household (spillover effects). In order to identify the causal effect of the program, we used a matching DID strategy comparing matched samples of treated and non-treated individuals before and after the treatment. Our main results are robust to the use of different matching algorithms.

As far as we know, this is the first paper analysing the direct and inter-generational spillover effects of a JFFS project using a quasi-experimental approach.

Using two different sources of data, we find that the program had positive effects on the students' level of agricultural knowledge. Treated students also seem to enhance their attitudes towards agriculture, as measured by the probability of their working in the home garden or of helping their parents with agriculture.

As regards inter-generational learning, we find evidence that the students' knowledge spills over directly to other members of the household, suggesting the importance of the information transmission channel from children learning at school to parents. A positive spillover effect is also found in terms of the project's positive impact on household food security and on diet improvements. Finally, we find a greater propensity to open all available land to agriculture in the households of the treated group as compared to the control group. The higher probability to open all land may be a potential channel to increase household income although, due to the unavailability of reliable data on quantities harvested and sold, we are unable to test this hypothesis more rigorously.

On the other hand, we do not find treatment effects on the adoption of improved agricultural techniques and on agricultural production. However, it is important to emphasize that little short-run spillover effects do not necessarily imply the lack of production spillover effects. Students' knowledge may trigger change of behaviours over a longer time span, through the acquisition of greater credibility to the eyes of parents, with age, or through their direct action in the family fields.

Moreover, we could expect long-run effects also on children. These latter could develop their abilities to direct their own future development thanks to the improved agricultural knowledge. Unfortunately, we have no data to evaluate such potential long-run effects. However, the qualitative indications on the effects of JFFS on students' attitudes and knowledge need to be considered in the evaluation of the possible long-run consequences of the program. In particular, the fact that students tend to dedicate more time to agriculture, together with the evidence of positive effects on household agricultural knowledge, opens future possibilities of improvements, given by enhanced parent-children interaction and students' direct and more skilled contribution to agricultural production.

Overall, our results point to the importance of adapting the basic principles of FFSs to children through junior farmer field schools, as they could improve short and long-term food security and well-being of both children and their households.

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Table 1

Summary statistics

| *Head characteristics* | N | All | Treatment | Control | Difference |
|---|---|---|---|---|---|
| Female | 559 | 0.367 | 0.351 | 0.382 | -0.031 |
| | | (0.02) | (0.029) | (0.029) | |
| Age | 559 | 46.893 | 46.758 | 47.027 | -0.269 |
| | | (0.492) | (0.665) | (0.727) | |
| Lives in couple | 559 | 0.631 | 0.645 | 0.618 | 0.027 |
| | | (0.02) | (0.029) | (0.029) | |
| Able to read or write | 559 | 0.623 | 0.616 | 0.629 | -0.012 |
| | | (0.021) | (0.029) | (0.029) | |
| No schooling | 559 | 0.213 | 0.226 | 0.200 | 0.026 |
| | | (0.017) | (0.025) | (0.024) | |
| Not completed primary | 559 | 0.463 | 0.459 | 0.468 | -0.009 |
| | | (0.021) | (0.030) | (0.030) | |
| Primary or not completed secondary | 559 | 0.254 | 0.265 | 0.243 | 0.022 |
| | | (0.018) | (0.026) | (0.026) | |
| Secondary or above | 559 | 0.070 | 0.050 | 0.089 | -0.039 |
| | | (0.011) | (0.013) | (0.017) | |
| Farming as main activity | 559 | 0.889 | 0.907 | 0.871 | 0.035 |
| | | (0.013) | (0.017) | (0.020) | |
| *Household characteristics* | | | | | |
| Size (nr. of members) | 559 | 7.190 | 7.348 | 7.032 | 0.316 |
| | | (0.098) | (0.135) | (0.143) | |
| Wealth Index | 559 | 0.000 | 0.060 | -0.059 | 0.119 |
| | | (0.092) | (0.132) | (0.128) | |
| Land size (acres) | 559 | 7.549 | 8.581 | 6.521 | 2.061 |
| | | (0.451) | (0.777) | (0.453) | |
| Number of breadwinners | 559 | 1.83 | 1.99 | 1.68 | 0.307 ** |
| | | (0.055) | (0.081) | (0.073) | |
| Attriters at the endline | 589 | 0.051 | 0.045 | 0.057 | 0.012 |
| | | (0.22) | (0.206) | (0.232) | |
| *Student characteristics* | | | | | |
| Female | 559 | 0.503 | 0.502 | 0.504 | -0.002 |
| | | (0.021) | (0.03) | (0.03) | |
| Age | 559 | 13.426 | 13.559 | 13.293 | 0.266 |
| | | (0.069) | (0.097) | (0.098) | |
| Number of years at school | 559 | 5.451 | 5.48 | | 0.059 |
| | | (0.056) | (0.075) | (0.082) | |
| *School characteristics* | | | | | |
| Enrolment | 20 | 611.6 | 542 | 681 | 138.8 |
| | | (260.7) | (150.5) | (331.9) | |
| Teacher per student | 20 | 48.17 | 49.69 | 46.7 | 3.03 |
| | | (11.9) | (8.8) | (14.7) | |
| Nr of student per class | 20 | 39.24 | 36.97 | 41.349 | 4.37 |
| | | (30.4) | (31.2) | (29.9) | |
| Nr of books per student | 20 | 2.46 | 2.96 | 1.96 | 0.999 |
| | | (1.69) | (1.81) | (1.48) | |

*Notes*. Mean (and standard deviations) of head, household, student and school characteristics. *** p<0.01, ** p<0.05, *, p<0.1

Table 2

Effect of JFFS on students' agricultural knowledge and practice

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Outcome variable | Baseline value treated | Baseline value control | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
| Knowledge score, 0-6 | 1.71 | 1.35 | 0.37 | 0.84 | 0.73*** | 0.85** | 0.69** |
| | | | (0.28) | (0.52) | (0.22) | (0.35) | (0.35) |
| Practices agriculture everyday | 0.14 | 0.20 | 0.025 | 0.21 | 0.17* | 0.21 | 0.21 |
| | | | (0.11) | (0.15) | (0.09) | (0.17) | (0.15) |
| Helps with agriculture often | 0.35 | 0.51 | 0.38*** | 0.78*** | 0.72*** | 0.78*** | 0.79*** |
| | | | (0.11) | (0.13) | (0.11) | (0.19) | (0.17) |
| Uses fertilizer often | 0.04 | 0.04 | 0.037 | -0.03 | -0.03 | -0.02 | -0.010 |
| | | | (0.060) | (0.07) | (0.07) | (0.09) | (0.09) |
| Cultivates own piece of land | 0.64 | 0.53 | -0.046 | -0.11 | -0.17* | -0.13 | -0.17 |
| | | | (0.11) | (0.16) | (0.10) | (0.18) | (0.16) |
| Observations | 162 | 49 | 422 | 422 | 211 | 211 | 211 |

*Notes.* Standard errors are clustered at school level in columns 3 and 4. Propensity score includes: head (gender, age, marital status, ability to read or write, level of schooling, agriculture as main activity, having a formal employment, received external support in the previous season), student (gender, age, number of years of schooling, class attended) and household (size, number of people earning, wealth index, land extension) characteristics. Common support is always imposed. The propensity score is balanced for all variables in each of the 5 blocks the sample has been divided. *** p<0.01, ** p<0.05, *, p<0.1

Table 3

Effect of JFFS on students' agricultural knowledge and practice - Guardians' perception

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Outcome variable | Baseline value treated | Baseline value control | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
| Student learned concepts and practice about agriculture | 0.69 | 0.25 | 0.19*** | 0.18** | 0.16*** | 0.17*** | 0.16*** |
| | | | (0.057) | (0.08) | (0.05) | (0.06) | (0.06) |
| Student works in home garden | 0.98 | 0.97 | 0.10*** | 0.08* | 0.08*** | 0.09*** | 0.11*** |
| | | | (0.026) | (0.04) | (0.03) | (0.03) | (0.03) |
| Observations | 279 | 280 | 1,118 | 1,118 | 559 | 559 | 559 |

*Notes*. See Table 2

Table 4

Effect of JFFS on household agricultural knowledge and practices

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Outcome variable | Baseline value treated | Baseline value control | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
| Agricultural knowledge score, 0-15 | 4.29 | 3.82 | 0.56 | 0.85** | 0.82** | 0.89*** | 0.90** |
| | | | (0.39) | (0.35) | (0.33) | (0.33) | (0.35) |
| Open all land to agriculture | 0.47 | 0.55 | 0.16** | 0.20*** | 0.21*** | 0.21*** | 0.22*** |
| | | | (0.06) | (0.05) | (0.06) | (0.06) | (0.07) |
| Cultivate a sack or kitchen garden | 0.71 | 0.71 | 0.03 | 0.07 | 0.05 | 0.05 | 0.05 |
| | | | (0.06) | (0.07) | (0.06) | (0.06) | (0.06) |
| Agricultural good practices, 0-10 | 4.41 | 4.34 | 0.06 | 0.14 | 0.08 | 0.08 | 0.07 |
| | | | (0.15) | (0.17) | (0.14) | (0.15) | (0.15) |
| At least one practice learned from students | 0.17 | 0.15 | 0.20*** | 0.22*** | 0.19*** | 0.22*** | 0.29*** |
| | | | (0.0529) | (0.045) | (0.049) | (0.049) | (0.05) |
| Observations | 279 | 280 | 1,118 | 1,118 | 559 | 559 | 559 |

*Notes*. See Table 2

Table 5

Effect of JFFS on household agricultural production

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Outcome variable | Baseline value treated | Baseline value control | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
| Nr of crops in the training adopted | | | | | | | |
| *II season 2012 vs II season 2011* | 0.79 | 0.68 | -0.038 | -0.03 | -0.01 | -0.02 | -0.01 |
| | | | (0.13) | (0.13) | (0.08) | (0.08) | (0.08) |
| *I season 2013 vs I season 2012* | 1.53 | 1.46 | -0.22* | -0.19 | -0.15 | -0.23** | -0.29*** |
| | | | (0.12) | (0.12) | (0.09) | (0.11) | (0.11) |
| New crops introduced | | | | | | | |
| *II season 2012 vs II season 2011* | 0.80 | 0.80 | 0.07 | 0.11 | 0.07 | 0.11** | 0.12** |
| | | | (0.07) | (0.08) | (0.05) | (0.06) | (0.06) |
| *I season 2013 vs I season 2012* | 0.90 | 0.91 | 0.02 | 0.04 | 0.03 | 0.04 | 0.03 |
| | | | (0.05) | (0.06) | (0.05) | (0.06) | (0.06) |
| New crop introduced because of child suggestion | | | | | | | |
| *II season 2012 vs II season 2011* | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | | | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| *I season 2013 vs I season 2012* | 0.02 | 0.01 | 0.02 | 0.03 | 0.03** | 0.02 | 0.02 |
| | | | (0.02) | (0.03) | (0.02) | (0.02) | (0.02) |
| Observations | 279 | 280 | 1,118 | 1,118 | 559 | 559 | 559 |

*Notes*. See Table 2

Table 6

Effect of JFFS on household food security and nutrition

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Outcome variable | Baseline value treated | Baseline value control | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
| FCS | 38.51 | 40.90 | 4.10* | 4.47 | 2.21 | 4.29*** | 5.57*** |
| | | | (2.30) | (2.78) | (1.44) | 1.54) | 1.62) |
| HDDS | 6.932 | 7.021 | 0.19 | 0.32 | 0.00 | 0.30 | 0.39* |
| | | | (0.25) | (0.25) | (0.17) | 0.19) | 0.19) |
| Number of weekly food types | 9.20 | 9.12 | 0.19 | 0.43 | 0.00 | 0.36 | 0.49 |
| | | | (0.38) | (0.41) | (0.28) | 0.30) | 0.31) |
| *Eat at least once per week* | | | | | | | |
| Cereals and tubers | 0.98 | 1.00 | 0.04*** | 0.04*** | 0.03*** | 0.04*** | 0.04** |
| | | | (0.01) | (0.01) | (0.01) | (0.01) | (0.02) |
| Pulses | 0.78 | 0.75 | -0.00 | 0.03 | -0.02 | 0.01 | 0.00 |
| | | | (0.06) | (0.07) | (0.05) | (0.05) | (0.05) |
| Vegetables | 0.83 | 0.88 | 0.07 | 0.05 | 0.03 | 0.05 | 0.06 |
| | | | (0.05) | (0.06) | (0.03) | (0.04) | (0.04) |
| Fruit | 0.92 | 0.90 | -0.06 | -0.07 | -0.09** | -0.06 | -0.05 |
| | | | (0.06) | (0.07) | (0.04) | (0.04) | (0.05) |
| Meat and fish | 0.62 | 0.74 | 0.16** | 0.14** | 0.08 | 0.14** | 0.14** |
| | | | (0.06) | (0.07) | (0.06) | (0.06) | (0.06) |
| Milk | 0.07 | 0.06 | 0.04 | 0.02 | 0.02 | 0.03 | 0.06** |
| | | | (0.032) | (0.04) | (0.03) | (0.03) | (0.03) |
| Sugar | 0.27 | 0.31 | 0.09* | 0.12** | 0.09* | 0.12** | 0.14** |
| | | | (0.05) | (0.05) | (0.05) | (0.05) | (0.06) |
| Oil fats | 0.72 | 0.62 | 0.03 | 0.07 | 0.09 | 0.05 | 0.02 |
| | | | (0.06) | (0.06) | (0.06) | (0.06) | (0.06) |
| Observations | 279 | 280 | 1,118 | 1,118 | 559 | 559 | 559 |

*Notes*. See Table 2

Diagram 1

Baseline and follow-up samples

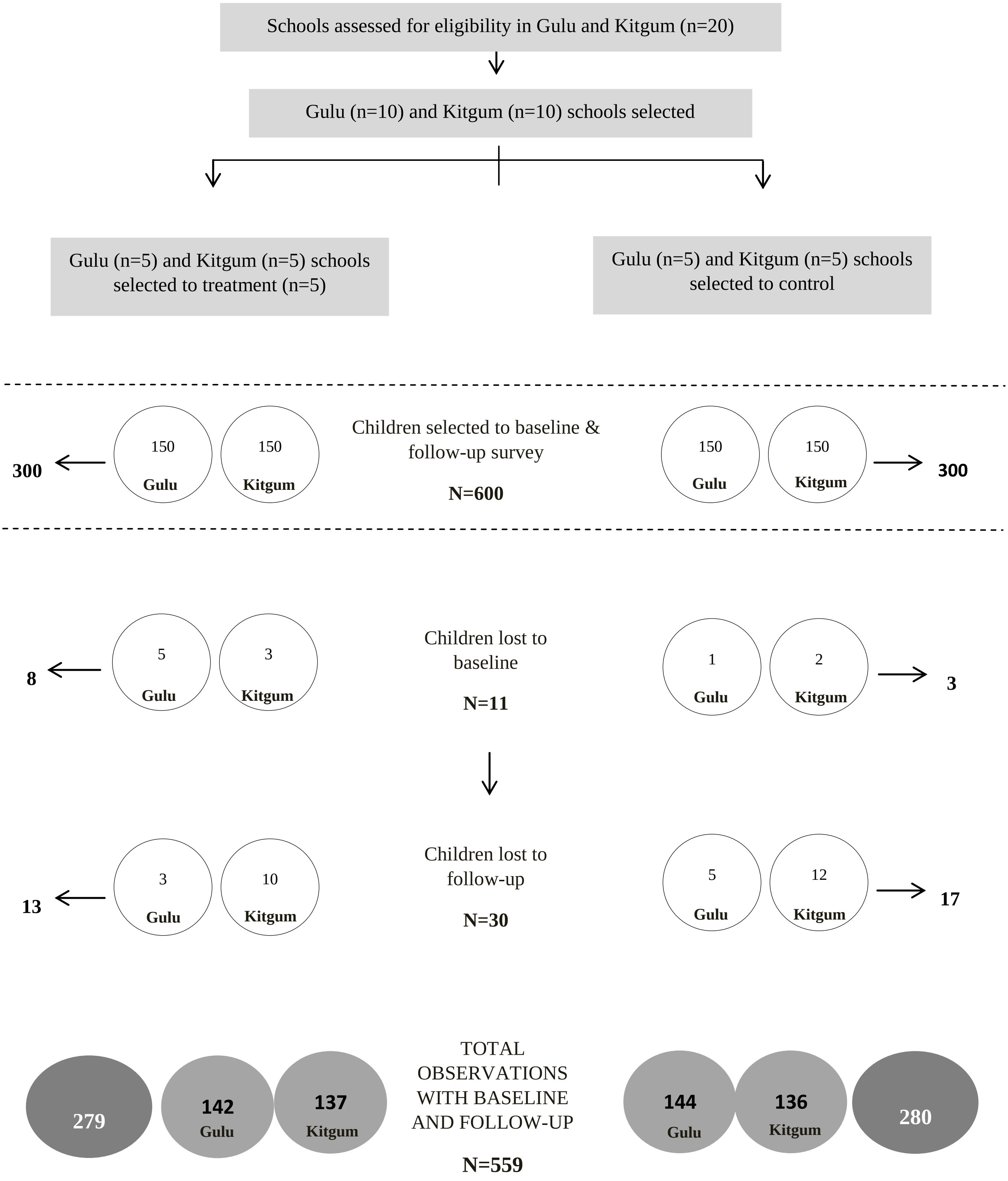

Table A1

Treatment and control schools and number of households interviewed

| District | Sub-county | School | Nr of interviewed households | | Treatment/Control |
|---|---|---|---|---|---|
| | | | *Baseline* | *Follow-up* | |
| Gulu | Lakuana | Atyang PS | 30 | 30 | Control |
| Gulu | Lakuana | Lakuana PS | 30 | 30 | Treatment |
| Gulu | Lakuana | Laminoluka PS | 28 | 27 | Treatment |
| Gulu | Laloogi | Aketket PS | 29 | 27 | Control |
| Gulu | Laloogi | Idobo PS | 30 | 29 | Control |
| Gulu | Laloogi | Lalogi PS | 30 | 30 | Control |
| Gulu | Laloogi | Loyo Ajonga PS | 30 | 29 | Treatment |
| Gulu | Odek | Lalogi Central PS | 30 | 28 | Control |
| Gulu | Odek | Aromo Wanglobo PS | 30 | 29 | Treatment |
| Gulu | Odek | Ora Pwoyo PS | 27 | 27 | Treatment |
| Kitgum | Lagoro | Akuna Laber PS | 30 | 29 | Control |
| Kitgum | Lagoro | Buluzi Lagoro PS | 30 | 30 | Control |
| Kitgum | Lagoro | Aloto PS | 29 | 28 | Treatment |
| Kitgum | Namokora | Agot Agot (Deite) PS | 30 | 28 | Treatment |
| Kitgum | Namokora | Guda PS | 29 | 25 | Treatment |
| Kitgum | Namokora | Namokora PS | 29 | 26 | Treatment |
| Kitgum | Omiya Anyima | Kalele PS | 29 | 28 | Control |
| Kitgum | Omiya Anyima | Lajokogayo PS | 30 | 27 | Control |
| Kitgum | Omiya Anyima | Lopur PS | 29 | 22 | Control |
| Kitgum | Omiya Anyima | Latututu PS | 30 | 30 | Treatment |
| TOTAL | | | 589 | 559 | |

Table A2

Determinants of students' knowledge data availability, treated and control sub-samples

| VARIABLES | Attriter treated | Attriter control |
|---|---|---|
| Head is female | -0.31* | -0.112 |
| | (0.15) | (0.072) |
| Age of head | -0.003 | -0.00 |
| | (0.00) | (0.00) |
| Head lives in couple | -0.12 | -0.06 |
| | (0.16) | (0.10) |
| Able to read or write | -0.12 | 0.11* |
| | (0.09) | (0.06) |
| Head has no schooling | 0.11 | 0.11 |
| | (0.18) | (0.09) |
| Head not completed primary | 0.15 | -0.11 |
| | (0.14) | (0.12) |
| Head primary or not compl sec | 0.082 | -0.05 |
| | (0.15) | (0.05) |
| Head farms as main activity | 0.24*** | -0.05 |
| | (0.05) | (0.08) |
| Head in formal sector | 0.00 | -0.33 |
| | (0.18) | (0.19) |
| Beneficiary of support program in 2011 | -0.11 | 0.05 |
| | (0.06) | (0.06) |
| Student is female | -0.02 | 0.05 |
| | (0.07) | (0.06) |
| Age of student | 0.04** | 0.04 |
| | (0.02) | (0.02) |
| Students' years at school | -0.02 | -0.03 |
| | (0.02) | (0.04) |
| Student attended P3 in 2012 | 0.18 | -0.35* |
| | (0.35) | (0.17) |
| Student attended P4 in 2012 | -0.27 | -0.21 |
| | (0.32) | (0.14) |
| Student attended P5 in 2012 | -0.29 | -0.25 |
| | (0.37) | (0.15) |
| Student attended P6 in 2012 | -0.32 | -0.23 |
| | (0.39) | (0.22) |
| Student attended P7 in 2012 | -0.19 | -0.068 |
| | (0.45) | (0.17) |
| Constant | 0.39 | 0.87** |
| | (0.44) | (0.29) |
| Observations | 279 | 280 |
| R-squared | 0.12 | 0.12 |
| Mean Dep Var. | 0.42 | 0.83 |

Robust standard errors clustered at school level in parentheses. ***p<0.01, **p<0.05, *p<0.1

Table A3

Treatment and control samples. Agricultural knowledge test sub-samples

| *Head characteristics* | N | All | Treatment | Control | Difference | |
|---|---|---|---|---|---|---|
| Female | 211 | 0.412 | 0.401 | 0.449 | -0.048 | |
| | | 0.034 | 0.039 | 0.072 | | |
| Age | 211 | 47.194 | 47.207 | 47.153 | 0.054 | |
| | | 0.764 | 0.874 | 1.592 | | |
| Lives in couple | 211 | 0.611 | 0.617 | 0.592 | 0.025 | |
| | | 0.034 | 0.038 | 0.071 | | |
| Able to read or write | 211 | 0.616 | 0.636 | 0.551 | 0.085 | |
| | | 0.034 | 0.038 | 0.072 | | |
| No schooling | 211 | 0.209 | 0.228 | 0.143 | 0.086 | |
| | | 0.028 | 0.033 | 0.051 | | |
| Not completed primary | 211 | 0.474 | 0.432 | 0.612 | -0.180 | |
| | | 0.034 | 0.039 | 0.070 | | |
| Primary or not completed secondary | 211 | 0.251 | 0.278 | 0.163 | 0.115 | |
| | | 0.030 | 0.035 | 0.053 | | |
| Secondary or above | 211 | 0.066 | 0.062 | 0.082 | -0.020 | |
| | | 0.017 | 0.019 | 0.040 | | |
| Farming as main activity | 211 | 0.863 | 0.870 | 0.837 | 0.034 | |
| | | 0.024 | 0.026 | 0.053 | | |
| *Student characteristics* | | | | | | |
| Female | 211 | 0.483 | 0.500 | 0.429 | 0.071 | |
| | | 0.034 | 0.039 | 0.071 | | |
| Age | 211 | 13.313 | 13.488 | 12.735 | 0.753 | ** |
| | | 0.105 | 0.117 | 0.214 | | |
| Number of years at school | 211 | 5.479 | 5.549 | 5.245 | 0.304 | |
| | | 0.084 | 0.098 | 0.158 | | |
| Student knowledge score, 0-6 | 211 | 1.626 | 1.710 | 1.347 | 0.363 | |
| | | 0.062 | 0.069 | 0.129 | | |
| Student practices agric everyday | 211 | 0.156 | 0.142 | 0.204 | -0.062 | |
| | | 0.025 | 0.028 | 0.058 | | |
| Student often helps with agric | 211 | 0.384 | 0.346 | 0.510 | -0.165 | |
| | | 0.034 | 0.037 | 0.072 | | |
| Student often uses fertilizer | 211 | 0.038 | 0.037 | 0.041 | -0.004 | |
| | | 0.013 | 0.015 | 0.029 | | |
| Student cultivates own piece | 211 | 0.616 | 0.642 | 0.531 | 0.111 | |
| | | 0.034 | 0.038 | 0.072 | | |
| *Household characteristics* | | | | | | |
| Size (nr. of members) | 211 | 7.275 | 7.216 | 7.469 | -0.253 | |
| | | 0.158 | 0.173 | 0.365 | | |
| Number of breadwinners | 211 | 1.995 | 1.963 | 2.102 | -0.139 | |
| | | 0.096 | 0.111 | 0.192 | | |
| Wealth Index | 211 | 0.124 | 0.226 | -0.212 | 0.438 | |
| | | 0.159 | 0.184 | 0.307 | | |
| Land size (acres) | 211 | 8.308 | 9.220 | 5.291 | 3.929 | ** |
| | | 0.981 | 1.233 | 1.022 | | |

*Notes*. Mean (and standard deviations) of head, student and household characteristics. ***p<0.01, **p<0.05, *p<0.1

Table A4

Placebo differences-in-differences

| Outcome variable | DD | DD PSM | Nearest neighbour | Biweight kernel | Radius |
|---|---|---|---|---|---|
| Household size | -0.0763 | 0.096 | 0.071 | 0.117 | 0.155 |
| | (0.183) | (0.238) | (0.163) | (0.198) | (0.207) |
| Use of paraffin or candles for lighting | 0.0265 | 0.037 | 0.004 | 0.034 | 0.053 |
| | (0.0469) | (0.058) | (0.039) | (0.041) | (0.043) |
| Nr of kitchen appliances | 0.0502 | 0.370 | 0.260 | 0.347 | 0.403 |
| | (0.333) | (0.334) | (0.339) | (0.359) | (0.381) |
| Nr of appliances (radio, tv) | -0.00714 | 0.027 | -0.025 | 0.026 | 0.001 |
| | (0.0510) | (0.077) | (0.060) | (0.067) | (0.071) |
| Observations | 1,118 | 1,118 | 1,118 | 1,118 | 1,118 |

*Notes*. See Table 2

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