IMPACT ASSESSMENT REPORT

Republic of Senegal

Projet d’Appui aux Filières Agricoles (PAFA)

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ACRONYMS AND ABBREVIATIONS

ANCAR	Agence Nationale de Conseil Agricole et Rural
CADL	Centre d'Appui au Développement Local
CEF	Conseiller à l'Exploitation Familiale
CNIF	Cadre National Interprofessionnel Filière
DRDR	Direction Régionale de Développement Rural
IA	Impact Assessment
MO	Market Operator
PAFA	Projet d'Appui aux Filières Agricoles
PO	Producer Organization
LOASP	Loi d'Orientation Agro-Sylvo-Pastorale
SPAM	Sous Projet d'Accès au Marché
SRADL	Services Régionaux d'Appui au Développement Local
SUTVA	Stable Unit Treatment Value

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Executive summary

Value chain development is an important strategy to achieve sustainable development for smallholder farmers. It focuses not only on farmers and their direct livelihood but recognizes that sustainable agricultural projects ought to consider the entire production process by not only improving the factors of production for smallholder farmers but also allowing for greater integration into local markets, and the strengthening of key stakeholders along the value chain.

The Agricultural Value Chains Support Project (in French *Projet d'Appui aux Filières Agricoles* (PAFA)) capitalizes on the value chain approach to improve the livelihoods of smallholder farmers in Senegal's Groundnut Basin. Approved in 2008 and put into effect on February 5th 2010, the Agricultural Value Chains Support Project has, as of today, reached 37,734 households. The project is articulated around five components: (1) agricultural diversification and access to local market (2) development and structuring of regional value chains, (3) national coordination, knowledge management and project management, (4) climate change adaptation, and (5) support services for rural finance. The project was innovative in that, in addition to providing support to farmers through producer organisations (POs), there was an emphasis on improving concertation and collaboration around key value chains.

This impact evaluation focuses on the first sub-component of component 1, the *Sous Projet d'Accès au Marché* (SPAM), which is a comprehensive support package consisting of certified inputs (seeds, fertiliser and pesticides), agricultural machinery, training on production best practices, innovative practices, post-harvest management and quality control, and a contractual agreement with a market operator. This comprehensive package was financed over three years partly by the project through a degressive subsidy to the farmers and partly by the PO. In the first year, the project financed 80% of the cost, while 20% was contributed by the PO; in the second year the project financed 60%, and 40% in the third year, with the participation of the PO increasing each year. The targeted value chains were maize, millet, sorghum, niebe (cowpea), bissap (roselle), aviculture, and *maraichage* (vegetable gardening/horticulture).

This study assesses the impact of the SPAM sub-component, as the support provided through a SPAM addresses directly the beneficiary POs and their members. This is not the case of the other components – components 2 and 3 for example – which support agricultural development, e.g. by strengthening the organisation and supporting the communication of different actors in a specific agricultural value chain. The effects of the latter PAFA activities cannot be disentangled and thus might affect PAFA beneficiary as well as non-beneficiary POs. Given that spillover effects might exist at the PO and household level, this study identified a valid counterfactual by considering two control groups in the analyses: the first, a "spillover" control group of non-beneficiary POs within the PAFA regions, and, the second, a "pure" control group of non-beneficiary POs outside of the PAFA regions. Within each PO a random sample of households was selected. The aim of this impact assessment is to determine the impact of PAFA on agricultural productivity; wellbeing measured in terms of income, asset-based indicators, and nutrition; access to market; and resilience to shocks for households in Senegal's Groundnut Basin. In order to assess these impacts, both qualitative and quantitative data were collected on household demographics, agricultural production, other income generating activities, social capital and shock exposure, as well as on PO level characteristics.

The study finds that overall PAFA was successful in increasing productivity for millet, niebe, and bissap as well as encouraging farmers to diversify away from groundnut and into more remunerative crops. Participating farmers were also more likely to commercialize their produce and sell larger quantities in the markets. These gains translated into higher crop income and overall gross income. Impacts were larger for members of women and youth organizations. It is worth noting that while the primary analysis conducted does not account for spillover effects, the secondary analysis reveals that accounting for these effects would lead to even higher project impacts.

1.Introduction

According to statistics from the International Labour Organization, the agricultural sector employs more than half (53 percent) of the Senegalese working population (World Bank, 2018). Nonetheless, the contribution of agriculture to the economy remains limited. In the past five years, agriculture contributed between 15 and 17 percent to the country's GDP (World Bank, 2016). The low return of the agricultural sector is in part due to low productivity levels, higher vulnerability in the wake of an increasingly volatile and erratic climate, and limited access to factors of production such as land and farm inputs. In the Senegalese context, these constraints are further exacerbated by highly disorganized agricultural value chains and low levels of commercialization. Agriculture in Senegal, as in much of Sub-Saharan Africa, is characterized by smallholder farming with small scale family farms responsible for more than 95 percent of the country's production. Additionally, more than three quarters of smallholder farmers cultivate groundnut, the main source of revenue in rural areas. In the last decade, the crisis of the groundnut sector crippled the economy and income for rural households, especially in Senegal's Groundnut Basin. Diversification therefore presents an opportunity for development.

It is against this backdrop that the Agricultural Value Chains Support Project (Projet d'Appui aux Filières Agricoles (PAFA)) was approved on November 5th 2010 by IFAD's Executive Board. The project was implemented between 2010 and 2014 in the four regions of Senegal's Groundnut Basin - Diourbel, Fatick, Kaffrine, and Kaolack. In the presence of a struggling groundnut industry at the inception of PAFA, its objectives aimed at supporting the development of alternative crop cultivation to increase food security in the project regions. These regions were particularly hard hit by the decline of revenues from groundnut production. The intervention aimed to improve the income earning potential of small-scale family farms through production diversification into more remunerative and sustainable value chains. More specifically, the project objectives were to 1) assist smallholder farmers in engaging in the production of crops with high earning and commercialization potential through the establishment of contractual agreements with market operators and 2) promote the development of value chains by bringing together smallholder farmers and other stakeholders to organize and to address constraints identified within these sectors, at both the local and national level.

In line with national priorities, PAFA positions itself as an anchor of the government's *Loi d'Orientation Agro-Sylvo-Pastorale* (LOASP)[1] which hinges on the improvement of the income earning potential and the living standards of rural communities through an agricultural sector that is more productive, highly diversified, and resilient to climatic shocks. Moreover, PAFA also acts as an important support for the strategic development goals established by the Government of Senegal as well as the global commitments ratified by the country. As part of its national agricultural policies, the government of Senegal is committed to propelling the economy with the sustainable development of the agricultural sector, through increased productivity of the highest potential value chains, improved infrastructure, and the establishment of a credit system in rural areas. PAFA is consistent with IFAD's overarching objective of empowering rural people to overcome poverty and achieve food security through remunerative, sustainable and resilient livelihoods. It further contributes to IFAD's strategic objectives 2016-2025 of 1) increasing poor rural people's productive capacities in a sustainable and resilient manner; 2) increasing and improving their engagement in markets, while enabling them to better manage related risks; and 3) strengthening the environmental sustainability and climate resilience of their economic activities.

PAFA consists of five components: (1) agricultural diversification and access to local market (2) development and structuring of regional value chains in Senegal's groundnut producing regions, (3) national coordination, knowledge management and project management, (4) climate change adaptation, and (5) support services for rural finance.

[1] Engl.: General law governing agriculture and agroforestry

This impact assessment will focus on the *Sous-projet d'accès aux marchés* (SPAM) (sub-projects submitted by producer organizations) and funded by PAFA under its component 1. SPAM is the main support for smallholder farmers under PAFA. The approach is innovative as the comprehensive support that farmers receive from the outset, is structured such that they are empowered during the project (for at least three years in each SPAM). Access to inputs, technical advice and linkages to markets are all put in place by the project. Financing these with a degressive subsidy enables farmers to gradually stem the costs for production themselves using the increased yields and gains from better marketed outputs.

In its conception, PAFA intervened at different stages of the value chain, from supporting farmers in focusing on particular crops to accessing markets and strengthening key actors along the value chain. PAFA is an important project in that it takes a value chain approach to agricultural development, which attempts to intervene along the production process of a product, from planting to commercialization. In the early 2000s, the value chain approach to development emerged as the solution to meet poverty reduction goals. Value chain development refers to linkages created between smallholder farms, input providers, buyers, and processors essential to bringing a product from production to consumption. That is, the set of activities that add value to agricultural products from farm to fork. Pro-poor value chain development can be defined as a "positive or desirable change in a value chain to extend or improve productive operations and generate social benefits: poverty reduction, income and employment generation, economic growth, environmental performance, gender equity, and other development goals (UNID0, 2011)." Such an integrated approach gives the opportunity to add value at different stages of the agricultural production process and benefits not only farmers but a wider range of stakeholders along the value chain (Roduner, 2007; Donovan and Dietmar, 2010). Moreover, value chain development has been found to increase farmers' efficiency and protect farmers from risks that arise during production and potential market fluctuations (Chen et al., 2015; Mutura et al., 2016). While value chain interventions have the potential to change the lives of the most vulnerable, there is surprisingly very scant evidence of the poverty impacts of such interventions. In fact, impact assessments of value chain interventions are rare, possibly due to the high specificity of such projects which makes them hardly reproducible, and the inherent complexity due to the many actors involved. Among the few studies that exist, only a handful are rigorously designed (Kidoido and Child, 2013). This impact assessment adds to recent studies that investigated the impact of agricultural projects related to research and technology adoption (Emerick et al., 2016; Verkaart et al., 2017), and agricultural extension services (Davis et al., 2012; Kondylis et al., 2017). Interventions aimed at improving agricultural productivity, along with strengthening farmers linkages with markets, are largely effective as they allow farmers to take advantage of economies of scale and/or economies of scope when marketing their crops.

This study's contribution to the literature is thus twofold. First, it contributes to knowledge by evaluating the impact of an intervention along multiple value chains. Second, this study adds to knowledge by having a robust identification strategy where two counterfactuals are constructed, a control group in the PAFA regions, to factor-in potential spillover effects and a control group in adjacent regions, which is considered a "pure" control group and allows us to identify the net impact of PAFA, free of indirect effects. In what follows, the project theory of change is presented, first detailing the channels through which project activities are expected to lead to changes in outcomes and impacts, followed by the research questions that this study seeks to answer. Next, the data collection process and the methods used to construct a valid sample and perform the analysis are explained. Then, the main results are presented. Finally, the lessons learned are discussed.

2. Theory of change and main research questions

2.1 PAFA's theory of change

The aim of the theory of change analysis in the impact assessment at hand is to assess whether the mechanism put in place by PAFA achieved the intended objectives at each step of the causal chain. Elaborating, in further detail, the different steps in this causal chain, as well as providing qualitative and empirical evidence to prove its validity is the main objective of this impact assessment.

The underlying hypothesis is that farmers lack access to inputs, lack adequate access to commercial markets and conduct their farming activities with inefficient means. Due to these constraints farmers lead insecure lives with little prospect of independently increasing productivity, access to markets and food insecurity. PAFA's main support mechanisms, namely the degressive subsidy to finance input acquisition, the training received, and the support to establish commercial contracts with market operators aimed at solving these obstacles. Ultimately, PAFA support was expected to generate higher crop yields, better productivity, and a higher share of commercially marketed output. These results in turn should have allowed higher farm incomes as well as higher resilience of farm households towards unexpected events. PAFA's targeting approach consisted of granting higher scores at the SPAM approval stage to POs with young and female membership and was precisely to ascertain that these groups would considerably benefit from PAFA's support.

Two main support mechanisms were developed under PAFA. The first support mechanism, SPAM, provided technical assistance and agricultural inputs to farmer organizations through a declining subsidy (80% in year 1, 60% in year 2 and 40% in year 3), and strengthened the linkages between POs and buyers of agricultural produce. The second mechanism provided financial and organizational support to develop and organize actors along the value-chain, and supported solutions to constraints that these actors identified. This mechanism relied heavily on the CNIF (Cadre National Interprofessionel Filière), multi-professional interest groups that formed around the respective agricultural products. The CNIF combine actors from different professions related to particular value chains. These groups identify obstacles to the development of the value chain, propose solutions and are, at times, also part of the solutions. For example, it is the CNIF that manages the distribution of barcodes that were acquired to allow marketing of PO output in supermarkets. The CNIF, to give a second example, also managed a platform that provided weather information via cell phones to farmers. The CNIF also played the role of mediator and arbitrator in case of conflict between different actors in the value chain.

The underlying concept of PAFA's SPAM program was to allow producer organizations to apply for the support in the production of millet/sorghum, niebe beans, bissap, sesame, village aviculture, or maize. Farmers could thus choose the value chain in which they wanted to be supported. Regardless of the value chain this support consisted , in general, of the following:

- Access to high quality production inputs such as certified seeds, fertilizer, pesticides, storage material and farming equipment.
- Technical consultation provided by so-called family-farm consultants who are local resource persons endogenous to the context (i.e. the local person).
- Access to farming equipment
- Access to innovative agricultural technologies, such as new crop varieties with shortened maturity cycles to increase climate change resilience of the producers, new planting techniques,

soil enrichment practices using phosphor and the association of pisciculture (fish farming) to gardening.

Further under component 1, PAFA provided support to set up village-level aviculture/poultry production. To this end, the POs received animals as well as infrastructure required (such as aviaries) for breeding and technical advice.

In addition to the production-focused support, PAFA recognized that increases in yield and agricultural production alone would not achieve the ultimate objective of increasing livelihood security and incomes of smallholder farmers unless the product was well-packaged and professionally commercialized with, optimally so, value added to the raw product. To achieve commercialization of the PO production, PAFA supported the creation of contractual linkages between beneficiary POs and market operators (MO) that purchase and commercialize the PO's output. To improve storage and packaging, storage locales were constructed and centres put in place where POs can acquire high-quality packaging material to maintain the freshness and the quality of the agricultural produce after harvest. To foster the financial sustainability of the project, and to prevent POs from depending on PAFA's support in the long term, a declining subsidy system financed the provision of the SPAM support. Over the course of three years, the share of the costs that the beneficiary POs have to cover by themselves increases each year. In year one of the SPAM, the PO pays 20%, in year two 40%, and in year three 80%. The beneficiary POs pay these shares in-kind from their increased production and increased marketed output.

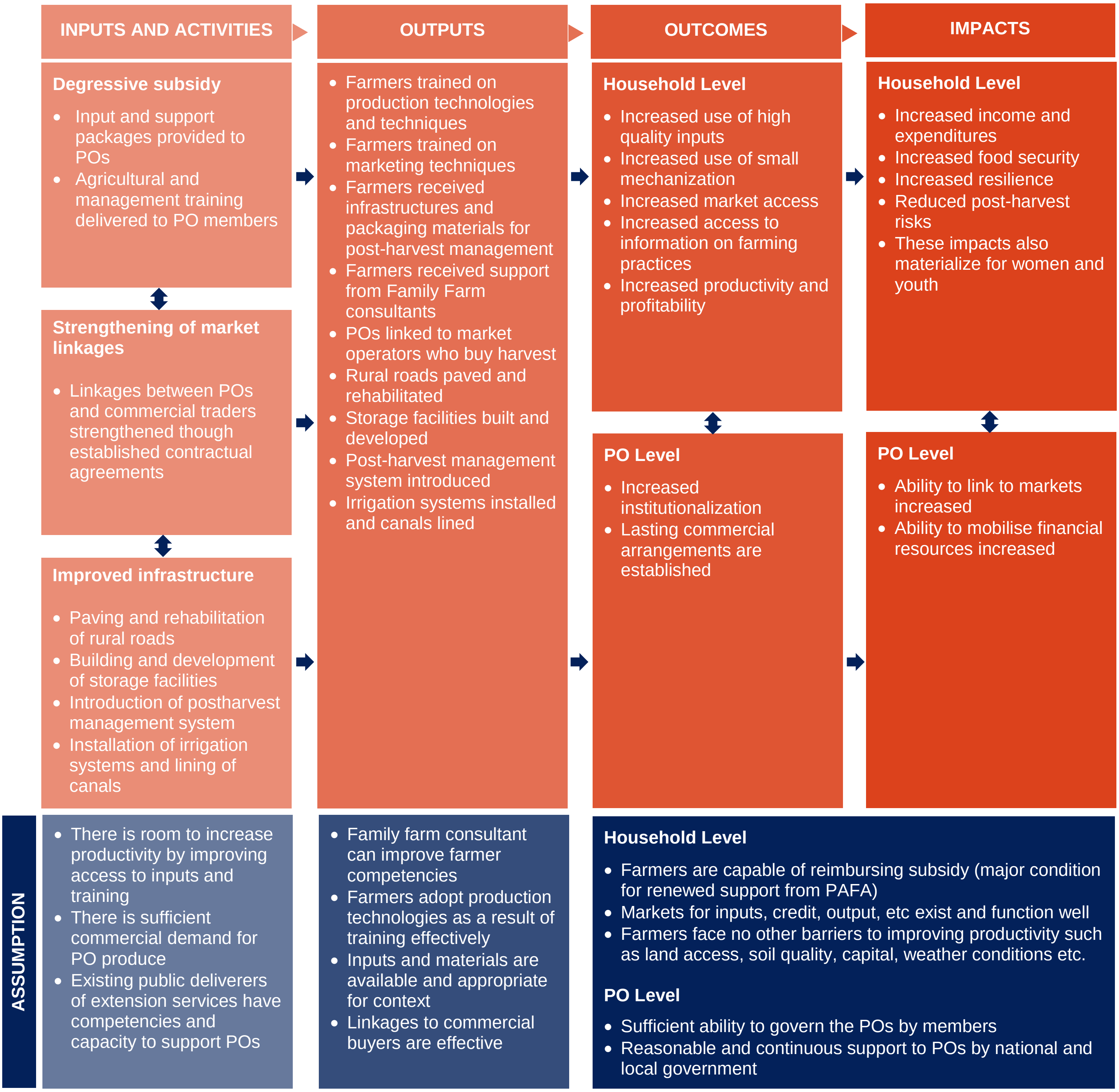
The theory of change presented in Figure 1 focuses exclusively on the activities funded by PAFA under component 1 and lays out the mechanism through which PAFA attempted to achieve the expected changes in the lives of the beneficiary farmers. PAFA's monitoring data on productivity and yields gives suggestive evidence that the implementation process was adequate and naïve before-and-after comparison based on these data indicate large effects on farmers' yields. To complement these results, this impact assessment will analyse to what extent the inputs and activities, presented in the first column of Figure 1 generated the expected outcomes and impacts as well as possible unintended impacts. It is also of fundamental interest to enquire whether the POs received the support packages they requested under SPAM, which services and inputs POs received explicitly, whether the timing of the provision was appropriate, whether the quality, e.g. of seeds, was adequate, etc. A mix of quantitative data, qualitative data and PAFA's administrative records will be exploited to elaborate on how successful PAFA was.

At the output level, PAFA was expected to generate a large number of outputs. First, farmers were trained on production technologies, agricultural techniques and marketing techniques. Second farmers received technical support from the family farm consultants, which were assumed to be sufficiently available and competent to introduce farmers to novel farming methods and techniques and to address issues farmers faced in the application of these methods and techniques. At the PO level, PAFA was expected to link the beneficiary POs to market operators to guarantee and boost harvest sales; as well as providing storage facilities and introducing post-harvest management systems. In addition PAFA had an infrastructure component both at the farmer and the PO level, whereby farmers received infrastructure support and packaging materials for post-harvest management. Last, PAFA supported local infrastructural development by paving and rehabilitating a number of rural roads as and installing irrigation systems including canals lining.

Within each PAFA PO not all members were SPAM beneficiaries, and to this end, as mentioned, a within PO targeting approach was conducted in order to choose as SPAM recipients, the most vulnerable, including women and youth. Therefore this impact assessment will also investigate whether there is a differential impact between SPAM and non-SPAM beneficiaries within a PAFA PO.

This impact assessment will focus on a number of outcomes of interest notably increased agricultural production across the PAFA supported crops via increased yields, and usage of high quality inputs and will assess differential impact across SPAM and non-SPAM recipients within PO and between PAFA and non-PAFA POs. Secondly, marketed harvest as well as other market access proxies such as value of sales will be compared between SPAM and non-SPAM beneficiaries. Ultimately, increases in agricultural production should translate into increases in income and assets accumulation as well as into higher food security and increased resilience to withstand economic as well as climatic shocks.

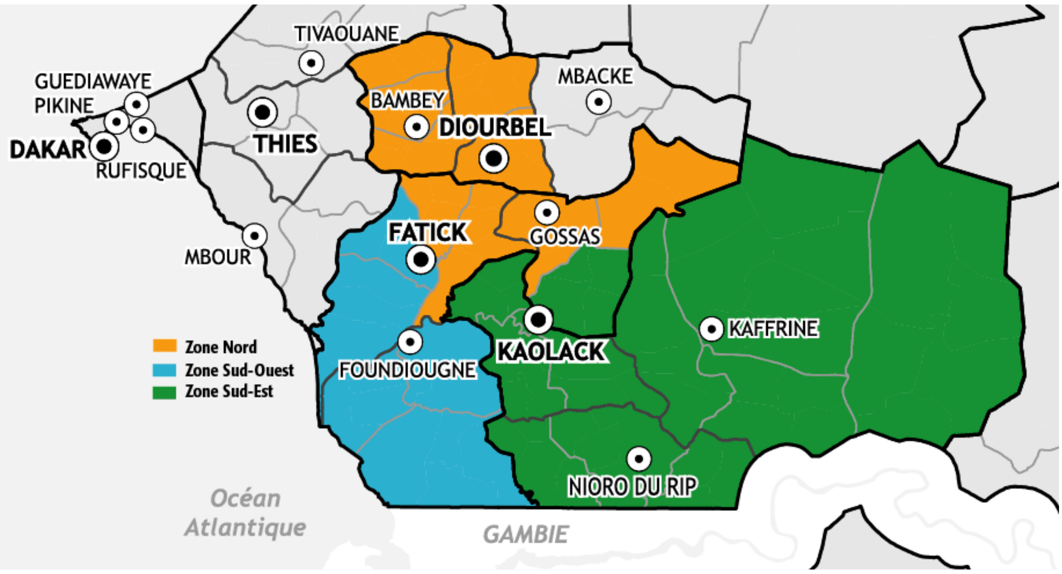
Figure 1: Theory of change



2.2 Project coverage and targeting

Geographically, the project covers four regions in the Groundnut Basin, notably Diourbel, Fatick, Kaolack and Kaffrine as seen in figure 2. In these regions, the project targeted specifically 1) vulnerable agricultural households that are landless or own land but with poor soil quality, and with low levels of income and crop diversification, low agricultural revenues, 2) women, and 3) unemployed rural youth. The targeting strategy was at the core of the choice of value chains to be included. The project identified existing food crops where production was mostly subsistent, with little commercialization structure, and in which poor households, young farmers, and women were heavily involved or those which they could easily join. A gender and vulnerable group specialist was hired during project implementation to ensure the inclusion of these groups. These value chains include millet, sorghum, sesame, niebe, bissap, aviculture, maize, and horticulture.

Figure 2. Project areas



Beneficiary selection for the SPAM followed a demand-based approach supporting small-scale agricultural producers associated in POs. PAFA conducted dissemination sessions during which project content and application process where presented to potential beneficiaries. Farmers then organized and submitted applications selecting themselves the kind of support they requested. Support was structured along different value chains and could either cover production of millet/sorghum, niebe beans, bissap, sesame, village aviculture, maize, or rice. According to discussions held with the project team, the following stylized process was applied during the selection of the beneficiary POs:

- PAFA conducted information sessions in the targeted localities and disseminated information about the planned project activities via radio broadcasts.
- POs filled in the pre-qualification forms. The pre-qualification forms list characteristics of the PO as well as names and characteristics of the most vulnerable PO members.
- POs submitted pre-qualification forms to PAFA.
- PAFA verified completeness of the information provided.
- PAFA conducted verification missions to verify the correctness of the information provided.
- The pre-qualification forms were anonymized and submitted to a selection committee, the Regional Approval Committee (RAC).

- The RAC reviewed the anonymized forms and evaluated them by applying the criteria and weighting mechanism defined by PAFA.
- The RAC selected the highest scoring project proposals. The number of projects that were approved depended on the funding available.
- The RAC submitted a selection report to PAFA listing the results of the scoring exercise and the projects selected for funding.

This selection process led to a total of 316 sub-projects (PAFA, 2017) that were supported during the PAFA implementation period through the SPAM subsidy.

During its implementation, PAFA was designed to be highly communal and non-restrictive, specially relating to the training component. One selected member (the family farm consultant) in each PO received training on best agricultural practices and was to share the knowledge acquired with other PO members. These local farm consultants were encouraged to not limit training and consultation to their POs but open it up to all interested. Moreover, part of the PAFA intervention was implemented at higher levels of aggregation, such as the infrastructure projects and the irrigation systems, which were constructed at the village level. Such a set-up could lead to potential spillover effects within villages or even communes in PAFA regions, and could result in an underestimation of the project's impact (Imbens and Angrist, 1994). Potential spillover effects within PAFA POs and PAFA regions will be taken into account as part of this impact assessment.

2.3 Research questions

By analysing the theory of change presented in Figure 1 it was possible to formulate the following research questions that will be explored in this impact assessment. Notably:

Question 1: Do households belonging to POs that received SPAM have higher agricultural productivity and production outcomes than those that did not benefit from SPAM support?

Question 2: Are households belonging to POs that received SPAM better connected to markets and traders than households in POs without SPAM support? Specifically, do households in SPAM POs sell more of their crop in the market relative to households in POs without SPAM, in relative and absolute terms?

Question 3: Do households belonging to POs that received SPAM generate greater levels of income from crop and livestock production than households belonging to POs without SPAM support?

Question 4: Do households belonging to POs that received SPAM have better nutritional outcomes compared with households belonging to POs without SPAM support?

Question 5: Are households belonging to POs that received SPAM more resilient to negative exogenous shocks than households in POs without SPAM support? Specifically, do they experience less frequent and less severe shocks, and are able to better recover from shocks than households in POs without SPAM support?

Question 6: Do households belonging to a women's POs exhibit higher benefits compared with households belonging to other types of POs?

Question 7: Do households belonging to youth centric POs exhibit significant impacts in the above mentioned domain compared to households belonging to other types of POs?

Question 1 would assess a key outcome according to PAFA's theory of change, e.g. to what extent access to PAFA support and services would allow farmers to increase the output they produce per cultivated hectare. In Senegal, a study shows that farmers who benefitted from national subsidy programs had higher production efficiency than those that did not receive any subsidy (Seck, 2016). Elsewhere in sub-Saharan Africa, studies found fertilizer subsidies to increase crop production. In the case of maize farmers in Malawi, fertiliser subsidy led to increased production not only within the same year, but also in subsequent seasons (Ricker-Gilbert and Jayne, 2010), whereas, Zambian farmers experienced a 89 percent growth in output directly attributable to the Fertilizer Support Program (FSP) launched by the Zambian government (World Bank, 2010). In addition, an impact assessment by Ambler et al. (2016) in Senegal evaluated the impact of a cash grant for farm management practices on agricultural production among small-scale farmers; it found that beneficiaries had higher farm productivity and livestock asset accumulation. The analysis also extended to uncovering that the cash grant allowed farmers to invest in farm inputs namely chemical fertilizers to increase crop yields.

Question 2 addresses the theory of change's outcome level by asking whether market access of PO members increased. The indicators of relevance here measure the extensive and intensive margin. That is, whether farmers marketed any of their output and, if so, how much they marketed in total, or how large the share of their marketed output is as compared to their total produce. A number of empirical papers estimate the impact of market access interventions. Earlier literature emphasizes the role of the transaction cost barrier in preventing smallholder farmers from participating in formal marketing channels (de Janvry et al., 1991: Key et al., 2000). Thus, policies or interventions that may reduce the transaction costs facing farmers when marketing their crops may help improve farm revenues, and thus have a direct implication on welfare outcomes (Besley and Burgess, 2000; Chamberlin and Jayne, 2013). Previous studies have shown that agricultural projects specifically focused on strengthening the linkages between farms and markets help increase farm productivity by boosting market participation opportunities for beneficiaries (Cavatassi et al., 2011; González-Flores et al., 2014). This study complements the existing literature by focusing on evaluating market linkages, and therefore examining the complementary effects of interventions related to improving farm practices and market access. This is in turn also a test of one of the underlying assumptions of the theory of change, namely that PAFA provided support that was lacking though important for increased productivity.

Question 3 and 4 assess impacts across income and nutritional outcomes. Specifically this impact assessment will estimate whether there are significant differences in income from agricultural activities exist between beneficiary and comparison farmers after controlling for observable, and optimally also for unobservable, differences.

To validate whether PAFAs intervention increased resilience, the centre of focus of question 5, an analysis of farmers behaviour in the face of shocks will be conducted.

Question 6 and 7 will assess differential impact for subgroup of PO types such as women and youth POs. The analysis of effects on sub-groups like women and youth was at the heart of PAFA's strategy from the outset. Testing how these types of POs have been affected is at the heart of these questions.

3. Impact assessment design: Data and methodology

3.1 Data

While there is suggestive evidence from PAFA's monitoring and evaluation activities that the project attained some of its desired goals using naïve before and after comparisons, this impact assessment design aims to establish causality of the PAFA project in the four regions of intervention. A mixed methods approach is employed to study the overall impacts of PAFA. Given that the intervention was implemented at the PO level, a quantitative PO questionnaire as well as a detailed household questionnaire was administered to a sample of beneficiary and non-beneficiary PO members and leaders.

Qualitative data

Qualitative interviews were conducted with different stakeholders notably program managers, PAFA field workers, community leaders, beneficiaries, non-beneficiaries, and other relevant stakeholders to both validate the selection of the comparison groups (described in the next section) and assess implementation delivery as well as the levels of input, activities and outputs. The main qualitative methods of enquiry were expert interviews (Key Informant Interviews, KII) and focus group discussions (FGDs). Two sets of FGDs were conducted 1) with project management unit staff, technical staff, providers and selected village leaders in every project region; 2) with beneficiaries and non-beneficiaries POs in all regions. One set of KIIs with project management unit staff and selected village leaders in every project region.

Experts in-depth interviews were used to ascertain that 1) the sample of villages chosen were appropriate for the quantitative data collection and 2) that PAFA targeting, provision of inputs, processes and outputs were delivered as planned. Relative to this last point, an exploration of which implementation challenges the SPAM faced, was conducted at different levels, and how these were mitigated. Shedding light on these issues could contribute to understanding the effects that will be observed in the quantitative analysis. Nine KIIs were conducted with PO leaders, representatives from PAFA's partner organizations, namely ANCAR, DRDR, and SRADL, project staff, and village leaders. Additionally, eight FGDs of 8 participants each, split equally between beneficiaries and non-beneficiaries were conducted as well as 4 FDGs with local stakeholders of the millet, niebe, bissap, and aviculture value chains. These were held separately in each region in selected villages through the help of the project management unit to get at expected and unintended impacts, as well possible spillover. Participation in the surveys was designed to include the under-represented groups targeted by the project, youth, and women. While the FGDs in Kaolack and Kaffrine included both men and women, there were only women in Fatick, and only men in Diourbel. The results from the qualitative survey were used to inform the design of the quantitative questionnaires and for cross validation.

Summary of qualitative data findings

From the qualitative interviews it was found that the agricultural sector in the target regions had lost dynamics due to the decline of the groundnut production, which also affected the vitality of the POs. PAFA succeeded in reinvigorating the producer organisations by supporting the production of crops that were formerly only planted for own consumption by farmers. PAFA beneficiaries expressed high satisfaction with the support they received. According to the respondents in the qualitative enquiry, the technical training and provision of technology increased their production and yields. Further, the brokering of contracts between farmers and market operators was essential to allow farmers to market their output lucratively. They stressed that in addition to the gains in yields that individual farmers achieved, the organisational support that PAFA provided to the value chain actors was also worthwhile as it empowered PAFA POs to take on a leadership role in their communities.

These new-found spirits were thus not only perceived to benefit the direct PAFA beneficiaries but also farmers who did either not belong to PAFA POs or members of PAFA beneficiary POs who were no direct beneficiaries. PAFA encouraged direct beneficiaries to share their new knowledge with others in their community and also gave them access to particular PAFA outputs, for example, storage facilities and improved seeds.

Information collected through qualitative interviews further pointed out that effects might not have been homogenous across value-chains. While they had earlier not been considered "cash-crops", intensive training in processing for millet and bissap production made these two crops particularly profitable. Also, the specific focus that PAFA put on young and female farmers supposedly led to these groups' experiencing particularly large improvements in income but also in their decision making power. Supposedly, PAFA also halted to some extent the youth's urge to migrate towards urban centres, which the region has suffered from since the stalling of the groundnut production.

Quantitative data

Counterfactual identification

The identification strategy for the quantitative enquiry of this impact assessment – requires the construction of a valid counterfactual, without which any impact is hardly attributable to the project. To this end, the following strategy was put in place. First, through consultation with project staff and other local stakeholders, communes similar to PAFA target communes in their agro-ecological, socioeconomic, and other relevant conditions were identified in the regions of intervention and in adjacent regions. Through this expert-based consultation 113 eligible control communes were identified. The regional nature of some of the interventions implemented under PAFA, created serious doubts for whether a pure control group, that had not been exposed directly or indirectly could be identified within the project regions. To ward off this issue, communities were identified in adjacent regions with similar geographic, climatic and socio-economic context and where farming and market conditions were very similar. Comparison POs from these communities were not exposed to regional PAFA activities at all and thus represented a good approximation of the counterfactual for the PAFA POs. Regarding comparison POs that were drawn within the PAFA regions, the interventions implemented at the local level directly benefited only the selected POs. However, smallholder farmers that were ineligible, or eligible but not selected, might have been indirectly affected by PAFA. If these non-beneficiaries become part of the control group, it will be unlikely that the impact estimates will be unbiased and free from contamination effects. In other words, the stable unit treatment value assumption (SUTVA) would be violated. Based on conversations with the project team and local officials, communes where only one PO benefitted from SPAM were considered part of the control. Spillover effects in these communes, if any, would be negligible.

Once the 113 control were identified through the consultation, an enumeration or census of POs in these communes was undertaken to be able to obtain a valid PO-level counterfactual. Due to budget and time constraints, a full enumeration of POs was not feasible. In each commune, a list of POs was obtained from the *Centre d'Appui au Développement Local* (CADL) to proceed to a listing of at least 25 POs per commune, equally divided, to the extent possible, between formal and informal POs. The threshold of 25 was determined based on the largest number of PAFA POs in the high intensity communes (e.g. communes with a very high number of PAFA POs). When the list available at the CADL had 25 or less POs, a full enumeration was conducted. However, to avoid introducing convenience bias, when the number POs exceeded 25, a random sample of 25 was selected. This enumeration exercise allowed the identification of non-beneficiary POs with similar characteristics (main culture harvested, age since creation of the group, number of members, main crop, geographical location and formalization status) to the beneficiary PAFA POs. The enumeration exercise concluded with a list of 3,038 POs. The listing or enumeration exercise collected relevant information to determine the PO level counterfactual notably the number of members, the number of male and female members, the gender of the PO leader, the main PO crop and income generating activities of the POs as well as the year when the PO was created. This information was paramount to get at the observable characteristics of the POs and to be able to establish a sample a group of treated and comparison POs with similar characteristics at baseline. This enumeration effectively constituted the sampling frame from which a valid counterfactual could be determined and from which the PO-level sample was drawn.

Spillover effects

Spillover effects are present at different levels. Within treated regions there was a high probability that the presence of PAFA POs would positively influence the outcomes of non-participants. In other words, the stable unit treatment value (SUTVA) could be violated within regions but could hold across them. Some of the spillover effects were induced during project implementation, while other spillover s also arose from social interactions between beneficiaries and non-beneficiaries. Trained family farm consultants or *conseiller à l'exploitation familiale* (CEF) were encouraged to share the acquired training with non PO members.

First, non-beneficiary POs in the intervention regions (Kaolack, Kaffrine, Fatick, and Diourbel) were likely to benefit from some communal aspects of the treatment such as road rehabilitation, irrigation instalments, and storage facilities. These can be thought of as externality spillovers (Angelucci and di Maro, 2015). A number of studies have found evidence of such effects with for example the introduction of genetically modified seeds which changed the genetic fabric of non-genetically modified species (Rieben et al., 2011), or in health related interventions where non-beneficiaries of deworming drugs were found to be less likely to fall sick as a results of deworming of other children in the neighbourhood (Miguel and Kremer, 2004). Non PAFA POs are likely to benefit from irrigation and storage facilities, and gain better access to markets as a results of improved infrastructure. In addition, based on conversations with the PMU and IFAD staff in Senegal, in PAFA regions – other development agencies had implemented development interventions similar to the PAFA ones generating additional contamination in the control POs in PAFA regions.

Second, there are possible spillover effects at the household level. In fact, within PAFA POs, while only selected households benefitted from the SPAM, anecdotal evidence and conversations with the PMU revealed that PO members that did not benefit from SPAM received assistance in the form of seed inputs, fertilizer, and pesticide from SPAM beneficiaries within the PO. In some POs, SPAM beneficiaries pooled their resources to provide a 'pseudo SPAM' for non-beneficiaries in their PO. These spillovers effects are based on social interactions where SPAM recipients share their resources with family, friends and fellow members in the POs and might influence them in adopting improved seeds for planting. Such effects are common in the literature. An impact evaluation of a conditional cash transfer in Mexico found that non-beneficiaries were increasingly likely to enrol in school as a result of peer effects from the treatment (Bobonis and Finan, 2009).

Therefore, as part of this impact assessment spillover effects at both PO and household level will be taken into account in order to avoid a potential underestimation of the project impact (Angelucci and Attanasio 2006).

In practical terms, in order to capture and isolate spillover effects across POs, two control groups were constructed 1) a "pure" control group which consisted of comparison POs sampled from non-PAFA regions (Thiès, Louga, and Tambacounda) with similar geographic, climatic and socio-economic context and where farming and market conditions were very similar, 2) a "spillover" control group which consisted of POs sampled within PAFA regions.

Based on the PO census/enumeration data, propensity score matching (PSM) was conducted to arrive at the final sample used for the analysis: e.g. matching was done prior to sampling the final number of POs in the various groups, and the households within the selected POs. The first stage consisted of using the nearest neighbour PSM with 5 neighbours to pair treated PAFA POs with control POs both within the PAFA regions and outside regions, based on a number of key baseline characteristics which were collected during the census process, notably: the number of years since the creation of the PO, the registration status at creation, whether the PO had an administrative board, whether they had a storage facility, whether the PO was all female, the number of members, the primary value chains, land area cultivated, quantity harvested, and funds available at creation. Matching ensured that POs in treatment and comparison groups were comparable in the key baseline characteristics. Tables 3.1 and 3.2 show summary statistics on the matching variables before and after matching for the two sets, respectively the PAFA POs versus control POs in PAFA regions, and PAFA POs versus control POs in non-PAFA or outside regions. In Appendix 1, two figures are presented, showing the propensity scores distribution of the treated and control group within PAFA regions (Figure 2) and of the treated and control POs outside the PAFA regions (Figure 3). The common support assumption holds in both cases. The diagnostic tests conducted after matching (Rosembaum and Rubin bias) indicates a reduction in the mean bias from 20.4% before matching to 3.5% after matching for the first set, and from 89.3% before matching to 14.8% after matching for the second. These levels are below the critical level of 25% suggested by the literature (Rosenbaum and Rubin (1985). These results indicate that the procedure was successful at balancing the distribution of covariates between the treated POs group and the within PAFA region control, as well as between the treated POs group and the outside PAFA region control group. In lay terms, a suitable counterfactual was found both in PAFA regions, and outside regions.

Table 3.1: Summary statistics before/after matching between treament and control POs within PAFA regions

	Before matching				After matching				Reductio n in Bias (%)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	
Years since creation	16.54	12.86	0.000***	23.6	16.42	15.92	0.56	5.02	78.73
	0.67	0.17	.	.	0.69	0.41	.	.	.
Number of members (log)	3.73	3.42	0.000***	23.3	3.70	3.69	0.95	0.56	97.61
	0.06	0.01	.	.	0.06	0.04	.	.	.
PO was formal at creation	0.65	0.63	0.511	3.95	0.65	0.65	0.90	1.03	74.02
	0.03	0.01	.	.	0.03	0.02	.	.	.
Female organization	0.35	0.56	0.000***	43.8	0.36	0.38	0.64	3.71	91.52
	0.03	0.01	.	.	0.03	0.02	.	.	.
Had an administrative board	1.95	1.95	0.608	4.46	1.96	1.95	0.54	6.10	-36.88
	0.01	0.00	.	.	0.01	0.01	.	.	.
Area harvested at creation (log)	3.08	2.00	0.000***	69.5	3.06	3.03	0.83	1.81	97.40
	0.10	0.03	.	.	0.10	0.07	.	.	.

Funds available at creation (log)	10.79	10.18	0.000***	17.6	10.79	10.86	0.68	3.26	81.50
	0.14	0.05	.	.	0.14	0.09	.	.	.
Harvest at creation (log)	10.34	9.14	0.000***	41.9	10.33	10.29	0.87	1.30	96.90
	0.18	0.06		.	0.18	0.14	.	.	.
Had a storage facility	0.12	0.06	0.000***	17.4	0.12	0.13	0.64	4.52	74.01
	0.02	0.00	.	.	0.02	0.01	.	.	.
Value chain at creation									
Bissap	0.14	0.15	0.501	3.09	0.14	0.13	0.86	1.40	54.76
	0.02	0.01	.	.	0.02	0.01	.	.	.
Maize	0.28	0.36	0.013**	9.24	0.28	0.28	1.00	0.00	100.00
	0.03	0.01	.	.	0.03	0.02	.	.	.
Millet	0.74	0.79	0.053*	9.16	0.74	0.76	0.67	3.47	62.12
	0.03	0.01	.	.	0.03	0.02	.	.	.
Sorghum	0.02	0.03	0.720	2.15	0.02	0.03	0.55	5.03	-133.51
	0.01	0.00	.	.	0.01	0.01	.	.	.
Rice	0.03	0.02	0.506	1.43	0.02	0.03	0.80	2.07	-45.27
	0.01	0.00	.	.	0.01	0.01	.	.	.
Sesame	0.05	0.01	0.000***	17.9	0.03	0.02	0.37	8.77	51.05
	0.01	0.00	.	.	0.01	0.01	.	.	.
Horticulture	0.10	0.12	0.224	12.9	0.10	0.11	0.73	2.54	80.31
	0.02	0.01	.	.	0.02	0.01	.	.	.
Aviculture	0.16	0.06	0.000***	28.7	0.16	0.19	0.32	10.3	64.19
	0.02	0.00			0.02	0.02			
No. of observations	258	2 591			243	1 558			

Note: Asterisks represent level of statistical significance of t-test/chi-squared test of difference in means..01 - ***; .05 - **; .1 - *;

Point estimates are sample means. Standard errors are reported below.

Matching is done on 2591 POs sampled from communes in the PAFA intervention regions, namely, Diourbel, Fatick, Kaolack and Kaffrine.

Table 3.2: Summary statistics before/after matching for PAFA and control POs outside PAFA regions

	Before matching				After matching				Reduction in Bias (%)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat. Mean/SE	Control Mean/SE	p-value	Bias	
Years since creation	16.54	14.47	0.020**	16.47	15.46	15.31	0.88	1.77	89.25
	0.67	0.59	.	.	0.54	0.70	.	.	.
Number of members (log)	3.73	3.65	0.296	5.34	3.70	3.68	0.85	2.31	56.72
	0.06	0.05	.	.	0.06	0.06	.	.	.
PO was formal at creation	0.65	0.65	0.939	4.85	0.67	0.69	0.76	3.78	21.99
	0.03	0.03	.	.	0.03	0.04	.	.	.
Female organization	0.35	0.53	0.00***	34.81	0.40	0.43	0.63	5.95	82.90
	0.03	0.03	.	.	0.03	0.04	.	.	.
Had an administrative board	1.95	1.99	0.026**	0.90	2.00	1.99	0.54	12.00	-1 239
	0.01	0.01	.	.	0.00	0.01	.	.	.
Area harvested at creation (log)	3.08	2.39	0.000***	34.33	3.03	2.98	0.79	3.32	90.32
	0.10	0.09	.	.	0.11	0.13	.	.	.
Funds available at creation (log)	10.79	10.58	0.324	1.66	10.88	10.95	0.81	2.91	-75.77
	0.14	0.15	.	.	0.15	0.19	.	.	.
Harvest at creation (log)	10.34	9.65	0.004***	21.00	10.41	10.30	0.73	4.08	80.58
	0.18	0.16	.	.	0.19	0.21	.	.	.
Had a storage facility	0.12	0.05	0.003***	6.64	0.08	0.09	0.80	3.77	43.21
	0.02	0.01	.	.	0.02	0.02	.	.	.
Value chain at creation									
Bissap	0.14	0.14	0.849	1.09	0.13	0.14	0.87	2.24	-106.67
	0.02	0.02	.	.	0.02	0.03	.	.	.
Maize	0.28	0.29	0.784	2.26	0.28	0.27	0.87	2.11	6.77
	0.03	0.03	.	.	0.03	0.04	.	.	.
Millet	0.74	0.67	0.082*	16.94	0.75	0.76	0.89	1.67	90.12
	0.03	0.03	.	.	0.03	0.03	.	.	.
Sorghum	0.02	0.05	0.074*	20.80	0.02	0.02	0.87	0.98	95.28
	0.01	0.01	.	.	0.01	0.01	.	.	.
Rice	0.03	0.02	0.654	8.41	0.02	0.02	0.85	1.80	78.62
	0.01	0.01	.	.	0.01	0.01	.	.	.
Sesame	0.05	0.01	0.004***	3.11	0.01	0.01	0.74	3.41	-9.41
	0.01	0.00	.	.	0.01	0.01	.	.	.
Horticulture	0.10	0.34	0.000***	60.73	0.11	0.11	0.88	1.17	98.07
	0.02	0.03	.	.	0.02	0.02	.	.	.
Aviculture	0.16	0.15	0.823	0.38	0.17	0.19	0.67	5.77	-1 427.86
	0.02	0.02	.	.	0.03	0.03	.	.	.
No. of observations	258	283	.	.	211	186	.	.	.

Note: Asterisks represent level of statistical significance of t-test/chi-squared test of difference in means. .01 - ***; .05 - **; .1 - *;

Point estimates are sample means. Standard errors are reported below.

Matching is done on 283 POs sampled from communes in adjacent regions outside PAFA intervention areas, namely, Tambacounda, Louga and Thies.

After running propensity score matching to obtain balanced groups, the second step consisted of drawing a sample of 65 treated POs, 65 “spillover” POs, and 50 “pure” controls from the common support identified earlier. Then, within each treated PO, 20 households were randomly selected divided as follows: 10 members who benefitted from SPAM (5 women and 5 men), and 10 ordinary members (non-SPAM, for brevity) who did not benefit from SPAM (5 women and 5 men). The group of ordinary members was sampled to be able to identify within-PO spillover effects e.g. indirect effects from SPAM to non-SPAM members. In cases where the target number of households could not be reached within a PAFA PO, an additional list of reserves POs was employed. This issue arose if all (or most) members of a PO were SPAM beneficiaries and there weren’t any (or enough) ordinary members or in cases where there were enough ordinary and SPAM members but they were from the same households, and therefore did not constitute separate households. In each region, 9 POs were randomly selected to serve as replacement and account for such cases. The reserve was triggered when less than 8 SPAM members or less than 8 non-SPAM members were available for interviews. In such cases the available members were completed and the reserve PO was also fully completed. Eventually, 20 reserves from the PAFA list were additionally sampled to reach the expected sample size. Along with each PAFA PO sampled, one matching control PO within and one matching outside the PAFA region were sampled.[2]

Within each spillover and control PO, 8 members were randomly selected (4 women and 4 men). The final PO sample used for the quantitative data collection consisted of 220 POs (85 treated, 86 spillover and 51 pure control POs) for a total 2233 households (835 SPAM households and 361 non-SPAM households; 387 from pure control POs; and 650 from spillover POs)) distributed across 7 regions.

In the third step of the analysis, household level treatment effects were computed from a starting sample of 2233 households. Propensity score matching was also conducted to assess the validity of the counterfactual at household level. Tables 3.3 to 3.5 present the summary statistics before and after matching, this time at the household level, for 3 sets: the first between SPAM households within PAFA POs and control households within the PAFA regions; the second between the SPAM households and control households outside the PAFA regions; and third where SPAM households were matched to the entire group of households in the two control groups combined. Even at household level, the diagnostic tests conducted after matching (Rosembaum and Rubin bias) indicates a reduction in the mean bias of 10.6% with the control within sample, and 25.1 with the control outside sample, and 13.8% when both controls are joined.

Table 3.3: Summary statistics before/after matching for SPAM households vs control households within the PAFA regions

	Before matching				After matching				Reduction in Bias (%)
	SPAM. Mean/SE	Control Mean/SE	p-value	Bias	SPAM Mean/SE	Control Mean/SE	p-value	Bias	
Household Size	12.69	12.00	0.017**	9.70	12.52	12.872	0.35	6.38	34.25
	0.20	0.21	.	.	0.19	0.239	.	.	.
Female head	0.09	0.12	0.144	7.02	0.09	0.093	0.96	0.24	96.59
	0.01	0.01	.	.	0.01	0.012	.	.	.
Dependency Ratio	0.99	0.91	0.039**	9.95	0.98	0.987	0.94	0.47	95.29
	0.03	0.03	.	.	0.03	0.027	.	.	.
Age of head	53.10	52.80	0.667	2.32	53.11	53.351	0.77	1.78	23.28

	0.47	0.52	.	.	0.47	0.547	.	.	.
Experienced a climatic shock 5 years ago	0.15	0.15	0.940	0.64	0.15	0.151	0.95	0.41	36.59
	0.01	0.01	.	.	0.01	0.014	.	.	.
Number of household members on the PO board	0.21	0.26	0.063*	9.33	0.21	0.218	0.83	1.21	87.01
	0.02	0.02	.	.	0.02	0.018	.	.	.
Baseline characteristics (1=Improved, 0=Unimproved)									
Walls	0.23	0.20	0.214	3.43	0.22	0.213	0.86	1.08	68.63
	0.01	0.02	.	.	0.01	0.016	.	.	.
Roof	0.03	0.05	0.028**	10.98	0.03	0.028	0.91	0.50	95.46
	0.01	0.01	.	.	0.01	0.007	.	.	.
Floor	0.39	0.41	0.386	5.06	0.39	0.388	0.97	0.25	95.09
	0.02	0.02	.	.	0.02	0.020	.	.	.
Toilet	0.14	0.20	0.010***	13.05	0.15	0.142	0.83	1.17	91.05
	0.01	0.02	.	.	0.01	0.014	.	.	.
Electricity	0.11	0.20	0.000***	23.59	0.11	0.122	0.64	2.30	90.25
	0.01	0.02	.	.	0.01	0.013	.	.	.
Water source	0.34	0.38	0.126	9.00	0.34	0.339	0.90	0.71	92.08
	0.02	0.02	.	.	0.02	0.019	.	.	.
Number of rooms	4.26	4.22	0.697	1.12	4.24	4.276	0.83	1.42	-26.55
	0.08	0.09	.	.	0.08	0.095	.	.	.
Belongs to Women PO	0.32	0.48	0.000***	31.01	0.33	0.338	0.71	2.06	93.35
	0.02	0.02	.	.	0.02	0.019	.	.	.
Size of PO (large)	0.30	0.30	0.839	0.14	0.30	0.321	0.50	4.14	-2 882.35
	0.02	0.02	.	.	0.02	0.019	.	.	.
PO created after 2010	0.72	0.61	0.000***	21.81	0.71	0.733	0.45	4.10	81.23
	0.02	0.02	.	.	0.02	0.018	.	.	.
Head edu==PRIMARY INCOMPLETE	0.08	0.09	0.336	4.95	0.08	0.071	0.78	1.51	69.56
	0.01	0.01	.	.	0.01	0.010	.	.	.
Head edu==PRIMARY/MIDDLE	0.07	0.11	0.032**	10.63	0.08	0.075	0.96	0.25	97.60
	0.01	0.01	.	.	0.01	0.011	.	.	.
Head edu==SECONDARY PLUS	0.02	0.03	0.032**	10.74	0.02	0.018	0.76	1.43	86.66
	0.00	0.01	.	.	0.00	0.005	.	.	.
Head edu==CORANIC	0.34	0.31	0.308	5.37	0.34	0.347	0.79	1.66	69.00
	0.02	0.02	.	.	0.02	0.019	.	.	.
No. of observations	835	650	.	.	820	650	.	.	.
Point estimates are sample means. Standard errors are reported below.									
Asterisks represent level of statistical significance of t-test/chi-squared test of difference in means. 01 - ***; .05 - **; .1 - *;									

Table 3.4: Summary statistics before/after matching for SPAM households vs control households outside the PAFA regions

	Before matching				After matching				Reduction in Bias (%)
	SPAM. Mean /SE	Control Mean/SE	p-value	Bias	SPAM Mean/SE	Control Mean/SE	p-value	Bias	
Household Size	12.69	11.41	0.00***	19.10	12.46	12.595	0.80	2.50	86.91
	0.20	0.28	.	.	0.20	0.314	.	.	.
Female head	0.09	0.14	0.006***	15.43	0.09	0.070	0.14	7.72	50.01
	0.01	0.02	.	.	0.01	0.014	.	.	.
Dependency Ratio	0.99	0.92	0.118	9.01	0.99	0.921	0.24	8.76	2.72
	0.03	0.04	.	.	0.03	0.034	.	.	.
Age of head	53.10	52.45	0.439	4.05	53.01	54.001	0.38	7.31	-80.31
	0.47	0.70	.	.	0.48	0.729	.	.	.
Experienced a climatic shock 5 years ago	0.15	0.21	0.006***	14.92	0.16	0.172	0.64	3.90	73.83
	0.01	0.02	.	.	0.01	0.020	.	.	.
Number of household members on the PO board	0.21	0.26	0.066*	10.90	0.21	0.192	0.54	4.40	59.69
	0.02	0.02			0.02	0.022			
Baseline characteristics (1=Improved, 0=Unimproved)									
Walls	0.23	0.22	0.617	1.85	0.22	0.238	0.74	3.16	-70.69
	0.01	0.02	.	.	0.01	0.023	.	.	.
Roof	0.03	0.01	0.008***	7.94	0.01	0.005	0.16	8.07	-1.57
	0.01	0.00	.	.	0.00	0.004	.	.	.
Floor	0.39	0.53	0.000***	26.68	0.40	0.397	0.88	1.22	95.41
	0.02	0.03	.	.	0.02	0.026	.	.	.
Toilet	0.14	0.18	0.085*	9.26	0.15	0.160	0.74	2.92	68.50
	0.01	0.02	.	.	0.01	0.020	.	.	.
Electricity	0.11	0.22	0.000***	29.95	0.11	0.123	0.70	2.52	91.60
	0.01	0.02	.	.	0.01	0.018	.	.	.
Water source	0.34	0.36	0.409	6.50	0.33	0.376	0.32	8.84	-36.00
	0.02	0.02	.	.	0.02	0.026	.	.	.
Number of rooms	4.26	4.63	0.008***	16.10	4.27	4.438	0.32	7.43	53.84
	0.08	0.11	.	.	0.08	0.106	.	.	.
Belong to Women PO	0.32	0.57	0.000***	49.69	0.33	0.331	0.95	0.47	99.05
	0.02	0.03	.	.	0.02	0.025	.	.	.
Size of PO (large)	0.30	0.24	0.045**	9.91	0.29	0.291	0.91	1.03	89.60
	0.02	0.02	.	.	0.02	0.024	.	.	.
PO created after 2010	0.72	0.52	0.000***	37.59	0.70	0.719	0.68	2.95	92.14
	0.02	0.03	.	.	0.02	0.024	.	.	.
Head edu==PRIMARY INCOMPLETE	0.08	0.06	0.309	5.06	0.07	0.048	0.17	9.47	-87.31
	0.01	0.01	.	.	0.01	0.011	.	.	.
Head edu==PRIMARY/MIDDLE	0.07	0.06	0.542	3.41	0.07	0.071	0.91	1.00	70.75
	0.01	0.01	.	.	0.01	0.014	.	.	.
Head edu==SECONDARY	0.02	0.04	0.012**	14.60	0.02	0.010	0.39	2.97	79.68

PLUS	0.00	0.01	.	.	0.00	0.005	.	.	.
Head edu==CORANIC	0.34	0.29	0.070*	11.13	0.34	0.395	0.19	12.26	-10.19
	0.02	0.02	.	.	0.02	0.026	.	.	.
No. of observations	835	387	.	.	792	387	.	.	.

Note: Asterisks represent level of statistical significance of t-test/chi-squared test of difference in means..01 - ***; .05 - **; .1 - *;

Point estimates are sample means. Standard errors are reported below.

Matching is done on 2591 POs sampled from communes the PAFA intervention regions, namely, Diourbel, Fatick, Kaolack and Kaffrine.

Table 3.5: Summary statistics before/after matching for SPAM households vs all control households

	Before matching				After matching				Reduction in Bias (%)
	SPAM. Mean/SE	Control Mean/SE	p-value	Bias	SPAM Mean/SE	Control Mean/SE	p-value	Bias	
Household Size	12.69	11.78	0.000***	15.72	12.64	12.628	0.96	0.27	98.28
	0.20	0.17			0.19	0.194			
Female head	0.09	0.13	0.020**	10.79	0.09	0.106	0.39	4.32	59.97
	0.01	0.01			0.01	0.010			
Dependency Ratio	0.99	0.92	0.023**	10.09	0.99	0.968	0.58	2.87	71.56
	0.03	0.02			0.03	0.022			
Age of head	53.10	52.67	0.492	3.32	53.12	53.274	0.83	1.16	65.06
	0.47	0.42			0.47	0.456			
Experienced a climatic shock 5 years ago	0.15	0.18	0.154	6.46	0.15	0.166	0.46	3.97	38.53
	0.01	0.01			0.01	0.012			
Number of household members on the PO board	0.21	0.26	0.029**	10.00	0.21	0.215	0.89	0.68	93.15
	0.02	0.01			0.02	0.014			
Baseline characteristics (1=Improved, 0=Unimproved)									
Walls	0.23	0.21	0.260	4.35	0.23	0.220	0.79	1.46	66.46
	0.01	0.01	.	.	0.01	0.014	.	.	.
Roof	0.03	0.03	0.538	2.80	0.03	0.028	0.91	0.55	80.23
	0.01	0.01	.	.	0.01	0.005	.	.	.
Floor	0.39	0.46	0.003***	13.52	0.39	0.398	0.84	1.07	92.06
	0.02	0.02	.	.	0.02	0.016	.	.	.
Toilet	0.14	0.19	0.008***	12.13	0.15	0.155	0.61	2.64	78.23
	0.01	0.01	.	.	0.01	0.012	.	.	.
Electricity	0.11	0.21	0.000***	26.50	0.11	0.122	0.53	2.71	89.76
	0.01	0.01	.	.	0.01	0.011	.	.	.
Water source	0.34	0.37	0.138	7.07	0.34	0.366	0.30	5.58	21.06
	0.02	0.02	.	.	0.02	0.016	.	.	.
Number of rooms	4.26	4.37	0.304	4.89	4.26	4.331	0.55	3.04	37.69
	0.08	0.07	.	.	0.08	0.071	.	.	.
Belong to Women PO	0.32	0.51	0.000***	39.28	0.32	0.315	0.71	1.84	95.32
	0.02	0.02	.	.	0.02	0.015	.	.	.
Size of PO (large)	0.30	0.28	0.404	3.93	0.30	0.321	0.37	5.04	-28.32
	0.02	0.01	.	.	0.02	0.015	.	.	.

PO created after 2010	0.72	0.58	0.000***	29.32	0.72	0.735	0.44	3.72	87.33
	0.02	0.02	.	.	0.02	0.015	.	.	.
Head edu==PRIMARY INCOMPLETE	0.08	0.08	0.830	0.86	0.08	0.075	0.93	0.45	47.63
	0.01	0.01	.	.	0.01	0.009	.	.	.
Head edu==PRIMARY/MIDDLE	0.07	0.09	0.202	5.82	0.07	0.084	0.53	3.32	42.97
	0.01	0.01	.	.	0.01	0.009	.	.	.
Head edu==SECONDARY PLUS	0.02	0.03	0.010***	12.19	0.02	0.015	0.90	0.46	96.21
	0.00	0.01	.	.	0.00	0.004	.	.	.
Head edu==CORANIC	0.34	0.30	0.105	7.62	0.34	0.359	0.45	4.23	44.55
	0.02	0.01	.	.	0.02	0.016	.	.	.
No. of observations	835.00	1 037.00	.	.	831.00	1 037.000	.	.	.
Point estimates are sample means. Standard errors are reported below.									
Asterisks represent level of statistical significance of t-test/chi-squared test of difference in means 01 - ***; .05 - **; .1 - *;									

3.2 Questionnaire and impact indicators

This impact assessment fielded two survey instruments; the household questionnaire which contains information on household demographics, agricultural production, other income generating activities, and a shock/resilience module; and a PO-level questionnaire where a detailed account of PO activities, their institutional structure, crop production, level of market access, and constraints faced were recorded. Using the data collected, the impact of PAFA was estimated on household-level indicators such as agricultural production, economic wellbeing, and resilience, and at the PO -level on market access, commercialization and asset levels, income and crop diversification.

Household level indicators

Adoption of crops promoted by PAFA

Given the focus of the project which aimed at promoting crops diversification of millet, maize, niebe and sorghum, this study estimates the impact on the probability of cultivating these crops and check whether, thanks to the PAFA SPAM subsidy there were any substitution effect with different types of crops.

Agricultural production, productivity

The IA looked at agricultural production and productivity indicators for the major crops that farmers cultivated during the 2017 rainy season. These crops include the PAFA supported crops and groundnut. The most commonly used agricultural production indicators are those pertaining to production of crops or livestock. For crop production, crop yields usually defined as the output per unit of land (kg/ha) are used. Additionally, crop sale value are used as an alternative indicator for crop production. For livestock production, the number of livestock units owned is used. As a measure of livestock units owned, the tropical livestock unit (TLU) was constructed by assigning weights to each livestock type based on their weight. To measure agricultural productivity, the rate of production for given inputs such as seeds, fertilizers, and pesticides are used. The reference period is the 12 months prior to the beginning of the survey.

Agricultural income

Among economic indicators, agricultural and rural household income indicators are considered key in assessing the impact of development policies. Crop income, livestock income and gross household income indicators were used to evaluate the impact of the project on household welfare. Gross household income was defined as the total amount generated from agricultural and non-agricultural activities. This includes income generated from sales of crops, livestock, and poultry, products from crops, livestock and poultry, other farm income (e.g. hiring out of livestock for drafting and letting farm property to others) and non-farm income (e.g. cash gifts, cash transfers, remittance, wage and self-employment income). Crop income includes the total value of crop sold, as well as the estimated value of crops stored, consumed, used for seeds or animal feed, and other specified uses. Livestock income is income from animals and animal products.

Economic mobility

Economic mobility indicators include both income and assets indicators which are the main impact indicators at household level. The income indicators presented indicate total gross income as well as crop and livestock income.

To measure long term impact on household's welfare, asset based indicators are considered better indicators. Hence, five asset indices, i.e. housing, durable, productive, livestock and an overall assets indices are additionally used to evaluate the welfare effect of the project. The asset indices aggregate household stocks with different units into a single measure using aggregating weights from PCA or MCA. For livestock assets, the TLU was also constructed as noted above.

Overall asset index that could be used as a solid measures for household economic status (Filmer and Scott, 2012). The overall asset index encompasses four indices to give a comprehensive picture of household wealth. These indices include a durable asset index, a productive asset index, a livestock asset index and a housing asset index. While the first three indices are computed using the principal components analysis (PCA) as the questions used to compute them are continuous, the multiple correspondence analysis (MCA) was used to calculate the housing asset index given the categorical nature of their questions. For the overall asset index, the principal components analysis based on the polychoric correlation is implemented, which allows to combine both continuous-based indices with categorical-based ones (Kolenikov and Angeles, 2004).

Food insecurity and diet diversity

Reducing food insecurity for farmers is one of the major objectives of PAFA. Dietary diversity is a qualitative measure of food consumption that reveals household access to a variety of food, which also proxies for nutrient adequacy of an individual's diet. To measure dietary diversity, the household dietary diversity score was used. Dietary diversity is measured at household level following FAO's guidelines, which measure household ability to access 16 food groups. A household dietary diversity scores (HDDS) is a simple count of food groups that a household or an individual has consumed over the 7 days preceding the interview (FAO, 2010).

The Food Insecurity Experience Scale (FIES) was also computed. The latter follows FAO's guidelines, which is based on eight questions that reflect household's access to adequate food during 2017 (over the last 12 months before the data collection). These questions assess whether 1) the household worried that they would not have enough food to eat, 2) they were unable to eat healthy and nutritious food, 3) they ate only a few kinds of foods, 4) they had to skip a meal, 5) they ate less than you thought you should, 6) ran out of food, 7) they were hungry but did not eat, and 8) went without eating for a whole day.

Crop and income diversification

Agricultural diversification is a concept of allocating resources to an increasing number of agriculture activities. Diversification can be measured using different types of indices that could range from the simple count index to more complex indices such as the Shannon, Margaleff and Berger Parker indices. In this impact assessment, a number of diversification indices are presented. Such indices take into consideration both the number of different crops and the share allocated to these crops.

Resilience

Given that there are several methodological approaches to build an indicator variable to explain resilience, the impact assessment relied on various indicators to measure resilience. Among others, a common approach developed as part of a household survey conducted in Ethiopia - the Pastoralist Areas Resilience Improvement and Market Expansion (PRIME) project (Frankenberger, 2015) - is to use polychoric factor analysis (PFA) to combine different sub-indices to form a single resilience index. A second approach is to use the FAO RIMA II model. The first approach is used to measure resilience in this impact assessment.

In addition, as a proxy for resilience, an index defined as the household's ability to recover was computed. Two versions of it are presented, one from all shocks and one for all the top five significant shocks encountered over the 12 months prior to the start of the data collection. . The top five significant shocks used for the overall resilience index might be different from one farmers to another, whereas for the one-shock resilience indices, a choice was made to focus on the top five shocks that were encountered by most farmers in Senegal. They are: low rainfall (41%), crop pests (28%), hike in input cost (25%), land grab (25%) and flood (22%) . These resilience indices are adjusted by the severity of each shock to allocate different weight depending on shock severity. In addition to the overall resilience index for all shocks, and the top five significant shocks that was encountered by farmers in Senegal during the last 5 years.

Market access

Market access was proxied by the extent of market participation (defined as the sale of crops in the previous 12 months) , the quantity and amount of sales, and whether crops were sold to a market operator. The indicators were also used to ascertain whether having a SPAM subsidy and being in a PAFA POs allows for better market access outcomes.

Producers Organizations (PO) level indicators

At PO level, indicators measuring the extent of commercialization/market access, income and crop diversification, asset indices, and access to information were computed. Market access and commercialization were estimated using the quantity of crop brought to the PO by members for sale, the quantity sold in the market, the value of crop sold, and the distance to the nearest market. Diversification indices are count indices. Asset indices follow the same construction as those at the household level, with however different assets. Finally, access to various types of information is measured.

3.3 Impact estimation

The estimation strategy presented in this IA report deviates slightly from the Impact Assessment Plan (IA Plan). Estimation strategy 2 from the IA plan is retained, while strategy 1, the regression discontinuity design (RDD) was no longer feasible. The RDD strategy relied on having access to the scores from the PO pre-qualification forms, which were not available upon request from the project staff. Consequently, as per strategy 2 of the IA Plan, the analysis was based solely on matching and selection on observables estimators such as the Inverse Probability Weighting Regression Adjustment (IPWRA).

As noted, in order to accurately estimate the impact of PAFA and more specifically the SPAM subsidy on farmers' agricultural production and welfare, it was necessary to explicitly account for selection on observables both at PO level and at household level. In other words, beneficiaries POs participation into PAFA might not have been randomly assigned.

Given the demand driven nature of the participation into PAFA, there is the possibility of seeing impacts driven by self-selection bias. For example, the most motivated and best-organized POs are more likely to obtain information on the opportunity to apply for a SPAM, meaning that there exists a selection into filling-in a SPAM pre-qualification form and submitting it. An attempt was made in this study to reduce this kind of bias by controlling for all relevant observable PO characteristics as, for example, education level of PO leaders, degree of remoteness of the PO, while identifying the counterfactual. Further, it was justifiable to assume that non-beneficiaries were unlikely to realize high results without the direct support of PAFA. If these assumptions hold, then contamination will certainly result in a downward bias of the effect estimates but it is unlikely that this bias will nullify the estimated effects. Controlling for the presence of beneficiary POs in the village of residence, distance to beneficiary POs in neighbouring villages, and inclusion of farm household from non-beneficiary communities inside and outside of the project regions would help to reduce the bias resulting from contamination.

Unfortunately, if selection bias is present, a simple comparison between beneficiaries POs (treatment) and non-beneficiaries POs (control) could lead to unreliable estimates of impact. In fact, systematic (observable and unobservable) differences between treatment and control POs are likely to exist even in absence of project participation. As mentioned above, POs with better capacity to organize could be more likely to participate in PAFA and are also more likely to obtain higher agricultural productivity regardless of the actual project intervention provided. In this case, differences in agricultural productivity between treatment PAFA POs and control POs might not be entirely due to project participation, but rather to unobservable POs characteristics that may also include entrepreneurial capacity and personality traits of the PO board members. More formally, under the potential outcome framework (Roy, 1951; Rubin, 1974), the binary treatment indicator D_i is equal to 1 if the individual or in this case the PO i receives the treatment and equal to 0 otherwise, with $i = 1, \dots, N$. The potential outcomes are defined as $Y_i(D_i)$. The most common parameters of interest in the evaluation literature are the average treatment effect on the treated (ATT) and the average treatment effect (ATE), which are defined as:

$$\tau_{ATT} = E[Y(1)|D = 1] - E[Y(0)|D = 1] \quad (1)$$

$$\tau_{ATE} = E[Y(1) - Y(0)] \quad (2)$$

The ATT gives the effect on those who actually received the treatment, while the ATE represents the average treatment effect on the whole population. The counterfactual mean for beneficiaries POs $E[Y(0)|D=1]$ should be observed for the ATT estimation and the two counterfactual means for beneficiaries $E[Y(0)|D=1]$ and non-beneficiaries $E[Y(1)|D=0]$ should be observed for the ATE estimation. However, this is impossible in reality and, therefore, feasible substitutes of the counterfactual means must be used.

In non-experimental impact assessments, using the mean outcome of non-beneficiaries, $E[Y(0)|D=0]$, instead of $E[Y(0)|D=1]$ leads to biased estimates of the ATT:

$$E[Y(1)|D=1]-E[Y(0)|D=0]=\tau_{ATT}+E[Y(0)|D=1]-E[Y(0)|D=0] \quad (3)$$

The difference between the left hand side of equation (3) and τ_{ATT} is the self-selection bias.

In order to obtain unbiased estimates of the ATT and the ATE, propensity score matching (PSM) was employed with five nearest neighbours to determine a valid counterfactual at the PO-level in PAFA regions and outside regions.

The matching strategy relies on two conditions: the common support condition and the conditional independence condition (CIA). The common support condition can be defined as:

$$0<p(X)=Pr(D=1 \mid X)<1 \quad (4)$$

This condition requires that each treatment observation has comparison control observations with similar propensity score and that each control observations has comparison treatment observations with similar propensity score. The propensity score, $p(X)$, is the probability to participate in the project given a set of observable characteristics X. The ATT and the ATE can be identified only on the area of the common support and observations off the common support region should be dropped.

The CIA requires that the potential outcomes must be independent on the treatment conditional on the propensity score:

$$Y(1),Y(0) \perp D| \, p(X) \quad (5)$$

In order to have this condition satisfied, a set of control variables are chosen that are not influenced by the treatment and that simultaneously influence the participation decision to the project and the outcome variables. Omitting important control variables can seriously lead to biased estimation results (Heckman, Ichimura and Todd 1997).

To be noted that, the ATT identification requires a weaker common support condition and a weaker CIA: $p(D=1 \mid X)<1$ and $Y(0) \perp D| \, p(X)$. The weaker common support condition requires only that each treatment observations have comparison control observations with similar propensity score. The weaker CIA refers only to the potential outcome $Y(0)$.

If the two conditions are satisfied, the ATT can be estimated as follows:

$$\tau_{ATT}^{PSM}=E\{E[Y(1)|p(X),D=1]-E[Y(0)|p(X),D=0]|D=1\} \quad (6)$$

The ATT and the ATE at household level were estimated using inverse probability weighting with regression adjustment (IPWRA) at household level where two treatments “PAFA SPAM beneficiaries" and "PAFA ordinary members" (NON-SPAM) and two controls (control households within POs in PAFA regions – the spillover control or "control in" in brevity; and control households within POs in outside project regions – the pure control or " control out") were used to determine impacts at household level.

The estimation strategy can be therefore summarized in four steps. In the first step, descriptive statistics at PO level and the quality of the counterfactual at PO level were scrutinized by looking at the t-test on the equality of means of control variables between beneficiaries and non-beneficiaries POs prior to matching. This test shows whether control variables, defined as variables that should not be affected by project participation, are balanced between the two groups.

In the second step, the propensity score was computed, through a probit regression, to examine whether the common support condition is satisfied at the PO-level. The Kernel density of the estimated propensity score of all observations by treatment status was presented in Figures 2 and 3 in Appendix 1. Such graphs are useful visuals for examining the distribution of propensity score across treatment and control groups and the quality of the counterfactual at the PO level. The common support region is determined by dropping all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group.

Last, the PSM with five nearest neighbours allows the analyst to assess its performance by looking at the Rosenbaum and Rubin (1985) reduction bias statistics.[3] Even though there is no clear successful threshold of the reduction bias, in most empirical studies a reduction bias below 25% indicates a good performance of the PSM procedure.

Before proceeding to the third step, and in order to improve the impact estimation, the sample is restricted to the POs on the common support region. The common support region is also trimmed at the lowest and highest 2% of the propensity score.

In the third step, the impact estimation of the ATT and the ATE at household level was conducted using the IPWRA estimator. Propensity score matching was also run prior to that, to identify the covariate distribution after matching.

In brief, the IPWRA estimator is suitable for observational studies where the selection into treatment is not random, but rather a choice made by the subjects under study. IPWRA addresses the endogeneity associated with this self-selection (into treatment) by modelling both the outcome and the treatment to account for the non-random treatment assignment. For this reason, it is said to be "doubly robust", which means that only one of the two models must be correctly specified to consistently estimate the treatment effects (in other words, the impact of the program) (Bang and Robins, 2005). Due to this property, this estimator generates the most reliable and accurate results compared with other selection on observable estimators.

The IPWRA estimator uses the inverse of the estimated treatment-probability weights to estimate missing-data-corrected regression coefficients that are subsequently used to compute the potential outcome means.

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[3] The Rosenbaum and Rubin (1985) reduction bias is the difference between the standardised bias before and after the matching, i.e. the difference between: $SB_{before} = 100\frac{(\bar{X}_1 - \bar{X}_0)}{\sqrt{0.5(V_1(X) - V_0(X))}}$ and $SB_{after} = 100\frac{(\bar{X}_{1M} - \bar{X}_{0M})}{\sqrt{0.5(V_{1M}(X) - V_{0M}(X))}}$, where $X_1(V_1), X_0(V_0)$ are the mean (variance) in the treatment and control group respectively before the matching and $X_{1M}(V_{1M}), X_{0M}(V_{0M})$ are the mean (variance) in the treatment and control group respectively after the matching.

The estimates reported are average treatment effect on the treated (ATT). Mathematically, the weighted-least squares regression equation to estimate ATT with the addition of covariates can be written as follows:

$Y_i = \alpha_0 + \tau T_i + \alpha_1 X_i + \alpha_2 (Xi - \overline{X}) T_i + \varepsilon_i$ (5)

where Y_i is the outcome variable of interest, T_i is the indicator for treatment, X_i is a vector of co-variates in the outcome equation, $\overline{X}$ is the sample average of X for the subsample of treated households, ε_i is the error term, and τ, α_1, and α_2 are parameters to be estimated. The matrix containing the weights assigned to observations in the sample to estimate the ATT effects can be specified as follows:

$\omega(t,x) = t + (1-t)\hat{P}(X)/(1-\hat{P}(X))$

where $\omega(t,x)$ is the weight applied, t represents Ti=1, $\hat{P}(X)$ is the estimated propensity score, and X is a vector of covariates (Lee, 2005).

The estimated ATT, or the beneficiary households can be expressed as follows:

$ATT = E(\delta_i|T=1) = E(Y_{i1/mi} - Y_{i0/mi}|T=1)$

IPWRA can only give an estimate of the direct impact of the project. However in the context of this study, the presence of indirect effects or "interference" - or spillover effects - from SPAM members of PAFA POs to untreated members of other POs is highly likely. Therefore, in order to estimate indirect impacts, a supplementary model was estimated to take into account the possibility that there are correlated effects (considered here exogenous or driven by the PAFA context) which depend on the predetermined characteristics of individuals and other POs members, in the neighbourhood of the PAFA SPAM participants, e.g. the actual control farmers in the POs in PAFA regions and outside POs.

Therefore, in this setting, the following assumptions are made (Cerulli, 2017):

i) The unit potential outcome depends on its own treatment and other units' potential outcome.

ii) The assignment is mean conditionally unconfounded.

iii) The treatment is binary (receiving the SPAM subsidy).

iv) Potential outcomes have a parametric form.

The essence of the model is to estimates ATEs under CMI (conditional mean independence) when neighbourhood interactions may be present. It incorporates such externalities within the traditional Rubin's Potential Outcome Model (POM). As such, it provides an attempt to relax the stable unit treatment assumption (SUTVA), a frequent assumption that is made in observational studies.

In order to estimate ATEs, the following will be implemented. Given an independent and identically distributed sample of observed variables for each household i,

$\{y_{i,} w_{i,} x_{i,}\}$ with i= 1, . . . ,N

1. A weighting matrix $\Omega = [\omega_{ij}]$ measuring some type of distance between the generic unit i (untreated) and unit j (treated) will be estimated;

2. Using OLS, a regression model of $y_{i,}$ on $\{1_, w_{i,} x_{i,} w_i(x_{i,} - \bar{x}), z_i\}$ will be fit

3.Then, $\{\widehat{\beta_0}, \hat{\delta}, \hat{\gamma}, \widehat{\beta_1}\}$ is obtained and put into the formulas of $\widehat{ATE}$s.

By comparing the formulas of the ATE with ($\gamma \neq 0$) and without ($\gamma = 0$) the neighbourhood effect, the estimated **neighbourhood bias** is defined as

Bias = $|ATEwithout - ATEwith| = |\gamma\mu_1 + \bar{v}\lambda|$

This is the bias arising when one neglects peer effects in assessing treatment effects in observational studies: it depends on the weights employed, the average of the observable confounders considered in x, and the magnitude of the coefficients γ and β_1. Such bias may be positive or negative. Furthermore, by defining $\gamma\beta_1 = \lambda$ it is also possible to determine whether this bias is statistically significant by simply testing the following null hypothesis:

$$H0 : \lambda_1 = \lambda_2 = \cdots = \lambda_M = 0$$

If this hypothesis is rejected, it would mean that neighbourhood effects are in place, thus significantly affecting the estimation of the causal parameters' ATEs. In a similar way, it is also possible to obtain an estimation of the neighbourhood bias for ATET and ATENT (average treatment effect on the untreated).

It is of policy relevance to estimate the neighbourhood bias – as this will lead to potential underestimation of the impact of the SPAM intervention. Intuitively, if there is contamination, e.g. or indirect effects, control farmers would have heard or even adopted the SPAM/PAFA practices, and they will have the same outcomes. If there is contamination, the PAFA impact, defined as the difference in the outcomes of treatment and control – will be small.

4. Profile of the project area and sample

4.1 PO census

POs in Senegal are part of a longstanding culture of village level organisation, and are relatively well organised. The census enumerated around 3300 producer organizations in the Groundnut Basin and in adjacent regions. Table 4.1 presents statistics on the enumeration sample disaggregated by PAFA POs, POs in the PAFA region (control in), and POs in the outside regions (control out). On average, two thirds of organisations are formalized and almost all of them have an administrative board.. POs in the sample are heavily women run, with 53 percent being organizations of women producers, 41 percent mixed gender organization and 5 percent with only male producers. PO members are mostly from vulnerable households in all groups.

Almost all the POs (98 percent) have an administrative board and three quarter of them have some sort of mandatory financial contribution from members.[4] The size of these producer organizations can vary between 5 and 2000 members, with an average of 77 members; although 95 percent of all POs have less than 200 members. Larger organisations are often the a*ssociations sportives et culturelles* (ASCs) with a less important focus on agriculture.

The main crops cultivated across POs are groundnut (83%), bissap (48%), maize (49%), millet (85%), sorghum (16 %), niebe (56 %). Besides agriculture, POs are involved in a number of other activities. These activities are a source of financing in some instances. The most important PO characteristics employed to identify the counterfactual at PO-level with propensity score matching were PO size,

[4] Adhesion fees can be up to 10,000 CFA.

whether the PO membership was all female, the size of communal farms, quantity harvested on these farms, and the funds available to the PO at its creation.

Table 4.1 - Descriptive statistics of the PO census

	Full sample		PAFA		Control in		Control out	
	N	Mean	N	Mean	N	Mean	N	Mean
PO is formal	3300	0.69	371	0.97	2643	0.65	286	0.7
PO has an administrative board	3300	0.98	371	1	2643	0.98	286	1
President is a woman	2492	0.66	279	0.48	2004	0.69	209	0.67
Age of the PO president	2492	50.5	279	54.3	2004	49.88	209	51.39
More than half of members are women	3300	0.73	371	0.69	2643	0.73	286	0.75
More than half of members are young	3300	0.2	371	0.18	2643	0.19	286	0.34
More than half of members are disabled	3300	0.01	371	0.01	2643	0.01	286	0.01
More than half of members are poor	3300	0.53	371	0.5	2643	0.53	286	0.64
Value chain								
Peanut	3298	0.76	370	0.64	2642	0.79	286	0.67
Bissap	3298	0.15	370	0.12	2642	0.15	286	0.14
Maize	3298	0.35	370	0.32	2642	0.36	286	0.29
Millet	3298	0.77	370	0.75	2642	0.79	286	0.67
Niebe	3298	0.33	370	0.31	2642	0.34	286	0.29
Sesame	3298	0.01	370	0.05	2642	0.01	286	0.01
Sorghum	3298	0.03	370	0.02	2642	0.03	286	0.05
Horticulture	3300	0.14	371	0.11	2643	0.12	286	0.34
Aviculture	3300	0.08	371	0.15	2643	0.07	286	0.15

4.2 PO sample

Comprehensive data was collected from 220 POs sampled from the matched POs in treatment, PAFA regions and outside regions. In order to find counterfactual POs and fully address any potential PO level spillover s, POs were selected in the regions where PAFA operates as well in adjacent communes of the regions of Louga, Tambacounda and Thies. The sample POs cover a wide territory in 7 regions and 79 communes. Out of the 220 POs, there are 85 PAFA POs and 135 control POs with 51 outside the PAFA regions and 86 inside the PAFA regions. Information on the characteristics of these organisations, their administrative structures, and characteristics of the communities within which they operate was collected as part of the PO-level survey.

Table 4.2 Distribution of sampled POs by group (PAFA POs, control POs in PAFA regions and control POs in outside regions) and Region.

	PAFA		Control within		Control outside	
Region	**Number of POs**	**(%) Female POs**	**Number of POs**	**(%) Female POs**	**Number of POs**	**(%) Female POs**
Diourbel	30	36.7	16	41.2	0	0
Fatick	19	31.6	25	50.0	0	0
Kaffrine	20	10.0	23	56.5	0	0
Kaolack	16	50.0	18	44.4	0	0
Louga	0	0	0	0	6	33.3
Tambacounda	0	0	0	0	19	57.9
Thies	0	0	0	0	25	57.7
Total	85	31.76	82	48.81	50	54.90

These producer organizations have similar demographics, with about two third female members, a third of members that are younger than 34 years, and between 2 and 4 percent members with a disability. There are, however, a few differences that are worth noting in the distribution presented above. The sampled PAFA POs are less likely to be female organizations and tend to be larger with on average 70 members. In terms of administrative structures, PAFA POs have presidents that are on average older and less educated. Moreover, PAFA POs are more likely to charge a fee for non-attendance of the group meetings. The main activities of these organizations are agriculture, livestock rearing and trade. Control POs in the PAFA regions are more likely to engage in livestock activities. PAFA POs are also more likely to be involved in the communities they operate in, engaging in community cleaning efforts (set settal) and various other social activities.

Table 4.3 – Descriptive statistics of the PO-level sample

	PAFA	**Control in**	**Control out**	***Difference (PAFA/ control in)***	***Difference (PAFA / control out)***
PO Demographics					
Distribution of Female POs (%)	31.80	48.88	55.00	*-0.17**	*-0.23***
Number of members	78.29	50.61	50.61	*15.71*	*27.69*
Share of women in the PO (%)	67.90	75.00	75.30	*-0.03*	*-0.07*
Share of members younger than 34 years (%)	38.90	35.80	35.80	*0.03*	*0.04*
Share of members with a disability (%)	2.39	3.89	3.03	*-0.02*	*-0.01*

PO administration					
President of the PO is a woman (%)	51.8	58.30	70.6	*-0.07*	*-0.188**
Age of the PO president	54.29	51.24	52.84	*3.06**	*1.45*
PO President is literate (%)	31.8	36.90	31.4	*-0.05*	*0.00*
Share of women in the board (%)	63	65.50	74.8	*-0.03*	*-0.12*
Share of board members that are literate (%)	10.1	12.00	15.5	*-0.02*	*-0.05*
Average age of board members	45.94	45.70	45.67	*0.24*	*0.27*
Share of POs that charge a late fee (%)	34.1	21.40	21.6	*0.13*	*0.13*
Information					
PO received credit (%)	15.3	8.33	0	*0.07*	*0.153***
PO received a subsidy (%)	2.35	5.95	3.92	*-0.04*	*-0.02*
PO received climate information (%)	81.2	77.40	80.4	*0.04*	*0.01*
PO received price information (%)	70.6	77.40	84.3	*-0.07*	*-0.14*
PO received production information (%)	47.1	45.20	39.2	*0.02*	*0.08*
Services provided to PO members					
Savings (%)	70.6	77.40	76.5	*-0.07*	*-0.06*
Financing (%)	42.4	50.00	60.8	*-0.08*	*-0.184**
Training (%)	30.6	23.80	19.6	*0.07*	*0.11*
Production advice (%)	20	11.90	13.7	*0.08*	*0.06*
Agricultural inputs (%)	12.9	14.30	17.6	*-0.01*	*-0.05*
Commercialization (%)	11.8	3.57	7.84	*0.08**	*0.04*
Activities that POs participate in					
Agriculture (%)	96.5	96.40	90.2	*0.00*	*0.06*
Livestock (%)	43.5	36.90	70.6	*0.07*	*-0.27***
Aviculture (%)	9.41	4.76	9.8	*0.05*	*0.00*
Trade (%)	42.4	32.10	39.2	*0.10*	*0.03*
Food processing (%)	5.88	4.76	3.92	*0.01*	*0.02*
Community cleaning (set settal) (%)	17.6	7.14	5.88	*0.11**	*0.12*
Sport (%)	2.35	1.19	0	*0.01*	*0.02*
Animation (%)	8.24	2.38	0	*0.059*	*0.08**

The PAFA subsample is made up of 85 organizations; 30 in Diourbel, 19 in Fatick, 20 in Kaffrine, and 16 in Kaolack. Half of these organizations are from PAFA's third generation, 33 percent from the second and 16 percent from the first generation (Table 4.4). Table 4.5 shows the breakdown by value chain supported under the SPAM subsidy; aviculture (11), bissap (15), millet/sorghum (24), niebe (20), maize (9), sesame (4), and horticulture (2). Among these organizations, between 40 and 86 percent declared having received agricultural inputs in the form of seeds, fertilizer, and pesticides (Table 4.6). Training on agricultural best practices and PO management were administered to 19 percent of the PAFA sample. Nearly two thirds received agricultural materials from PAFA and 22 percent declared having had access to a market operator through PAFA. None of the sampled PAFA POs organizations benefitted from an irrigation scheme or road infrastructure ("piste rurales") in the communities in which they operate.

Table 4.4: Distribution of sampled PAFA POs by generation.

	PAFA POs			
Region	**First generation (2011/2014)**	**Second generation (2012/2015)**	**Third generation (2013/2016)**	**All**
Diourbel	4	12	14	30
Fatick	4	6	9	19
Kaffrine	3	5	12	20
Kaolack	3	5	8	16
Total	14	28	43	85

Table 4.5: Distribution of sampled PAFA POs by generation and value chain.

	PAFA POs			
Value chain	**First generation (2011/2014)**	**Second generation (2012/2015)**	**Third generation (2013/2016)**	**All**
Aviculture	0	4	7	11
Bissap	0	2	13	15
Maize	0	2	7	9
Horticulture	0	1	1	2
Millet / sorghum	5	9	10	24
Niebe	7	10	3	20
Sesame	2	0	2	4
Total	14	28	43	85

Table 4.6: Distribution of PAFA activities within the sampled PAFA POs

PAFA activities	% of PAFA PO that said they received
Seeds	86
Fertilizer	82
Pesticide	41
Training	19
Agricultural material	62
Market access	18
Management training	19
Storage	7
Irrigation	0
Rural roads (piste rurale)	0
Training on aviculture technique	13
Market operator	4
Credit	0

4.3 Household sample

The household data used in this analysis are from a sample of about 2,233 rural agricultural[5] households. Table 4.7 shows the distribution of households by region and by treatment status: 835 SPAM households, 361 non-SPAM households, 650 control households in the PAFA regions and 387 control households outside PAFA regions.

Table 4.7 - Household sample distribution, by treatment and control, by Region.

Region	Treated POs		Control POs		Total
	SPAM beneficiaries	Non SPAM beneficiaries	Households within PAFA regions "Control in"	Households outside PAFA regions "Control out"	
Diourbel	302	185	134	0	621
Fatick	187	73	195	0	455
Kaffrine	187	68	183	0	438
Kaolack	159	35	138	0	332
Louga	0	0	0	48	48
Tambacounda	0	0	0	152	152
Thies	0	0	0	187	187

[5] Non agricultural households were excluded from the sample (70).

Total	835	361	650	387	2,233

Table 4.8 presents descriptive statistics of the survey sample, average characteristics are presented for households belonging to SPAM, non-SPAM, control in, control out and the two control groups combined.[6] There are a number of significant differences that are worth noting. SPAM households are on average larger in size than any other groups with an average of 12 members, with a higher dependency ratio. Compared to the control outside, SPAM households are less likely to be female headed, and have a migrant. In terms of education, SPAM households have fewer years of average education than control in households and have fewer adults with at least a primary education. In terms of productive assets, SPAM households are better off. They have more plots of land compared to all groups, a higher share of plots that have black nutritious soil, that are irrigated and with a flat slope.

Table 4.8 Descriptive statistics of household demographics

Variable	SPAM	Non SPAM	Control in	Control out	All controls
	N=835	N=361	N=650	N=387	N=1037
Demographics					
Household Size	12.685	11.704***	11.995**	11.406***	11.775***
Female head	0.092	0.116	0.115	0.145***	0.126**
Dependency Ratio	0.991	0.975	0.913**	0.919	0.916**
Age of head in years	53.101	50.562***	52.798	52.455	52.67
Average years of education	1.319	1.247	1.829***	1.439	1.684**
Share of adults that have at least a primary education	0.657	0.709***	0.676	0.725***	0.694***
Share of adults that are literate (%)	0.211	0.179**	0.257***	0.268***	0.261***
Household has at least one migrant	0.172	0.139	0.172	0.124**	0.154
Households obtained credit in the past 12 months	0.150	0.139	0.182	0.111*	0.155
Household holds savings	0.092	0.08	0.097	0.171***	0.124**
Received transfer	0.460	0.465	0.411*	0.421	0.415**
Agricultural holdings					
Land area of family farms, HA	5.754	5.314	5.592	5.155	5.434
Number of plots	2.655	2.548	2.442***	2.039***	2.291***
Share of plots that are irrigated	0.010	0	0.001	0	0.001
Share of plots with black soil	0.327	0.266**	0.298	0.301	0.299
Share of flat plots	0.866	0.866	0.837*	0.796***	0.822***
Share of plots with an anti-erosion structure	0.035	0.045	0.022*	0.028	0.024*

[6] Stars represent the significance level of the difference in means between SPAM and the group mean

Number of crops	2.516	2.379***	2.302***	2.218***	2.272***
PO/PAFA variables					
Number of board members in the household	0.211	0.083***	0.255*	0.261*	0.257**
Number of PAFA members they know	26.410	14.338***	3.097***	0.519***	2.135***

Table 4.9 presents related descriptive statistics for agricultural variables across the samples along with the test of significance of mean differences. PAFA in its design encouraged the uptake of cropsp; on average SPAM households were more likely to grow millet, maize, sorghum, niebe, sesame, bissap and even groundnut which was not part of the supported value but is an important crop in the area. Non-beneficiary households within PAFA POs seem to uptake the PAFA crops at the same level as SPAM households, except for maize and bissap where they have a lower share of growers. SPAM households reported using fertilizer (both organic and inorganic) on their plots more often than any other group. The same is true for fertilizer use. Additionally, SPAM households have higher harvests compared to the other groups for millet, niebe and bissap. As per the project design, harvest sold to market operator with a contractual guarantee was more prevalent among SPAM households.

Table 4.9 – Descriptive statistics of production variables across all samples

	SPAM N =835	NON SPAM N=361		CONTROL IN N=650		CONTROL OUT N=387		ALL CONTROLS N=1037	
	Mean	Mean	Diff	Mean	Diff	Mean	Diff	Mean	Diff
Adoption (Yes =1)									
Millet	0.91	0.91	0.01	0.89	-0.02	0.80	-0.11***	0.86	-0.051***
Maize	0.18	0.09	-0.085***	0.14	-0.033*	0.13	-0.042*	0.14	-0.036**
Sorghum	0.05	0.03	-0.01	0.02	-0.024**	0.03	-0.02	0.03	-0.022**
Niebe	0.33	0.35	0.03	0.24	-0.088***	0.19	-0.14***	0.22	-0.107***
Sesame	0.02	0.01	0.00	0.01	-0.012**	0.01	-0.01*	0.01	-0.012**
Bissap	0.10	0.06	-0.040**	0.05	-0.050***	0.02	-0.08***	0.04	-0.060***
Peanut	0.90	0.87	-0.02	0.87	-0.028*	0.80	-0.01***	0.84	-0.055***
Fertilizer use	0.73	0.64	-0.097***	0.65	-0.088***	0.52	-0.21***	0.60	-0.135***
Organic fertilizer use	0.55	0.54	-0.01	0.50	-0.050*	0.36	-0.19***	0.45	-0.102***
Inorganic fertilizer use	0.44	0.28	-0.164***	0.39	-0.051**	0.30	-0.14***	0.36	-0.084***
Pesticide use	0.10	0.07	-0.03	0.07	-0.036**	0.07	-0.037**	0.07	-0.036***
Crop yield (kg/ha)									
Millet	771.62	651.3	-120.29	784.29	12.67	592.6	-179**	712.75	-58.87
Maize	157.48	86.06	-71.418*	116.55	-40.93	47.66	-109.***	90.84	-66.642**
Sorghum	18.18	9.61	-8.57	9.34	-8.84	56.07	37.892*	26.78	8.60
Niebe	117.80	70.94	-46.87	115.43	-2.37	145.7	27.95	126.74	8.94

Sesame	4.71	2.90	-1.80	0.66	-4.047**	1.36	-3.34	0.92	-3.784**
Bissap	41.29	20.37	-20.921*	27.40	-13.89	54.57	13.29	37.54	-3.75
Peanut	991.65	1977	985.72	1155.6	163.93	681.92	-309.74	978.82	-12.84
Harvest (kg)									
Millet	1333.9	998.4	-335.56**	1104.1	-229.89**	857.60	-476***	1012.1	-321.8***
Maize	171.00	113.7	-57.30	118.59	-52.42	62.69	-108***	97.73	-73.3***
Sorghum	21.49	27.62	6.13	6.15	-15.34**	36.31	14.82	17.41	-4.08
Niebe	51.08	28.95	-22.124**	28.31	-22.76***	33.07	-18.009*	30.09	-21***
Sesame	5.45	4.04	-1.41	1.08	-4.37	5.17	-0.28	2.60	-2.85
Bissap	24.69	5.36	-19.335**	5.83	-18.86***	2.97	-21.72**	4.76	-19.93***
Peanut	1526.3	1130	-396.1**	1690.8	164.45	986.61	-539***	1428	-98.33
Harvest sold to market operator (Yes=1)	0.12	0.12	0.00	0.09	-0.031*	0.07	-0.06***	0.08	-0.041***

The differences in the income indicators between SPAM and control in households are not stark (see table 4.10). There are however a few notable differences in terms of crop income and other sources of income, with SPAM households having on average higher crop income than non-SPAM and control households outside the PAFA regions. However, control out households gain more from self-employment activities and non-agricultural employment activities. Despite these differences, income diversification is similar across the groups with on average 3 different sources of income. In terms of assets, non-SPAM households are less wealthy than their SPAM counterparts.

Table 4.10 Descriptive statistics of economic mobility indicators across all samples

	SPAM N=835	NON SPAM N=361		CONTROL IN N=650		CONTROL OUT N=387		ALL CONTROLS N=1037	
	Mean	**Mean**	**Diff**	**Mean**	**Diff**	**Mean**	**Diff**	**Mean**	**Diff**
Income indicators (in 1000 XOF)									
Gross income	1 100	760	340**	1 100	-9	1 400	370	1 200	130
Crop income	610	440	-170***	570	-40	400	-210***	510	-110***
Livestock income	110	77	-37	170	57	110	-4	150	35
Wage income from agricultural	6	3	-3	2	-4	0	-6	2	-4
Wage income from non-agricultural activities	140	110	-24	170	29	230	90**	190	53
Self -employment income	130	54	-72	96	-30	650	520**	300	180
Transfer income	74	63	-11	56	-17	46	-28**	53	-21**
Income diversification									

Income diversification index (count)	3.31	3.26	-0.05	3.22	-0.09	3.18	-0.13	3.20	-0.105*
Income diversification index (margalef)	3.18	3.13	-0.05	3.09	-0.09	3.05	-0.13	3.08	-0.105*
Income diversification index (shannon)	0.36	0.35	-0.01	0.34	-0.02	0.34	-0.02	0.34	-0.02
Assets									
Tropical livestock unit	3.58	2.89	-0.690**	3.33	-0.26	4.68	1.091***	3.83	0.25
Overall asset index	1.31	1.10	-0.210***	1.34	0.03	1.37	0.06	1.35	0.04
Durable asset index	1.56	1.32	-0.239***	1.75	0.183**	1.84	0.279***	1.78	0.219***
Productive livestock index	1.67	1.38	-0.286***	1.61	-0.06	1.54	-0.124**	1.58	-0.085*
Livestock index	0.50	0.44	-0.058*	0.47	-0.03	0.60	0.103**	0.52	0.02

Table 4.11 shows crop descriptive statistics of the treatment sample for the supported value chains. The millet value chain is the most prevalent with 759 SPAM households. Yields in general remain low with 848.88 kg/ha for millet and slightly higher numbers for maize. Table 4.12 shows the same information across all samples.

Table 4.11: Descriptive of production indicators by value chain (SPAM households)

Value chain	Number of households	Area planted (ha)	Harvest (kg)	Yields (kg/ha)	Value of crop production (XOF)
Maize	147	1.38	971.34	894.53	159000
Millet	759	2.79	1467.54	848.88	269000
Sorghum	39	1.31	460.05	389.25	106000
Niebe	271	1.31	157.38	362.97	46508
Sesame	14	1.13	325	280.61	132000
Bissap	80	0.74	257.7	430.92	110000
Horticulture	4	0.72	32.5	2242.89	62912

Table 4.12 shows the most prevalent crop combinations within the sampled households, notably peanut and millet, followed by peanut, millet and niebe, then maize, peanut and niebe.

Table 4.12: Crop portfolio distribution by most prevalent crop combination across the 4 groups sampled (proportions).

Crop portfolio	PAFA	NON SPAM	CONTROL IN	CONTROL OUT	TOTAL
Peanut / millet	0.37	0.41	0.48	0.43	0.42
Peanut / millet / niebe	0.21	0.11	0.12	0.05	0.18
Maize / peanut / millet	0.11	0.03	0.07	0.04	0.09

Other combination	0.31	0.11	0.21	0.18	0.31

5. Results

This section presents the impact estimation results on the outcome and impact indicators described in the previous sections. First, treatment effects are computed for PAFA SPAM beneficiaries versus the two control groups combined. Second, given the presence of spillover effects, impact estimates are disaggregated – and computed separately across the two different groups (controls inside the PAFA regions and controls outside the PAFA regions).

Results from two different estimators are presented. The first referenced estimation approach is the inverse probability weighting with regression adjustment (IPWRA in the results tables below). Results are also presented using a second estimation approach – which is used to assess the possible bias in the results due to the presence of spillover effects. Focusing on a comparison between SPAM and the control samples combined, these analyses explicitly quantify the magnitude of spillover effects. For the sake of brevity, the discussion will only focus on significant results[7], and isolate the possible bias due to spillover based on neighbourhood effects (proxied by distance).

Based on the specific definitions of the indicators, the magnitudes of the impact estimates are either expressed in levels or in percentages. Whenever convenient, however, the discussion of the results may convert impact estimates from percentages to levels in order to illustrate the magnitude of the effects relative to the control group means (which are all presented in levels).

5.1 Intermediate outcome indicators: Adoption

The first sets of results present treatment effects across adoption outcomes. Notably, intermediate outcomes such as adoption of the crops promoted by PAFA are examined first and compared to the prevalent crop, groundnut or peanut. According to the project TOC, PAFA promoted crop diversification and therefore farmers should have adopted the promoted crops accordingly (millet/sorghum, niebe beans, bissap, sesame, maize). In addition, impact on adoption of various inputs (fertilizers, total and disaggregated by organic and inorganic, as well as pesticides) is presented.

Table 5.1 Results on adoption of major crops and inputs

	SPAM VS ALL CONTROLS			
Adoption indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Millet (Yes=1)	1856	0.0302**	(0.0151)	0.86
Maize (Yes=1)	1856	0.0000171	(0.0203)	0.14
Sorghum (Yes=1)	1856	0.0131	(0.0104)	0.03
Niebe (Yes=1)	1856	0.0948***	(0.0224)	0.22
Sesame (Yes=1)	1856	0.00889	(0.00590)	0.01

[7] Results based on the ntreatreg estimator are available upon request.

Bissap (Yes=1)	1856	0.0684***	(0.0118)	0.04
Peanut (Yes=1)	1856	0.0364**	(0.0163)	0.84
Fertilizer use (Yes=1)	1856	0.0985***	(0.0231)	0.60
Organic fertilizer use (Yes=1)	1856	0.0629**	(0.0246)	0.45
Inorganic fertilizer use (Yes=1)	1856	0.0807***	(0.0241)	0.36
Pesticide use (Yes=1)	1856	0.0241	(0.0147)	0.07

Results show that on average, PAFA SPAM beneficiaries had a larger probability of adopting the crops in question than farmers in any of the two control groups. Regarding the adoption of new crops, it is niebe that stands out with a large 43% increase relative to the control. Maize adoption on the other hand was not affected by PAFA as well as adoption of sorghum, sesame, and the use of pesticides. Regarding the adoption of fertilizer, PAFA brought about a 16 % increase.

However, when the control groups are disaggregated (Table 5.2)– impacts are much larger when comparing SPAM with the comparison group in the outside regions (control out) given the absence of spillover effects. This suggests that the presence of spillover effects in the PAFA regions, leads to an underestimation of the potential impacts of PAFA

Table 5.2 Results on adoption of major crops and inputs (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Adoption indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Control mena**
Millet (Yes=1)	1470	0.00313	-0.02	0.89	1213	0.0664***	(0.02)	0.8
Maize (Yes=1)	1470	-0.00626	-0.02	0.14	1213	0.00325	(0.03)	0.13
Sorghum (Yes=1)	1470	0.0122	-0.01	0.02	1213	-0.00846	(0.02)	0.03
Niebe (Yes=1)	1470	0.0716***	-0.03	0.24	1213	0.108***	(0.04)	0.19
Sesame (Yes=1)	1470	0.0111*	-0.01	0.01				
Bissap (Yes=1)	1470	0.0580***	-0.01	0.05				
Peanut (Yes=1)	1470	0.018	-0.02	0.87	1213	0.0937***	(0.03)	0.8
Fertilizer use (Yes=1)	1470	0.0555**	-0.02	0.65	1213	0.235***	(0.04)	0.52
Organic fertilizer use (Yes=1)	1470	0.000919	-0.03	0.5	1213	0.209***	(0.04)	0.36
Inorganic fertilizer use (Yes=1)	1470	0.0491*	-0.03	0.39	1213	0.197***	(0.03)	0.3

5.2 Agricultural production and productivity

Tables 5.3 to 5.7 present treatment effects on production (quantities harvested, value of production), productivity indicators (crop yields) followed by input use indicators.

The results indicate that the harvests of millet, niebe and bissap are significantly higher for the SPAM beneficiaries compared to the combined control group of farmers. Impacts can also be seen at aggregate level, across quantities harvested from cereals, horticulture and pulses. The effects on the value of the production of millet, niebe and bissap are also remarkably large compared to counterfactual farmers. Overall the effects on the value of the production vary from around 1 percentage points for sesame to 7 percentage point increases for niebe.

Table 5.3 Results on production indicators

	SPAM vs All Controls			
Production indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Total harvest - millet (kg, log)	1856	0.327***	(0.109)	1014.7
Total harvest - maize (kg, log)	1856	0.0854	(0.123)	98.0
Total harvest - sorghum (kg, log)	1856	0.0758	(0.0561)	17.5
Total harvest - niebe (kg, log)	1856	0.407***	(0.102)	30.3
Total harvest - sesame (kg, log)	1856	0.0497	(0.0313)	2.6
Total harvest - bissap (kg, log)	1856	0.345***	(0.0543)	4.8
Total harvest - peanut (kg, log)	1856	0.126	(0.122)	1435.5
Total harvest - cereals (kg, log)	1856	0.307***	(0.103)	1135.1
Total harvest - horticulture (kg, log)	1856	0.372***	(0.0666)	36.7
Total harvest - pulses (kg, log)	1856	0.407***	(0.102)	30.3
Total harvest - oilseeds (kg, log)	1856	0.146	(0.122)	1438.1
Value of millet production (XOF, log)	1856	0.726***	(0.187)	170000
Value of maize production (XOF, log)	1856	0.0653	(0.227)	21722
Value of sorghum production (XOF, log)	1856	0.155	(0.109)	4827
Value of niebe production (XOF, log)	1856	0.906***	(0.226)	10631
Value of sesame production (XOF, log)	1856	0.111*	(0.0640)	1088
Value of bissap production (XOF, log)	1856	0.742***	(0.122)	2174
Value of peanut production (XOF, log)	1856	0.306	(0.206)	291000
Value of cereals production (XOF, log)	1856	0.663***	(0.175)	197000
Value of horticulture production (XOF, log)	1856	0.745***	(0.138)	6321
Value of pulses production (XOF, log)	1856	0.906***	(0.226)	10631
Value of oilseeds production (XOF, log)	1856	0.349*	(0.204)	292000

The results presented in Table 5.4 allow one to dig deeper into selection issues. Here beneficiary households are benchmarked separately against non-beneficiaries from PAFA target regions (control-in) and against non-beneficiaries from adjacent regions where PAFA had no activities (control-out). The approach does, unfortunately, not allow us to disentangle whether differences across these two estimation approaches stem from pre-existing differences between SPAM and control-in farmers or whether control-in farmers indirectly benefitted from PAFA which led to underestimation of the true effect in the estimations including SPAM and control in households. Effects, for example, on millet production are huge (78 percentage points) and highly significant in the comparison with farmers from adjacent regions. This result would not be surprising, as PAFA strongly supported production of the crop that was formerly produced mainly for household consumption. In the comparison with control-in households, the effect is much smaller at ten percent and not significant at all. This might hypothetically indicate that control-in farmers successfully delved into professional millet production alongside with the PAFA beneficiaries, despite not receiving direct support from PAFA.

Table 5.4 Results on production indicators (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Production indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Contro l mean**
Total harvest - millet (kg, log)	1470	0.105	(0.12)	1109.10	1213	0.780***	(0.17)	857.46
Total harvest - maize (kg, log)	1470	0.0536	(0.14)	119.10	1213	0.0808	(0.18)	62.85
Total harvest - sorghum (kg, log)	1470	0.105*	(0.06)	6.22	1213	-0.111	(0.12)	36.40
Total harvest - niebe (kg, log)	1470	0.313***	(0.11)	28.62	1213	0.446***	(0.17)	33.15
Total harvest - sesame (kg, log)	1470	0.0571*	(0.03)	1.09	1213	0.0451	(0.04)	5.18
Total harvest - bissap (kg, log)	1470	0.304***	(0.06)	5.90	1213	0.334***	(0.06)	2.97
Total harvest - peanut (kg, log)	1470	-0.101	(0.13)	1704.53	1213	0.855***	(0.23)	987.35
Total harvest - cereals (kg, log)	1470	0.0842	(0.11)	1241.41	1213	0.806***	(0.17)	958.01
Total harvest - horticulture (kg, log)	1470	0.349***	(0.07)	51.82	1213	0.394***	(0.07)	11.39
Total harvest - pulses (kg, log)	1470	0.313***	(0.11)	28.62	1213	0.446***	(0.17)	33.15
Total harvest - oilseeds (kg, log)	1470	-0.0801	(0.13)	1705.62	1213	0.874***	(0.23)	992.53
Value of millet production (XOF, log)	1470	0.102	(0.20)	196000	1213	1.865***	(0.29)	126000
Value of maize production (XOF, log)	1470	0.0537	(0.25)	19145	1213	-0.0731	(0.35)	26015
Value of sorghum production (XOF, log)	1470	0.192	(0.12)	4247	1213	-0.164	(0.23)	5793
Value of niebe production (XOF, log)	1470	0.678***	(0.25)	8867	1213	1.024***	(0.37)	13570
Value of sesame production (XOF, log)	1470	0.122*	(0.07)	433	1213	0.107	(0.08)	2179
Value of bissap production (XOF, log)	1470	0.642***	(0.13)	2467	1213	0.734***	(0.14)	1687
Value of peanut production (XOF, log)	1470	-0.0466	(0.22)	339000	1213	1.472***	(0.41)	211000
Value of cereals production (XOF, log)	1470	0.0538	(0.18)	220000	1213	1.855***	(0.29)	159000
Value of horticulture production (XOF, log)	1470	0.677***	(0.15)	6839	1213	0.808***	(0.16)	5458
Value of pulses production (XOF, log)	1470	0.678***	(0.25)	8867	1213	1.024***	(0.37)	13570
Value of oilseeds production (XOF, log)	1470	-0.00189	(0.22)	339000	1213	1.512***	(0.41)	213000

As expected by the PAFA project management unit, yields strongly increased as a result of the PAFA support to PO members. SPAM beneficiaries experienced significant gains in yields. In fact, millet yields for SPAM beneficiaries was nearly 30 percentage points higher than the combined control farmers. Similarly, niebe, sesame and bissap yields increased respectively by 38, 5.5, and 37 percent. For horticulture and pulses yields exhibit productivity increases of almost 40 percentage points.

Table 5.5 Results on crop productivity

	SPAM VS ALL CONTROLS			
Productivity indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Millet yields (kg/ha, log)	1856	0.282***	(0.10)	710.6
Maize yields (kg/ha, log)	1856	0.0954	(0.12)	91.5
Sorghum yields (kg/ha, log)	1856	0.0648	(0.06)	27.0
Niebe yields (kg/ha, log)	1856	0.382***	(0.12)	127.7
Sesame yields (kg/ha, log)	1856	0.0555*	(0.03)	0.9
Bissap yields (kg/ha, log)	1856	0.374***	(0.06)	37.8
Peanut yields (kg/ha, log)	1856	0.152	(0.12)	983.4
Cereals yields (kg/ha, log)	1856	0.208**	(0.09)	571.53
Horticulture yields (kg/ha, log)	1856	0.396***	(0.07)	50.2
Pulses yields (kg/ha, log)	1856	0.382***	(0.12)	127.73
Oilseeds yields (kg/ha, log)	1856	0.169	(0.11)	826.68

Turning to the results disaggregated by control group samples, once again effects on millet productivity are large (71% gain) and highly significant when SPAM beneficiaries are compared to counterfactual farmers in outside regions. In the comparison with control farmers residing in PAFA regions, the effect is much smaller (6%) and not significant. This might reflect possible spillover , and presence of similar projects – that adopted the PAFA approach – hence generating similar gains for comparison farmers in PAFA supported regions. Interesting to note, that effects on sorghum is now significant (albeit only at 10% level), indicating a gain to PAFA-SPAM beneficiary farmers of about 10% when compared to other farmers in the same project regions. Effects remain positive and significant for other supported value chains such as niebe, bissap and horticulture across all comparison groups.

Looking at peanut yields –the effect is not significantly different when one compares the benefits of SPAM in PAFA regions, while the effect becomes huge once PAFA SPAM beneficiaries – are compared to control farmers in outside regions, this can be explained by the traditional focus on peanut production in the PAFA regions, which certainly reduced compared to historical output levels but is still much larger than in adjacent regions.

Table 5.6 Results on crop productivity (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Productivity indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Control mean**
Millet yields (kg/ha, log)	1470	0.057	(0.11)	781.24	1213	0.710***	(0.16)	592.95
Maize yields (kg/ha, log)	1470	0.036	(0.14)	117.66	1213	0.151	(0.17)	47.78
Sorghum yields (kg/ha, log)	1470	0.101*	(0.06)	9.44	1213	-0.209	(0.17)	56.22
Niebe yields (kg/ha, log)	1470	0.256*	(0.13)	116.68	1213	0.416**	(0.20)	146.13
Sesame yields (kg/ha, log)	1470	0.0603*	(0.03)	0.67	1213	0.0533	(0.04)	1.37
Bissap yields (kg/ha, log)	1470	0.324***	(0.07)	27.69	1213	0.376***	(0.07)	54.72
Peanut yields (kg/ha, log)	1470	-0.0688	(0.12)	1163.81	1213	0.885***	(0.22)	682.78
Cereals yields (kg/ha, log)	1470	0.00943	(0.10)	602.4	1213	0.649***	(0.16)	520.09
Horticulture yields (kg/ha, log)	1470	0.363***	(0.08)	42.44	1213	0.434***	(0.08)	63.13
Pulses yields (kg/ha, log)	1470	0.256*	(0.13)	116.68	1213	0.416**	(0.20)	146.13
Oilseeds yields (kg/ha, log)	1470	-0.0178	(0.12)	939.36	1213	0.825***	(0.22)	638.99

Input usage was strongly affected by PAFA according to the estimates in Table 5.6. Fertilizer usage increased by 41 percentage points , inorganic fertilizer by 35 % and usage of pesticides increased by a highly significant 2.5 %. Also the quality of fertilizers used improved as well as the expenditure for fertilizer. These results are not surprising given that PAFA explicitly supported SPAM farmers' access to these inputs.

Table 5.6 Results on input use, rate of input use

	SPAM VS ALL CONTROLS			
Input use indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Fertilizer use (kg/ha, log)	1856	0.411***	(0.135)	192.7
Organic fertilizer use (kg/ha, log)	1856	0.205	(0.147)	178.3
Inorganic fertilizer use (kg/ha, log)	1856	0.350***	(0.0990)	14.4
Pesticide use (kg/ha, log)	1856	0.0258**	(0.0130)	0.1
Quantity of seeds used (kg, log)	1856	0.0872	(0.0898)	55.4
Quantity of fertilizer used (kg, log)	1856	0.222*	(0.115)	71.5
Quantity of pesticide used (kg, log)	1856	0.0230	(0.0155)	3.1
Seed expenditure (XOF, log)	1856	0.225	(0.197)	8512.0
Fertilizer expenditure (XOF, log)	1856	0.438**	(0.222)	12232.5
Pesticide expenditure (XOF, log)	1856	0.0439	(0.0662)	129.3

Similar results can be seen when impact estimates are computed across the two control samples separately. Gains in fertilizer uses are much larger when one compares SPAM beneficiaries to comparison farmers in outside regions. However, results remain positive and significant, regardless of the presence of spillover effects in PAFA regions, for inorganic fertilizer use (20% percentage points), and quantity of pesticide used (2.5%).

Table 5.7 Results on input use, rate of input use (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Input use indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Control mean**
Fertilizer use (kg/ha, log)	1470	0.0806	(0.151)	205.31	1213	1.326***	(0.219)	171.60
Organic fertilizer use (kg/ha, log)	1470	-0.162	(0.164)	187.71	1213	1.089***	(0.222)	162.57
Inorganic fertilizer use (kg/ha, log)	1470	0.209*	(0.111)	17.60	1213	0.869***	(0.119)	9.03
Pesticide use (kg/ha, log)	1470	0.0277**	(0.0131)	0.09	1213	0.0292**	(0.0125)	0.07
Quantity of seeds used (kg, log)	1470	-0.0661	(0.104)	79.70	1213	0.375***	(0.111)	14.96
Quantity of fertilizer used (kg, log)	1470	0.0599	(0.131)	91.35	1213	0.733***	(0.126)	38.54
Quantity of pesticide used (kg, log)	1470	0.0254*	(0.0153)	0.09	1213	0.0272	(0.0172)	8.17
Seed expenditure (XOF, log)	1470	-0.114	(0.227)	9306.31	1213	0.821***	(0.256)	7188.86
Fertilizer expenditure (XOF, log)	1470	0.126	(0.252)	15631.34	1213	1.411***	(0.245)	6570.60
Pesticide expenditure (XOF, log)	1470	0.00653	(0.0778)	104.28	1213	0.127	(0.0859)	170.98

5.2 Economic mobility

When it comes to economic mobility, PAFA was very successful. Total gross income for direct PAFA beneficiaries increased by 11.3 percentage points (at 10% statistical significance) and income from crop production increased by 47.5 percent and for livestock income by 56.3 percent. All these are obtained with varying levels of statistical significance (Table 5.8). Wage income from agriculture, which was not supported by PAFA, does not show any significant changes, neither does income from non-agricultural activities. Income from self-employment is negatively affected by the intervention, suggesting that beneficiaries were less likely to engage in self-employment jobs, rather choosing to increase their over-reliance on agriculture. As we will see in later tables, there is no significant impact of PAFA on income diversification.

Table 5.8 Results on income and asset indices

	SPAM VS ALL CONTROLS			
Economic mobility indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Total gross income (XOF, log)	1856	0.113*	(0.0637)	1210000
Crop income (XOF, log)	1856	0.475***	(0.103)	508000
Livestock income (XOF, log)	1856	0.563**	(0.262)	150000
Wage income from agricultural activities (XOF, log)	1856	0.0374	(0.0592)	1524
Wage income from non-agricultural activities (XOF, log)	1856	0.0670	(0.220)	191000
Self -employment income (XOF, log)	1856	-0.318*	(0.173)	305000
Transfer income (XOF, log)	1856	0.222	(0.281)	52041
Tropical livestock unit	1856	-0.0350	(0.0325)	3.8
Overall asset index	1855	-0.016	(0.03)	1.2
Housing asset index	1855	0.005	(0.01)	0.3
Durable asset index	1855	-0.028	(0.04)	1.3
Productive asset index	1855	0.006	(0.05)	1.6
Livestock index	1855	-0.058	(0.05)	0.7

Gains in crop income still remain for SPAM beneficiaries when samples are disaggregated – about 20 percentage point gain when comparing treated farmers with farmers in PAFA regions, and extremely large gains when beneficiaries gains are compared to counterfactual farmers in outside regions (113 percentage points). Livestock income exhibits similar results.

Table 5.9 Results on income and asset indices (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Economic mobility indicators	**N**	**Treatm ent effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Control mean**
Total gross income (XOF, log)	1470	0.0526	(0.0682)	1070000	1213	0.337***	(0.115)	1450000
Crop income (XOF, log)	1470	0.206**	(0.104)	575000	1213	1.137***	(0.234)	397000
Livestock income (XOF, log)	1470	0.566*	(0.289)	173000	1213	0.992***	(0.378)	111000
Wage income from agricultural (XOF, log)	1470	0.0600	(0.0551)	2308	1213	-0.228	(0.181)	218
Wage income from non-agricultural activities (XOF, log)	1470	-0.0755	(0.250)	167000	1213	0.432	(0.287)	231000
Self -employment income (XOF, log)	1470	-0.140	(0.187)	96845	1213	-0.671**	(0.283)	652000
Transfer income (XOF, log)	1470	0.321	(0.312)	55620	1213	0.248	(0.451)	46079
Tropical livestock unit	1470	0.0120	(0.034)	3.34	1213	-0.0799	(0.0690)	4.68

Overall asset index	1469	-0.030	(0.03)	0.75	1212	0.0727*	(0.04)	0.81
Housing asset index	1469	-0.007	(0.01)	0.23	1212	0.0283**	(0.01)	0.29
Durable asset index	1469	-0.046	(0.04)	1.17	1212	0.036	(0.06)	0.91
Productive asset index	1469	-0.019	(0.05)	0.94	1212	0.251***	(0.07)	1.19
Livestock index	1469	-0.018	(0.05)	1.06	1212	-0.198**	(0.08)	0.23

The SPAM subsidy did not generate any impact on poverty indicators (based on assets) – when comparing SPAM beneficiaries to the pooled comparison group (Table 5.10). When disaggregating the comparison groups, modest gains of up to 17 % can be seen when one compares poverty outcomes for beneficiaries with farmers in outside regions. Results are not significant when SPAM beneficiaries are compared to farmers in PAFA regions. Here some negative effects are also present. This may be due to selection issues e.g. the fact that SPAM targeted the poorest and the most vulnerable members within POs. Moreover, given the short time horizon of the impact assessment, this might suggest that the effects observed on yields and incomes have not yet translated into accumulation of assets. This might also be due to the character of the subsidy which is diminishing over time. Before investing into assets, farmers might be certain that they are capable of keeping up once the subsidy is fully withdrawn. To further investigate this, a follow up study might look at heterogeneous effects across PAFA cohorts.

Table 5.10 Results on poverty indices

	SPAM VS ALL CONTROLS			
Poverty reduction indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Above the overall asset-based poverty line, 40th percentile	1855	-0.014	(0.02)	0.60
Above the housing asset-based poverty line, 60th percentile	1855	-0.012	(0.02)	0.40
Above the durable asset-based poverty line, 40th percentile	1855	-0.007	(0.02)	0.60
Above the durable asset-based poverty line, 60th percentile	1855	-0.030	(0.02)	0.40
Above the productive asset-based poverty line, 40th percentile	1855	0.004	(0.02)	0.60
Above the productive asset-based poverty line, 60th percentile	1855	0.007	(0.02)	0.40
Above the livestock asset-based poverty line, 40th percentile	1855	0.000	(0.02)	0.60
Above the livestock asset-based poverty line, 60th percentile	1855	0.019	(0.02)	0.40
Above the housing asset-based poverty line, 40th percentile	1855	-0.010	(0.02)	0.55
Above the housing asset-based poverty line, 60th percentile	1855	0.023	(0.02)	0.38

Table 5.11 Results on poverty indices (disaggregated controls)

	SPAM VS CONTROL IN				SPAM VS CONTROL OUT			
Poverty reduction indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatment effect**	**Std. error**	**Control mean**
Above the overall asset-based poverty line, 40th percentile	1469	-0.009	(0.02)	0.62	1212	0.026	(0.04)	0.5
Above the housing asset-based poverty line, 60th percentile	1469	-0.024	(0.02)	0.41	1212	0.027	(0.03)	0.33
Above the durable asset-based poverty line, 40th percentile	1469	-0.023	(0.02)	0.58	1212	0.0569**	(0.03)	0.53
Above the durable asset-based poverty line, 60th percentile	1469	-0.0521**	(0.02)	0.4	1212	-0.007	(0.03)	0.31
Above the productive asset-based poverty line, 40th percentile	1469	-0.002	(0.02)	0.62	1212	0.026	(0.04)	0.55
Above the productive asset-based poverty line, 60th percentile	1469	0.007	(0.03)	0.37	1212	0.060	(0.04)	0.38
Above the livestock asset-based poverty line, 40th percentile	1469	0.013	(0.03)	0.59	1212	0.101***	(0.04)	0.59
Above the livestock asset-based poverty line, 60th percentile	1469	-0.003	(0.03)	0.4	1212	0.030	(0.04)	0.37
Above the housing asset-based poverty line, 40th percentile	1469	-0.0397*	(0.02)	0.52	1212	0.0531*	(0.03)	0.58
Above the housing asset-based poverty line, 60th percentile	1469	0.011	(0.02)	0.38	1212	0.037	(0.03)	0.33

5.3 Market Access

Market access outcomes, notably the probability of selling crops in the previous 12 months – exhibit positive results. SPAM farmers are more likely to sell their millet harvest with an 82 % higher probability compared with the pooled control groups , and a 51% higher probability of selling niebe compared to all controls.

Table 5.12 Results on market participation by crop

	SPAM VS ALL CONTROLS			
Market participation indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Harvest sold to market operator (Yes=1)	1856	0.0225	(0.0167)	0.1
Market participation - millet (Yes=1)	1856	0.0981***	(0.0190)	0.12
Market participation - maize (Yes=1)	1856	0.0179*	(0.00960)	0.02
Market participation - sorghum (Yes=1)	1856	0.00292	(0.00694)	0.01
Market participation - niebe (Yes=1)	1856	0.0358**	(0.0153)	0.07
Market participation - bissap (Yes=1)	1856	0.0673***	(0.0103)	0.02
Market participation - peanut (Yes=1)	1856	0.00891	(0.0222)	0.68

Results become significant when samples are disaggregated for the likelihood of selling the harvest to market operators. SPAM households have a larger probability of selling to market operators compared to comparison farmers in outside regions by an equivalent of more than 6 percentage points (0.065% significant at the 1% level). Given that such market operators are present in PAFA regions, the effects remain positive but not significant in such regions. Positive results remain across the board for the probability of selling millet and bissap.

Table 5.13 Results on market participation by crop (disaggregated controls)

	Spit is AM vs Control in				SPAM vs Control out			
Market access indicators	N	Treatment effect	Std. error	Control mean	N	Treatment effect	Std. error	Control mean
Harvest sold to market operator (Yes=1)	1470	0.0233	(0.0179)	0.09	1213	0.0625***	(0.0194)	0.06
Market participation - millet (Yes=1)	1470	0.0497**	(0.0225)	0.18	1213	0.198***	(0.0172)	0.03
Market participation - maize (Yes=1)	1470	0.00590	(0.0126)	0.03	1213	0.0371***	(0.0069)	0.002
Market participation - sorghum (Yes=1)	1470	0.00323	(0.0079)	0.01				
Market participation - niebe (Yes=1)	1470	0.0268	(0.0175)	0.08	1213	0.0201	(0.0237)	0.06
Market participation - bissap (Yes=1)	1470	0.0606***	(0.0111)	0.03	1213	0.0749***	(0.0102)	0.01
Market participation - peanut (Yes=1)	1470	-0.0251	(0.0235)	0.73	1213	0.159***	(0.0394)	0.59

Turning to quantities of crops sold by crop and value of sales, results are largely positive and significant when comparing SPAM beneficiaries to the whole group of comparison farmers. Quantity of crops sold are larger for beneficiaries by 54 percentage points in the case of millet, 12% for maize, 18.5% for niebe, 33% for bissap, and 35% for horticulture. Similarly, value of sales for millet are larger by more than 100% for millet, 20% more in the case of maize, 39% in the case of niebe, 73% in the case of bissap, 76% in the case of horticultural crops (Table 5.14).

Table 5.14 Results on quantity sold and value of sales

	SPAM VS ALL CONTROLS			
Market sales indicators	N	Treatment effect	Std. error	Control mean
Quantity of crop sold - millet (kg, log)	1856	0.542***	(0.118)	94.7
Quantity of crop sold - maize (kg, log)	1856	0.120**	(0.0566)	14.6
Quantity of crop sold - sorghum (kg, log)	1856	0.0190	(0.0367)	3.7
Quantity of crop sold - niebe (kg, log)	1856	0.185***	(0.0685)	11.1
Quantity of crop sold - sesame (kg, log)	1856	0.0502**	(0.0252)	1.4
Quantity of crop sold - bissap (kg, log)	1856	0.333***	(0.0480)	2.8
Quantity of crop sold - peanut (kg, log)	1856	-0.00823	(0.156)	998.3
Quantity of crop sold - cereals (kg, log)	1856	0.547***	(0.127)	113.7
Quantity of crop sold - horticulture (kg, log)	1856	0.353***	(0.0600)	32.3
Quantity of crop sold - pulses (kg, log)	1856	0.185***	(0.0685)	11.1

Quantity of crop sold - oilseeds (kg, log)	1856	0.0136	(0.155)	999.6
Value of crop sold - millet (XOF, log)	1856	1.036***	(0.216)	16841.8
Value of crop sold - maize (XOF, log)	1856	0.204**	(0.103)	2441.0
Value of crop sold - sorghum (XOF, log)	1856	0.0369	(0.0723)	1252.4
Value of crop sold - niebe (XOF, log)	1856	0.393**	(0.153)	3794.3
Value of crop sold - sesame (XOF, log)	1856	0.111**	(0.0524)	540.3
Value of crop sold - bissap (XOF, log)	1856	0.734***	(0.108)	1246.6
Value of crop sold - peanut (XOF, log)	1856	0.0725	(0.271)	205000.0
Value of crop sold - cereals (XOF, log)	1856	1.023***	(0.231)	20656.7
Value of crop sold - horticulture (XOF, log)	1856	0.758***	(0.126)	4883.1
Value of crop sold - pulses (XOF, log)	1856	0.393**	(0.153)	3794.3
Value of crop sold - oilseeds (XOF, log)	1856	0.118	(0.271)	205000.0

Table 5.15 presents the same results by estimating impacts using separate control samples. Results are similar; SPAM beneficiaries sold 119% larger quantities of millet compared to control farmers in outside regions and 24% larger millet quantities compared to control farmers in the PAFA regions.

Table 5.15 Results on quantity sold and value of sales (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Market Sales indicators	**N**	**Treatment effect**	**Std. error**	**Contol mean**	**N**	**Treatme nt effect**	**Std. error**	**Control mean**
Quantity of crop sold - millet (kg, log)	1470	0.241*	(0.138)	139.03	1213	1.193***	(0.105)	20.78
Quantity of crop sold - maize (kg, log)	1470	0.0607	(0.0674)	23.20	1213	0.248***	(0.0435)	0.26
Quantity of crop sold - sorghum (kg, log)	1470	0.0397	(0.0378)	2.05	1213	-0.129	(0.0955)	6.35
Quantity of crop sold - niebe (kg, log)	1470	0.171**	(0.0743)	7.91	1213	0.142	(0.121)	16.42
Quantity of crop sold - sesame (kg, log)	1470	0.0494*	(0.0286)	0.77	1213	0.060***	(0.0231)	2.31
Quantity of crop sold - bissap (kg, log)	1470	0.308***	(0.0508)	3.51	1213	0.373***	(0.0468)	1.52
Quantity of crop sold - peanut (kg, log)	1470	-0.312*	(0.168)	1213.28	1213	1.065***	(0.255)	640.06
Quantity of crop sold - cereals (kg, log)	1470	0.240	(0.147)	165.06	1213	1.131***	(0.145)	28.03
Quantity of crop sold - horticulture (kg, log)	1470	0.341***	(0.0619)	47.27	1213	0.437***	(0.0549)	7.47
Quantity of crop sold - pulses (kg, log)	1470	0.171**	(0.0743)	7.91	1213	0.142	(0.121)	16.42
Quantity of crop sold - oilseeds (kg, log)	1470	-0.290*	(0.167)	1214.05	1213	1.087***	(0.255)	642.37
Value of crop sold - millet (XOF, log)	1470	0.478*	(0.253)	25284.2	1213	2.237***	(0.193)	2778.50
Value of crop sold - maize (XOF, log)	1470	0.0871	(0.126)	3634.14	1213	0.447***	(0.0773)	453.37

Value of crop sold - sorghum (XOF, log)	1470	0.0656	(0.0782)	1494.95	1213	-0.227	(0.181)	848.45
Value of crop sold - niebe (XOF, log)	1470	0.338**	(0.170)	2533.13	1213	0.334	(0.264)	5895.08
Value of crop sold - sesame (XOF, log)	1470	0.109*	(0.0589)	311.04	1213	0.131***	(0.0484)	922.28
Value of crop sold - bissap (XOF, log)	1470	0.672***	(0.115)	1430.33	1213	0.844***	(0.104)	940.41
Value of crop sold - peanut (XOF, log)	1470	-0.449	(0.290)	245000	1213	1.950***	(0.453)	138000
Value of crop sold - cereals (XOF, log)	1470	0.444*	(0.268)	30491.0	1213	2.105***	(0.270)	4274.61
Value of crop sold - horticulture (XOF, log)	1470	0.720***	(0.132)	5500.31	1213	0.954***	(0.115)	3854.92
Value of crop sold - pulses (XOF, log)	1470	0.338**	(0.170)	2533.13	1213	0.334	(0.264)	5895.08
Value of crop sold - oilseeds (XOF, log)	1470	-0.403	(0.289)	245000.	1213	1.995***	(0.453)	139000.

5.4 Resilience and food security

Table 5.16 displays the estimated project impacts regarding resilience (including crop diversification) and food security outcomes such as the household's dietary diversity score. Besides being a characteristic of the agricultural production undertaken, crop diversification can be also seen as a proxy for resilience (i.e. greater crop diversity being associated with greater resilience). The estimated results suggest that treated households are on average more diversified in terms of their agricultural production regardless of the diversity metrics used.[8] This is in line with PAFA's targeting and encouragement at diversification.

Note that resilience indices are not statistically significant. The dietary diversity score exhibits a negative coefficient, which indicates that despite higher incomes and production diversity of SPAM households, this doesn't translate in quality food. Similar results were found in previous studies suggesting that as incomes increases households might prefer better tasting food to quality food (Banerjee and Duflo, 2011).

Table 5.16 Results on resilience and food security

	SPAM VS ALL CONTROLS			
Resilience and food security indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**
Income diversification index (count)	1856	0.0771	(0.0589)	3.2
Income diversification index (margalef)	1856	0.0771	(0.0589)	3.1
Income diversification index (shannon)	1856	0.0166	(0.0173)	0.3
Crop diversification (count)	1445	0.147***	-0.05	2.3
Crop diversification (margalef)	1445	0.0191***	-0.01	0.17
Crop diversification (shannon)	1445	0.0633***	-0.02	0.68
Crop diversification (berger parker)	1445	0.0924***	-0.03	1.74

[8] Notice that for both the Shannon and the Berger-Parker indices larger figures indicate lower diversity

Resilience index (PRIME), normalized	1250	0.176	(0.745)	42.3
Ability to recover (all shocks)	1250	0.00408	(0.0741)	3.2
Ability to recover (5 major shocks)	1070	0.0847	(0.0808)	3.2
Household dietary diversity score	1851	-0.359***	(0.121)	7.0
FIES	1856	0.131	(0.115)	2.9

Table 5.17 Results on resilience and food security (disaggregated controls)

	SPAM vs Control in				SPAM vs Control out			
Resilience and food security indicators	**N**	**Treatment effect**	**Std. error**	**Control mean**	**N**	**Treatmen t effect**	**Std. error**	**Control mean**
Income diversification index (count)	1470	0.0554	(0.065)	3.21	1213	0.103	(0.102)	3.19
Income diversification index (margalef)	1470	0.0554	(0.065)	3.08	1213	0.103	(0.102)	3.06
Income diversification index (shannon)	1470	0.0162	(0.019)		1213	0.0300	(0.0279)	0.34
Crop diversification (count)	1445	0.147***	(0.045)	2.31	973	0.101*	(0.0587)	2.22
Crop diversification (margalef)	1445	0.0191***	(0.006)	0.17	973	0.0132*	(0.0076)	0.16
Crop diversification (shannon)	1445	0.0633***	(0.018)	0.69	973	0.0572**	(0.0251)	0.68
Crop diversification (berger parker)	1445	0.0924***	(0.036)	0.47	973	0.0658	(0.0401)	3.58
Resilience index (PRIME), normalized	1023	-0.0336	(0.825)	42.45	811	0.135	(0.847)	42.06
Ability to recover (all shocks)	1023	0.0737	(0.082)	3.16	811	-0.344***	(0.108)	3.37
Ability to recover (5 major shocks)	870	0.159*	(0.088)	3.16	707	-0.0513	(0.118)	3.34
Household dietary diversity score	1465	-0.420***	(0.136)	6.95	1208	-0.0106	(0.188)	7.08
FIES	1470	0.114	(0.129)	2.99	1213	0.299*	(0.165)	2.70

5.5 Disaggregation (Subgroup analysis)

On yield indicators, SPAM households that were members of youth POs enjoyed double the gains compared to members of other POs. Similarly, in terms of total harvest and value of production, youth POs are better off. Nonetheless, other types of POs are only marginally better off in terms of crop income.

Table 5.17 Results on production, income and assets disaggregated by youth

	YOUTH POs				OTHER POs			
Productivity indicators	N	Treatment effect	Std. Error	Control mean	N	Treatmen t effet	Std. Error	Control mean
Millet yields (kg/ha, log)	642	0.515***	(0.19)	711.95	1215	0.271**	(0.13)	709.76
Maize yields (kg/ha, log)	642	0.216	(0.21)	81.32	1215	0.0102	(0.16)	97.81
Niebe yields (kg/ha, log)	642	0.650***	(0.22)	111.33	1215	0.330**	(0.14)	138.03
Bissap yields (kg/ha, log)	642	0.678***	(0.13)	12.45	1215	0.250***	(0.07)	53.78
Peanut yields (kg/ha, log)	642	0.266	(0.21)	1021.24	1215	0.15	(0.14)	959.57
Cereals yields (kg/ha, log)	642	0.353**	(0.17)	545.53	1215	0.222*	(0.12)	587.86
Horticulture yields (kg/ha, log)	642	0.636***	(0.14)	34.38	1215	0.304***	(0.09)	60.14
Pulses yields (kg/ha, log)	642	0.650***	(0.22)	111.33	1215	0.330**	(0.14)	138.03
Oilseeds yields (kg/ha, log)	642	0.246	(0.20)	911.02	1215	0.176	(0.14)	773.71
Production indicators								
Total harvest - millet (kg, log)	642	0.558***	(0.19)	889.40	1215	0.325**	(0.14)	1093.41
Total harvest - maize (kg, log)	642	0.145	(0.22)	67.96	1215	0.0198	(0.16)	116.87
Total harvest - niebe (kg, log)	642	0.571***	(0.20)	23.65	1215	0.379***	(0.12)	34.51
Total harvest - bissap (kg, log)	642	0.638***	(0.12)	6.86	1215	0.230***	(0.06)	3.50
Total harvest - peanut (kg, log)	642	0.243	(0.22)	1286.88	1215	0.095	(0.15)	1528.86
Total harvest - cereals (kg, log)	642	0.466***	(0.18)	964.16	1215	0.328**	(0.13)	1242.48
Total harvest - horticulture (kg, log)	642	0.597***	(0.13)	76.34	1215	0.291***	(0.08)	11.73
Total harvest - pulses (kg, log)	642	0.571***	(0.20)	23.65	1215	0.379***	(0.12)	34.51
Total harvest - oilseeds (kg, log)	642	0.237	(0.22)	1292.17	1215	0.126	(0.15)	1529.81
Value of millet production (XOF, log)	642	1.124***	(0.33)	143000	1215	0.762***	(0.24)	186000
Value of maize production (XOF, log)	642	0.157	(0.41)	17299	1215	-0.027	(0.28)	24501
Value of niebe production (XOF, log)	642	1.317***	(0.43)	7887	1215	0.836***	(0.27)	12355
Value of bissap production (XOF, log)	642	1.406***	(0.26)	2467	1215	0.481***	(0.13)	1990
Value of peanut production (XOF, log)	642	0.403	(0.37)	265000	1215	0.346	(0.26)	307000
Value of cereals production (XOF, log)	642	0.895***	(0.30)	162000	1215	0.757***	(0.23)	219000
Value of horticulture production (XOF, log)	642	1.304***	(0.28)	10881	1215	0.537***	(0.16)	3456
Value of pulses production (XOF, log)	642	1.317***	(0.43)	7887	1215	0.836***	(0.27)	12355
Value of oilseeds production (XOF, log)	642	0.394	(0.37)	268000	1215	0.41	(0.26)	307000
Economic mobility indicators								

Total gross income (XOF, log)	642	0.112	(0.11)	1070000	1215	0.0902	(0.09)	1310000
Crop income (XOF, log)	642	0.561***	(0.17)	451000	1215	0.567***	(0.14)	544000
Livestock income (XOF, log)	642	0.991**	(0.47)	209000	1215	0.419	(0.33)	113000
Wage income from agricultural (XOF, log)	642	0.056	(0.06)	0	1215	0.0226	(0.09)	2481
Wage income from non-agricultural activities (XOF, log)	642	-0.0195	(0.38)	229000	1215	0.0793	(0.28)	167000
Self -employment income (XOF, log)	642	0.0559	(0.33)	116000	1215	-0.600***	(0.22)	424000
Transfer income (XOF, log)	642	0.69	(0.49)	48421	1215	-0.107	(0.35)	54315
Tropical livestock unit	642	-0.0739	(0.05)	3.55	1215	0.013	(0.04)	4.02
Overall asset index	641	0.0874	(0.06)	1.14	1214	-0.0741*	(0.04)	1.15
Housing asset index	641	0.0155	(0.02)	0.29	1214	-0.00714	(0.01)	0.32
Durable asset index	641	0.134	(0.10)	1.28	1214	-0.141**	(0.07)	1.32
Productive livestock index	641	0.114	(0.09)	1.64	1214	-0.0110	(0.06)	1.59
Livestock index	641	-0.0784	(0.05)	0.64	1214	-0.0395	(0.06)	0.65

The results disaggregated by gender are more mixed, and crop dependent. SPAM beneficiaries belonging to women POs experience higher yields than the control group for niebe and bissap. However, in the case of millet and horticulture yields, beneficiaries from mixed organizations had higher gains. At the exception of millet, gains in crop harvest and value of production are higher for members of female organizations than other types of POs. These gains translated into higher income gains. Beneficiaries from female POs experienced a 40 percent increase in gross income as a result of the intervention, while beneficiaries from non-female POs did not see increases in their incomes, but rather a decline which is however not significant.

Table 5.18 Results on production, income and assets disaggregated by gender

	WOMEN'S POs				OTHER POs			
Productivity indicators	**N**	**Treatment effect**	**Std. Error**	**Control mean**	**N**	**Treatment effect**	**Std. Error**	**Control mean**
Millet yields (kg/ha, log)	791	0.126	(0.17)	689.39	1066	0.369***	(0.13)	732.80
Maize yields (kg/ha, log)	791	0.3	(0.20)	45.19	1066	-0.00732	(0.16)	139.82
Niebe yields (kg/ha, log)	791	0.465**	(0.20)	131.24	1066	0.314**	(0.15)	124.05
Bissap yields (kg/ha, log)	791	0.371***	(0.12)	22.13	1066	0.364***	(0.08)	54.24
Peanut yields (kg/ha, log)	791	0.345*	(0.20)	928.68	1066	0.0571	(0.15)	1040.54
Cereals yields (kg/ha, log)	791	0.18	(0.16)	583.03	1066	0.238**	(0.12)	559.50
Horticulture yields (kg/ha, log)	791	0.391***	(0.13)	28.23	1066	0.400***	(0.09)	73.19
Pulses yields (kg/ha, log)	791	0.465**	(0.20)	131.24	1066	0.314**	(0.15)	124.05
Oilseeds yields (kg/ha, log)	791	0.341*	(0.19)	768.59	1066	0.0855	(0.14)	887.44

Production indicators								
Total harvest - millet (kg, log)	791	0.125	(0.18)	867.05	1066	0.407***	(0.14)	1169.10
Total harvest - maize (kg, log)	791	0.279	(0.19)	55.09	1066	-0.0104	(0.16)	142.87
Total harvest - niebe (kg, log)	791	0.494***	(0.16)	26.64	1066	0.354***	(0.13)	34.17
Total harvest - bissap (kg, log)	791	0.389***	(0.11)	6.24	1066	0.313***	(0.06)	3.29
Total harvest - peanut (kg, log)	791	0.277	(0.21)	1240.37	1066	0.0256	(0.16)	1639.56
Total harvest - cereals (kg, log)	791	0.25	(0.17)	926.74	1066	0.333**	(0.13)	1352.99
Total harvest - horticulture (kg, log)	791	0.418***	(0.12)	12.91	1066	0.353***	(0.08)	61.49
Total harvest - pulses (kg, log)	791	0.494***	(0.16)	26.64	1066	0.354***	(0.13)	34.17
Total harvest - oilseeds (kg, log)	791	0.28	(0.21)	1240.75	1066	0.0543	(0.16)	1644.53
Value of millet production (XOF, log)	791	0.588*	(0.31)	141000	1066	0.772***	(0.24)	200000
Value of maize production (XOF, log)	791	0.427	(0.36)	16134	1066	-0.121	(0.29)	27566
Value of niebe production (XOF, log)	791	1.277***	(0.38)	9818	1066	0.705**	(0.29)	11482
Value of bissap production (XOF, log)	791	0.868***	(0.24)	2276	1066	0.667***	(0.14)	2068
Value of peanut production (XOF, log)	791	0.535	(0.35)	248000	1066	0.154	(0.27)	336000
Value of cereals production (XOF, log)	791	0.763**	(0.30)	160000	1066	0.620***	(0.22)	235000
Value of horticulture production (XOF, log)	791	0.892***	(0.25)	4803	1066	0.686***	(0.16)	7908
Value of pulses production (XOF, log)	791	1.277***	(0.38)	9818	1066	0.705**	(0.29)	11482
Value of oilseeds production (XOF, log)	791	0.539	(0.35)	248000	1066	0.215	(0.26)	338000
Economic mobility indicators								
Total gross income (XOF, log)	791	0.394***	(0.13)	936000	1066	-0.0237	(0.07)	1500000
Crop income (XOF, log)	791	0.459***	(0.17)	425000	1066	0.445***	(0.14)	595000
Livestock income (XOF, log)	791	1.630***	(0.41)	57856	1066	0.0583	(0.34)	247000
Wage income from agricultural (XOF, log)	791	0.053	(0.05)	0	1066	0.0554	(0.07)	3117
Wage income from non-agricultural activities (XOF, log)	791	0.268	(0.34)	189000	1066	0.0572	(0.28)	193000
Self -employment income (XOF, log)	791	-0.312	(0.29)	210000	1066	-0.271	(0.21)	405000
Transfer income (XOF, log)	791	1.117**	(0.47)	44506	1066	-0.25	(0.35)	59921
Tropical livestock unit	791	0.0295	(0.05)	3.56	1066	-0.0655	(0.04)	4.14
Overall asset index	791	0.00493	(0.01)	1.05	1064	0.00743	(0.01)	1.25
Housing asset index	791	-0.0501	(0.10)	0.30	1064	-0.0570	(0.07)	0.31
Durable asset index	791	0.0635	(0.08)	1.20	1064	-0.0190	(0.06)	1.41

Productive asset index	791	-0.00833	(0.06)	1.43	1064	-0.0349	(0.04)	1.80
Livestock index	791	-0.0216	(0.05)	0.55	1064	-0.0602	(0.05)	0.74

5.6 Spillover effects

This section presents the results on the spillover analysis to assess the presence of bias based on the distance of the control POs from the PAFA POs. Tables A3.1 to A3.8 in Appendix 3 hold the results for the analysis. The first column of results shows the estimation of treatment effects taking into consideration the proximity of control POs to PAFA POs (ATE with neighbourhood effects), and the second column shows the treatment effects without the neighbourhood effects. The bias caused by not accounting for neighbourhood effects is presented in the last two columns. Overall, ignoring neighbourhood effects leads to an underestimation of PAFA's impact on most indicators.

In terms of productivity, neglecting neighbourhood effects (defined as effects from treated units to control units) would lead to an underestimation of project impact in millet yields by 30% and 40% for niebe yields.[9] Similarly, the bias is around 30 percent for total harvest of millet and niebe, but around 1% for bissap; the value of crop production for millet presents a 59 % underestimation. Average treatment effects are underestimated by 36% for crop income and 122% for self-employment income when neighbourhood effects are not taken into account. This indicates that the further away control POs are from PAFA POs, the stronger the treatment effect.

Market access indicators show a small but positive bias; which is at 4% for millet and 2.5% for bissap, suggesting that not taking into account neighbourhood effects overestimates treatment effects. Similar results are found for the quantity and value of crop sold for millet and bissap with an overestimation bias ranging between 2 and 6%. Crop diversification (count) is overestimated by 11%. These results indicate the presence of strong spillover effects in areas near PAFA POs. Ignoring these effects underestimates project impacts.

Results on non-SPAM

In this section we present results on spillover within the PO; members of PAFA POs that did not receive SPAM are compared with the control groups. Tables A2.1 to A2.9 in Appendix 2 hold the results of this analysis.

On adoption indicators, non-SPAM members are more likely to adopt the targeted crops (at the exception of maize) and use fertilizer than the outside control group. This suggests the presence of spillover effects within POs. Similar results are found on the value of crop production, total harvest, and yields, which are higher for the Non SPAM except for maize, which is lower.

In terms of economic mobility, non-SPAM households have higher crop and livestock income than both controls. However, similar to SPAM households, self-employment income is lower. Estimates for gross income are not significant. Asset indices are persistently negative as well.

Compared to controls inside the regions of intervention, there is no significant impact of belonging to a PAFA PO and not receiving SPAM on market participation. However, vis-à-vis the control outside the region, gains are significant. Non SPAM households were more likely to sell their harvest with their quantity of crop sold increased by 121 % in the case of millet, 14.7% for maize, 7% for sesame, and 11% for bissap. These gains are large and suggest that non SPAM also benefitted from PAFA's

[9] In the case of bissap, the treatment effects are similar, and there is therefore no bias.

market access component. This is in line with expectations given that the market operator linkages were established at the PO level, thus benefitting all PO members.

Estimates on resilience measured in terms of crop diversification are positive, suggesting that non SPAM households have a more diversified crop portfolio. Other resilience indicators show no significance.

5.7 PO-level impacts

This section assesses treatment impact at the PO level. Impact at PO level is estimated on a set of indicators to measure access to market, the extent of commercialization, diversification of the sources of income for the PO, crop diversification, asset indices and access to information. PAFA in its support assisted in the establishment of contractual agreements with market operators for the sale of members produce. The results show that on average, POs that benefitted from PAFA had 158 % gains in quantity of crop commercialized, and earned 218% more on crops sold.

In terms of income diversification, PAFA POs were nearly 13% more likely to engage in income generating activities other than agriculture compared to their non PAFA counterparts. Results on access to information are mixed and not significant, probably due to the fact that POs were encouraged to share information beyond their organization.

Table 5.19 Results on PO level indicators

PO level indicators	N	Treatment effect	Std. Error	Control mean
Harvest commercialized (kg, log)	220	1.579***	(0.396)	2315.19
Value of crop sold (kg, log)	220	2.181***	(0.617)	74570.37
Harvest brought by PO members (kg, log)	220	1.530***	(0.402)	2392.59
Income diversification (count)	220	0.128*	(0.0660)	1.09
Crop diversification (count)	220	-0.00539	(0.0232)	2.7
Overall asset index	220	-0.180**	(0.0883)	35.55
Durable asset index	220	-1.081	(1.121)	1.44
Productive asset index	220	-1.580**	(0.700)	41.27
Distance to nearest market (km)	220	-0.0462	(0.0571)	0.16
PO received storage information	220	0.0235	(0.0718)	0.43
PO received production information	220	0.00306	(0.0750)	0.43
PO received price information	220	-0.0982	(0.0682)	0.8
PO received marketing information	220	-0.0441	(0.0706)	0.41
PO received climate information	220	0.0429	(0.0693)	0.79

PO received information on buyers	220	-0.0955	(0.0664)	0.72

6.Conclusion

The *Projet d'Appui aux Filières Agricoles* (PAFA) was active between 2010 and 2016. During these 6 years, 3 cohorts of farmer organizations and their members were provided agricultural support in the form of a degressive subsidy, access to quality inputs, technical training, and market access. The goal of this impact assessment was to determine the impact of SPAM – PAFA's main intervention on agricultural production, economic mobility, market access, and other relevant indicators.

Anecdotal evidence from the qualitative analysis suggests that SPAM beneficiaries were often referred to as "borom tool you naat yi" "those with the green / luscious fields." The results of this impact assessment support this assertion. Overall, PAFA was successful in boosting the production capabilities of participating households as well as in encouraging the adoption of particular crops, diversifying away from groundnut production which traditionally dominated the region. Crop adoption was higher for niebe, bissap and millet. Crop harvest as well as the value of production for millet, niebe and bissap were higher for beneficiaries. Moreover, SPAM households enjoyed a more diverse crop portfolio, which often can act as an insurance mechanism. These households were also more likely to use fertilizer on their plots, whether organic or inorganic. These gains translated into higher yields for millet, niebe, and bissap.

As expected, among beneficiaries, PAFA resulted in higher crop income, higher livestock income and higher overall gross income. However, results reveal no impact on income from wage employment, and lower income from self-employment. This suggests that while PAFA might have encouraged cultivation of various crops and thus made agricultural production more remunerative for farmers, it also decreased the need for smallholder farmers to engage in wage and self-employment activities. Although, these latter forms of employment might provide an insurance mechanism by acting as a cushion against shocks in the agricultural sector, they are themselves often unstable.

PAFA beneficiaries have better access to markets now as a result of the intervention; they are more likely to sell crops and tend to commercialize a larger quantity across all crops. Contrary to the impact of PAFA on yields which is only significant for three out of the six supported crops, PAFA's effect on market access is positive for all six crops. PAFA farmers were also more likely to sell to a market operator, which provides more guarantee of output sale, and reduces price uncertainty.

Results on resilience remain however, inconclusive. Further analysis would be needed to determine project impact on resilience. In terms of food insecurity indicators, the analysis reveals that the treatment increased food security, specially vis-à-vis control households in the outside regions. At the PO level, impacts are evident for market access. PAFA POs enjoyed greater market access than control POs.

In general, PAFA was a success in achieving the goals set up at its inception. The impact of PAFA is more important for POs with a large youth membership as well as women POs who experienced higher gains. This is an indication that PAFA's targeting was successful. The spillover analysis reveals that ignoring peer effects further underestimates project impact. This means that, had the neighbourhood effects been taken into consideration, once could expect higher impacts of PAFA. Moreover, households that belonged to PAFA POs even without receiving the SPAM, were better off than households from other POs, with a higher likelihood to sell their harvest, higher quantity sold, and higher crop and gross income than control households.

In general, the study finds that PAFA’s value chain approach was successful. Value chain development programs that simultaneously facilitate market access are crucial in making production profitable for smallholder farmers. Market access increased at the intensive, and more so at the extensive margin for PAFA’s beneficiary households. Moreover, PAFA’s targeting strategy was also successful in bringing about higher gains for women and youth organizations. A key lesson for project targeting to be effective is that the targeting had both the demographic and their activities in mind during project design. Targeting was successful because gender and youth were integrated into the project at an early stage of the project inception; as early as the selection of the value chains. In fact, value chains where selected that most likely employed women and youth. PAFA’s success was in large due to its rigorous design, but most importantly perhaps the flexibility of the project to adapt its planned implementation to the realities in the field. A key project component was modified to accommodate cash-constrained participants who were at times unable to bring their cash contribution, the contributions were now to be given in kind.

The impact assessment shows the sustainability of the project, the three cohorts stopped receiving support in 2013, 2014, and 2016 respectively. Five years in, project impacts are still very high, which suggests that the project gains were sustainable over time. Further analysis could determine in greater detail the trajectory of the different cohorts.

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APPENDIX 1

Figure 2 - Propensity score matching treated and within PAFA regions POs

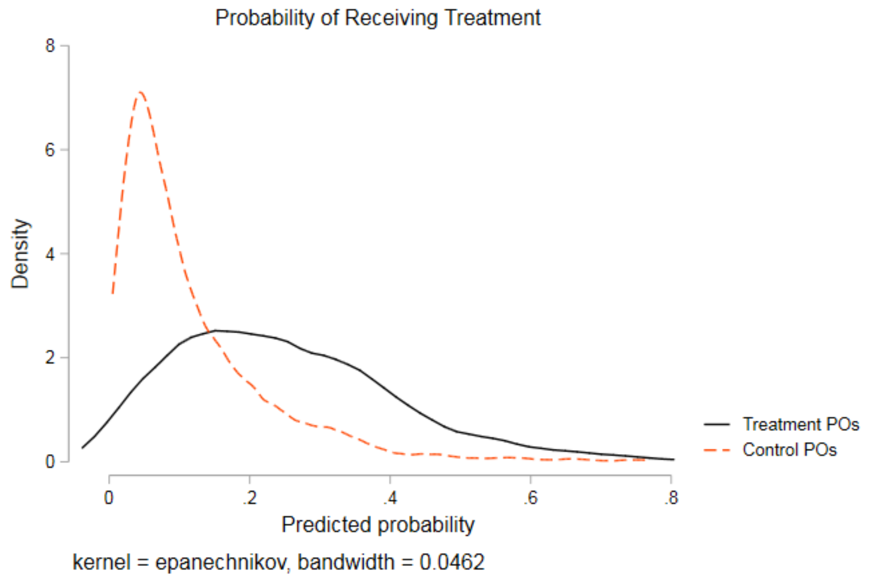


Figure 3 - Propensity score matching treated and outside PAFA regions POs

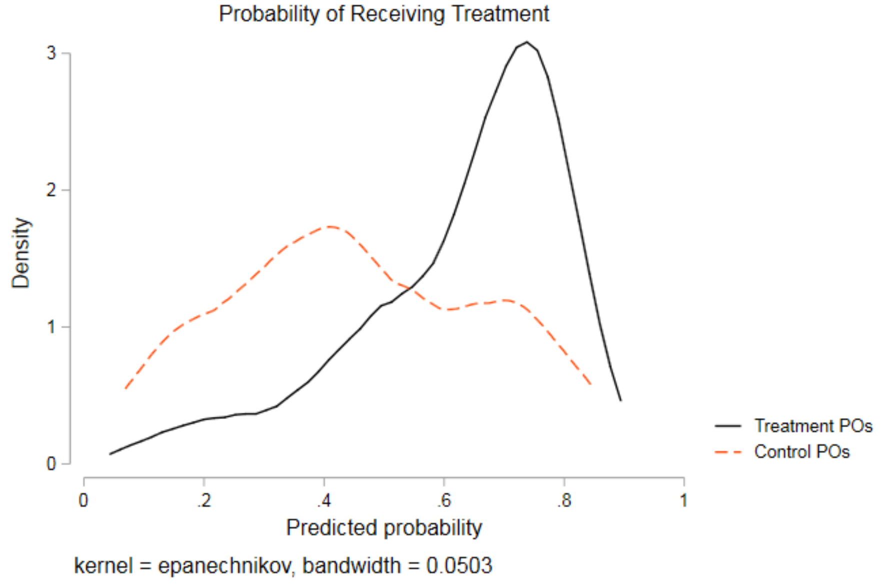


Figure 4 - Propensity score matching SPAM households vs All controls

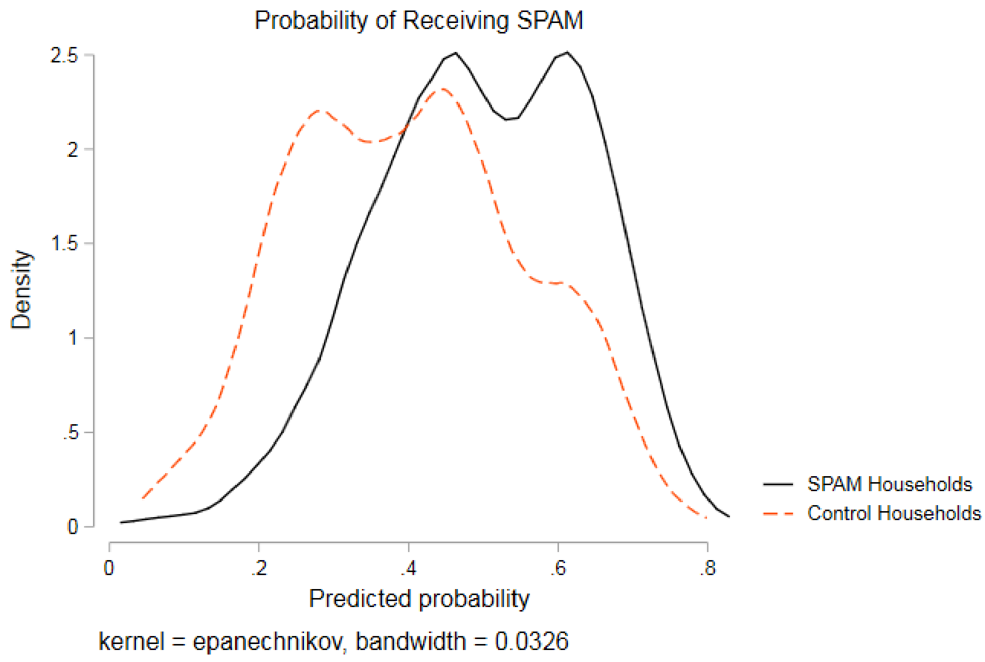


Figure 5 - Propensity score matching SPAM households vs control households within PAFA regions

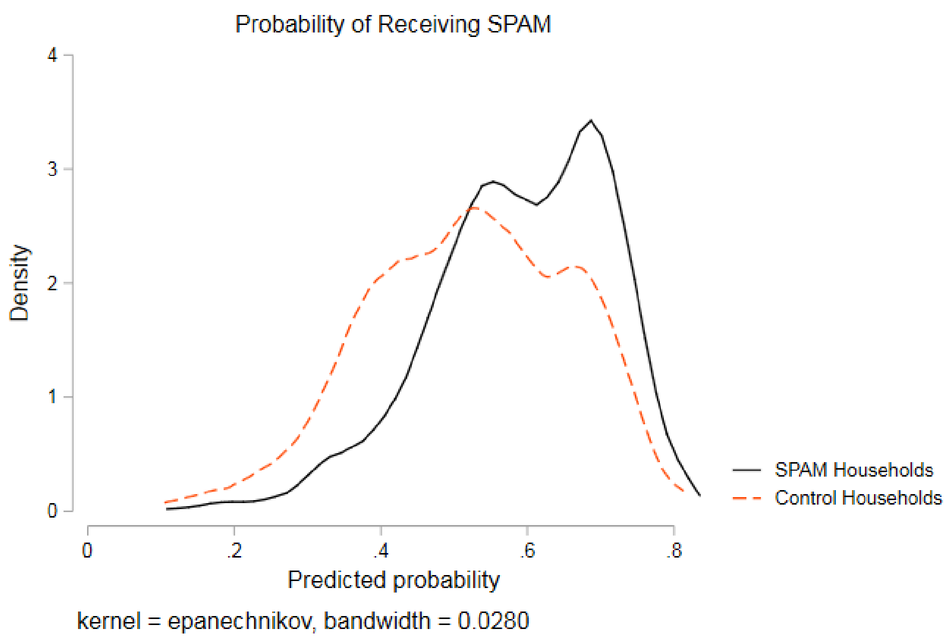


Figure 6 - Propensity score matching SPAM households vs control households outside PAFA regions

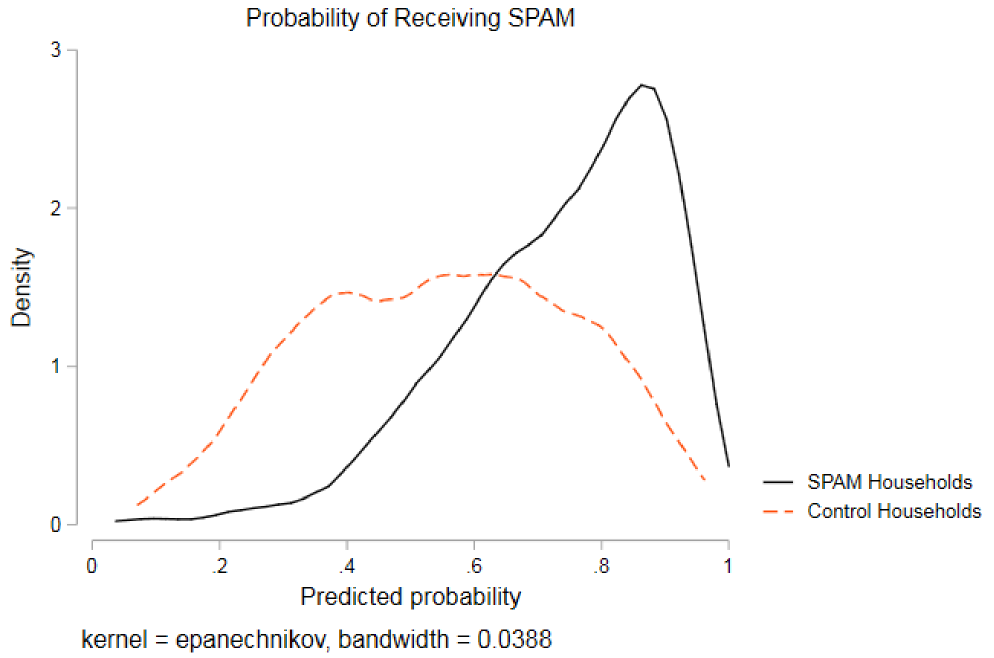
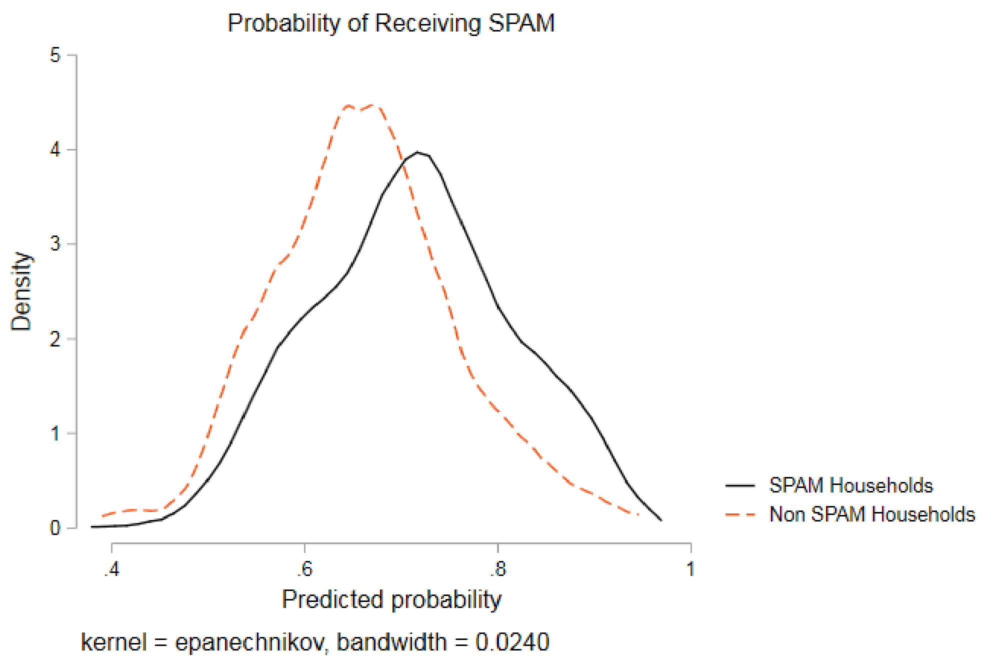


Figure 7 - Propensity score matching SPAM vs Non SPAM



APPENDIX 2

Table A2.1 - Results on crop and other input adoption (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Adoption indicators	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**	**N**	**Treatmen t effect**	**Std. error**
Millet (Yes=1)	1381	0.0501**	(0.0213)	995	0.0184	(0.0211)	738	0.0905***	(0.0318)
Maize (Yes=1)	1381	-0.0648***	(0.023)	995	-0.064**	(0.0254)	738	-0.0754**	(0.0319)
Sorghum (Yes=1)	1381	0.00202	(0.0130)	995	0.00323	(0.0138)	738	-0.0277	(0.0235)
Niebe (Yes=1)	1381	0.137***	(0.0307)	995	0.116***	(0.0339)	738	0.152***	(0.0385)
Sesame (Yes=1)	1381	0.00753	(0.0073)	995	0.00726	(0.0080)	738	-0.0111	(0.0105)
Bissap (Yes=1)	1381	0.0262*	(0.0146)	995	0.0142	(0.0166)			
Peanut (Yes=1)	1381	0.0427*	(0.0256)	995	0.0287	(0.0281)	738	0.107**	(0.0477)
Fertilizer use (Yes=1)	1381	0.0476	(0.0337)	995	0.0179	(0.0355)	738	0.171***	(0.0512)
Organic fertilizer use (Yes=1)	1381	0.0883***	(0.0337)	995	0.0357	(0.0358)	738	0.217***	(0.0476)
Inorganic fertilizer use (Yes=1)	1381	-0.0365	(0.0308)	995	-0.0601*	(0.0327)	738	0.0726**	(0.0349)
Pesticide use (Yes=1)	1381	-0.00674	(0.0185)	995	-0.0148	(0.0210)	738	-0.00266	(0.0234)

Table A2.2 Results on harvest and value of crops (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Production indicators	**N**	**Treatmen t effect**	**Std. error**	**N**	**Treatmen t effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**
Total harvest - millet (kg, log)	1381	0.357**	(0.148)	995	0.151	(0.155)	738	0.829***	(0.227)
Total harvest - maize (kg, log)	1381	-0.339**	(0.140)	995	-0.331**	(0.155)	738	-0.411**	(0.197)
Total harvest - sorghum (kg, log)	1381	0.0263	(0.069)	995	0.0576	(0.069)	738	-0.107	(0.126)
Total harvest - niebe (kg, log)	1381	0.479***	(0.130)	995	0.406***	(0.140)	738	0.535***	(0.182)
Total harvest - sesame (kg, log)	1381	0.0495	(0.038)	995	0.0479	(0.041)	738	0.0783**	(0.037)
Total harvest - bissap (kg, log)	1381	0.109*	(0.057)	995	0.0618	(0.066)	738	0.112	(0.077)
Total harvest - peanut (kg, log)	1381	0.00468	(0.181)	995	-0.176	(0.199)	738	0.740**	(0.324)
Total harvest - cereals (kg, log)	1381	0.291**	(0.144)	995	0.0836	(0.149)	738	0.806***	(0.228)
Total harvest - horticulture (kg, log)	1381	0.108	(0.071)	995	0.0779	(0.079)	738	0.132	(0.094)
Total harvest - pulses (kg, log)	1381	0.479***	(0.130)	995	0.406***	(0.140)	738	0.535***	(0.182)

Total harvest - oilseeds (kg, log)	1381	0.0219	(0.181)	995	-0.158	(0.198)	738	0.759**	(0.324)
Value of millet production (XOF, log)	1381	0.825***	(0.254)	995	0.264	(0.264)	738	1.921***	(0.392)
Value of maize production (XOF, log)	1381	-0.703***	(0.257)	995	-0.646**	(0.280)	738	-0.972**	(0.389)
Value of sorghum production (XOF, log)	1381	0.0634	(0.134)	995	0.108	(0.139)	738	-0.161	(0.233)
Value of niebe production (XOF, log)	1381	1.195***	(0.300)	995	0.999***	(0.326)	738	1.354***	(0.412)
Value of sesame production (XOF, log)	1381	0.109	(0.080)	995	0.103	(0.085)	738	0.166**	(0.076)
Value of bissap production (XOF, log)	1381	0.256*	(0.137)	995	0.141	(0.158)	738	0.278	(0.183)
Value of peanut production (XOF, log)	1381	0.157	(0.316)	995	-0.139	(0.345)	738	1.401**	(0.576)
Value of cereals production (XOF, log)	1381	0.678***	(0.246)	995	0.128	(0.251)	738	1.814***	(0.401)
Value of horticulture production (XOF, log)	1381	0.224	(0.155)	995	0.137	(0.174)	738	0.300	(0.205)
Value of pulses production (XOF, log)	1381	1.195***	(0.300)	995	0.999***	(0.326)	738	1.354***	(0.412)
Value of oilseeds production (XOF, log)	1381	0.196	(0.315)	995	-0.0987	(0.343)	738	1.442**	(0.576)

Table A2.3 - Results on productivity (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Productivity indicators	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**
Millet yields (kg/ha, log)	1381	0.350**	(0.142)	995	0.139	(0.149)	738	0.794***	(0.222)
Maize yields (kg/ha, log)	1381	-0.348**	(0.135)	995	-0.357**	(0.150)	738	-0.364**	(0.184)
Sorghum yields (kg/ha, log)	1381	0.000760	(0.069)	995	0.0418	(0.066)	738	-0.204	(0.159)
Niebe yields (kg/ha, log)	1381	0.507***	(0.152)	995	0.412**	(0.166)	738	0.558**	(0.223)
Sesame yields (kg/ha, log)	1381	0.0499	(0.036)	995	0.0475	(0.038)	738	0.0756**	(0.034)
Bissap yields (kg/ha, log)	1381	0.136*	(0.075)	995	0.0742	(0.089)	738	0.158*	(0.094)
Peanut yields (kg/ha, log)	1381	0.167	(0.174)	995	-0.00550	(0.189)	738	0.890***	(0.315)
Cereals yields (kg/ha, log)	1381	0.213	(0.132)	995	0.0165	(0.137)	738	0.696***	(0.214)
Horticulture yields (kg/ha, log)	1381	0.134	(0.087)	995	0.0867	(0.099)	738	0.181*	(0.109)
Pulses yields (kg/ha, log)	1381	0.507***	(0.152)	995	0.412**	(0.166)	738	0.558**	(0.223)
Oilseeds yields (kg/ha, log)	1381	0.148	(0.168)	995	-0.000991	(0.183)	738	0.800**	(0.313)

Table A2.4 – Results on the rate of input use (Non SPAM vs Controls)

	Non SPAM vs all Controls	Non SPAM vs Control in	Non SPAM vs Control out

Input use indicators	N	Treatment effect	Std. error	N	Treatment effect	Std. error	N	Treatment effect	Std. error
Fertilizer use (kg/ha, log)	1381	0.259	(0.193)	995	-0.0187	(0.207)	738	1.083***	(0.301)
Organic fertilizer use (kg/ha, log)	1381	0.340*	(0.198)	995	0.0209	(0.213)	738	1.114***	(0.307)
Inorganic fertilizer use (kg/ha, log)	1381	-0.141	(0.129)	995	-0.263*	(0.139)	738	0.430***	(0.138)
Pesticide use (kg/ha, log)	1381	0.0111	(0.0168)	995	0.00941	(0.0183)	738	0.0245*	(0.014)
Quantity of seeds used (kg, log)	1381	0.178	(0.129)	995	0.0196	(0.140)	738	0.500***	(0.149)
Quantity of fertilizer used (kg, log)	1381	-0.0500	(0.135)	995	-0.152	(0.145)	738	0.462***	(0.138)
Quantity of pesticide used (kg, log)	1381	0.0707**	(0.032)	995	0.0698**	(0.0317)	738	0.0836***	(0.031)
Seed expenditure (XOF, log)	1381	0.452	(0.279)	995	0.0753	(0.304)	738	1.139***	(0.337)
Fertilizer expenditure (XOF, log)	1381	-0.0515	(0.261)	995	-0.257	(0.282)	738	0.920***	(0.272)
Pesticide expenditure (XOF, log)	1381	0.0886	(0.0900)	995	0.0630	(0.0962)	738	0.140	(0.136)

Table A2.5 Results on income and asset indices (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Economic mobility indicators	N	Treatment effect	Std. error	N	Treatment effect	Std. error	N	Treatment effect	Std. error
Total gross income (XOF, log)	1381	-0.0898	(0.1000)	995	-0.139	(0.103)	738	0.0779	(0.155)
Crop income (XOF, log)	1381	0.269*	(0.158)	995	-0.00924	(0.155)	738	1.098***	(0.321)
Livestock income (XOF, log)	1381	0.736**	(0.340)	995	0.859**	(0.356)	738	0.959*	(0.491)
Wage income from agricultural (XOF, log)	1381	-0.00275	(0.0689)	995	0.0265	(0.0642)	738	-0.199	(0.151)
Wage income from non agricultural activities (XOF, log)	1381	-0.111	(0.280)	995	-0.248	(0.307)	738	0.0804	(0.387)
Self -employment income (XOF, log)	1381	-0.604***	(0.203)	995	-0.533**	(0.221)	738	-0.858***	(0.331)
Transfer income (XOF, log)	1381	0.401	(0.378)	995	0.574	(0.416)	738	-0.00473	(0.583)
Tropical livestock unit	1381	-0.0709	(0.0448)	995	0.0115	(0.0426)	738	-0.180	(0.111)
Overall asset index	1381	-0.0869**	(0.0383)	995	-0.094**	(0.0420)	738	-0.0336	(0.073)
Durable asset index	1381	-0.0969	(0.0658)	995	-0.138*	(0.0712)	738	0.0857	(0.086)
Productive livestock index	1381	-0.108**	(0.0530)	995	-0.117**	(0.0574)	738	-0.102	(0.125)
Livestock index	1381	-0.0508	(0.0411)	995	-0.00079	(0.0406)	738	-0.0902	(0.072)

Table A2.6 Results on poverty indicators (Non SPAM vs Controls)

	NON SPAM VS ALL CONTROLS			NON SPAM VS CONTROL IN			NON SPAM VS CONTROL OUT		
Poverty reduction indicators	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**
Above the overall asset-based poverty line, 40th percentile	1381	-0.0143	(0.0293)	995	-0.0085	(0.0316)	738	-0.0252	(0.050)
Above the overall asset-based poverty line, 60th percentile	1381	-0.0039	(0.0314)	995	0.00297	(0.0342)	738	-0.0266	(0.048)
Above the durable asset-based poverty line, 40th percentile	1381	-0.0311	(0.0254)	995	-0.047*	(0.0267)	738	0.0458	(0.046)
Above the durable asset-based poverty line, 60th percentile	1381	-0.050*	(0.0299)	995	-0.07**	(0.0316)	738	0.0297	(0.045)
Above the productive asset-based poverty line, 40th percentile	1381	-0.0071	(0.0321)	995	-0.0068	(0.0351)	738	0.0563	(0.053)
Above the productive asset-based poverty line, 60th percentile	1381	-0.0506	(0.0332)	995	-0.067*	(0.0361)	738	-0.0027	(0.052)
Above the livestock asset-based poverty line, 40th percentile	1381	0.0292	(0.0316)	995	0.0313	(0.0345)	738	0.0783*	(0.047)
Above the livestock asset-based poverty line, 60th percentile	1381	0.0142	(0.0332)	995	0.0339	(0.0352)	738	0.00937	(0.053)

Table A2.7 Results on market participation (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Market access indicators	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**
Harvest sold to market operator (Yes=1)	1381	0.0262	(0.0221)	995	0.0239	(0.0233)	738	0.0634**	(0.0284)
Market participation - millet (Yes=1)	1381	0.101***	(0.0267)	995	0.0474	(0.0305)	738	0.206***	(0.0250)
Market participation - maize (Yes=1)	1381	0.00310	(0.0119)	995	-0.00868	(0.0155)	738	0.0208**	(0.00879)
Market participation - peanut (Yes=1)	1381	-0.0329	(0.0325)	995	-0.0548	(0.0351)	738	0.101*	(0.0538)

Table A2.8 Results on quantity sold and value of crop (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Market Sales indicators	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**	**N**	**Treatment effect**	**Std. error**
Quantity of crop sold - millet (kg, log)	1381	0.529***	(0.157)	995	0.223	(0.177)	738	1.212***	(0.144)
Quantity of crop sold - maize (kg, log)	1381	0.0173	(0.067)	995	-0.0388	(0.083)	738	0.147***	(0.045)
Quantity of crop sold - sorghum (kg, log)	1381	-0.00841	(0.040)	995	0.0067	(0.042)	738	-0.0885	(0.078)
Quantity of crop sold - niebe (kg, log)	1381	0.129*	(0.076)	995	0.116	(0.081)	738	0.158	(0.105)
Quantity of crop sold - sesame (kg, log)	1381	0.0603	(0.038)	995	0.0582	(0.040)	738	0.0726**	(0.035)

Quantity of crop sold - bissap (kg, log)	1381	0.0734**	(0.036)	995	0.0507	(0.0418)	738	0.111***	(0.034)
Quantity of crop sold - peanut (kg, log)	1381	-0.393*	(0.218)	995	-0.607**	(0.237)	738	0.526	(0.351)
Quantity of crop sold - cereals (kg, log)	1381	0.483***	(0.165)	995	0.169	(0.185)	738	1.160***	(0.166)
Quantity of crop sold - horticulture (kg, log)	1381	0.0798	(0.0553)	995	0.0685	(0.0586)	738	0.156***	(0.053)
Quantity of crop sold - pulses (kg, log)	1381	0.129*	(0.0759)	995	0.116	(0.0812)	738	0.158	(0.105)
Quantity of crop sold - oilseeds (kg, log)	1381	-0.373*	(0.217)	995	-0.587**	(0.237)	738	0.546	(0.351)
Value of crop sold - millet (XOF, log)	1381	1.049***	(0.293)	995	0.476	(0.329)	738	2.321***	(0.269)
Value of crop sold - maize (XOF, log)	1381	0.0456	(0.125)	995	-0.0660	(0.158)	738	0.285***	(0.094)
Value of crop sold - sorghum (XOF, log)	1381	-0.0176	(0.081)	995	0.00419	(0.0858)	738	-0.157	(0.151)
Value of crop sold - niebe (XOF, log)	1381	0.324*	(0.178)	995	0.275	(0.192)	738	0.397	(0.242)
Value of crop sold - sesame (XOF, log)	1381	0.131*	(0.079)	995	0.127	(0.0837)	738	0.156**	(0.074)
Value of crop sold - bissap (XOF, log)	1381	0.229**	(0.101)	995	0.171	(0.112)	738	0.329***	(0.097)
Value of crop sold - peanut (XOF, log)	1381	-0.560	(0.386)	995	-0.946**	(0.419)	738	1.117*	(0.621)
Value of crop sold - cereals (XOF, log)	1381	0.970***	(0.308)	995	0.376	(0.344)	738	2.229***	(0.313)
Value of crop sold - horticulture (XOF, log)	1381	0.211*	(0.124)	995	0.173	(0.133)	738	0.399***	(0.117)
Value of crop sold - pulses (XOF, log)	1381	0.324*	(0.178)	995	0.275	(0.192)	738	0.397	(0.242)
Value of crop sold - oilseeds (XOF, log)	1381	-0.517	(0.386)	995	-0.903**	(0.418)	738	1.160*	(0.621)

Table A2.9 Results on resilience and food security indicators (Non SPAM vs Controls)

	Non SPAM vs all Controls			Non SPAM vs Control in			Non SPAM vs Control out		
Resilience and food security indicators	N	Treatment effect	Std. error	N	Treatment effect	Std. error	N	Treatment effect	Std. error
Crop diversification (count)	1321	0.138**	(0.0541)	973	0.101*	(0.0587)	695	0.137	(0.085)
Crop diversification (margalef)	1321	0.0180**	(0.0070)	973	0.0132*	(0.0076)	695	0.0178	(0.011)
Crop diversification (shannon)	1321	0.0654***	(0.0234)	973	0.0572**	(0.0251)	695	0.0610	(0.037)
Crop diversification (berger parker)	1321	0.0666*	(0.0364)	973	0.0658	(0.0401)	695	0.0613	(0.049)
Income diversification index (count)	1381	0.0835	(0.0798)	995	0.0711	(0.0855)	738	0.0337	(0.129)
Income diversification index (margalef)	1381	0.0835	(0.0798)	995	0.0711	(0.0855)	738	0.0337	(0.129)
Income diversification index (shannon)	1381	0.0272	(0.0222)	995	0.0292	(0.0237)	738	0.0283	(0.035)
Resilience index (PRIME)	927	0.484	(0.402)	700	0.298	(0.427)	488	0.411	(0.443)
Resilience index (PRIME), normalized	927	1.222	(1.014)	700	0.751	(1.078)	488	1.038	(1.119)

Perceived ability to recover (corrected)	772	0.0285	(0.106)	577	0.0902	(0.113)	406	-0.528***	(0.129)
Household dietary diversity score	1380	-0.411**	(0.177)	994	-0.450**	(0.201)	737	-0.177	(0.260)

APPENDIX 3

Table A3.1 Spillover analysis results on the adoption of crop and other inputs

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias (%)
Crop adoption					
Millet (Yes=1)	1855	0.0589**	0.0284	-0.031	-107.4
Maize (Yes=1)	1855	-0.00260	0.0283	0.031	109.2
Sorghum (Yes=1)	1855	-0.000525	0.0144	0.015	103.6
Niebe (Yes=1)	1855	0.135***	0.0980***	-0.037	-37.7
Sesame (Yes=1)	1855	0.00765	0.0106	0.003	27.8
Bissap (Yes=1)	1855	0.0719***	0.0707***	-0.001	-1.7
Peanut (Yes=1)	1855	0.0417	0.0410*	-0.001	-1.7
Other input adoption					
Fertilizer use (Yes=1)	1855	0.0689*	0.119***	0.050	42.1
Organic fertilizer use (Yes=1)	1855	0.00731	0.0738**	0.066	90.1
Inorganic fertilizer use (Yes=1)	1855	0.0492	0.0930***	0.044	47.1
Pesticide use (Yes=1)	1855	0.00334	0.0233	0.020	85.7

Table A3.2 Spillover analysis results on productivity, harvest, and crop value

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Bias (%)
Yields					
Millet yields (kg/ha, log)	1855	0.335*	0.258*	-0.08	-29.84
Maize yields (kg/ha, log)	1855	-0.00647	0.250*	0.26	102.59
Niebe yields (kg/ha, log)	1855	0.514***	0.370***	-0.14	-38.92
Sesame yields (kg/ha, log)	1855	0.0499	0.0475	0.00	-5.05
Bissap yields (kg/ha, log)	1855	0.377***	0.377***	0.00	0.00
Peanut yields (kg/ha, log)	1855	0.196	0.178	-0.02	-10.11
Pulses yields (kg/ha, log)	1855	0.514***	0.370***	-0.14	-38.92
Harvest					
Total harvest - millet (kg, log)	1855	0.401*	0.305**	-0.10	-31.48
Total harvest - maize (kg, log)	1855	0.0320	0.242*	0.21	86.78

Total harvest - sorghum (kg, log)	1855	-0.0129	0.0782	0.09	116.50
Total harvest - niebe (kg, log)	1855	0.529***	0.392***	-0.14	-34.95
Total harvest - sesame (kg, log)	1855	0.0440	0.0424	0.00	-3.77
Total harvest - bissap (kg, log)	1855	0.363***	0.359***	0.00	-1.11
Total harvest - peanut (kg, log)	1855	0.178	0.172	-0.01	-3.49
Total harvest - cereals (kg, log)	1855	0.340*	0.321**	-0.02	-5.92
Total harvest - pulses (kg, log)	1855	0.529***	0.392***	-0.14	-34.95
Total harvest - oilseeds (kg, log)	1855	0.198	0.189	-0.01	-4.76
Value of crop production (XOF, log)					
Millet	1855	1.125***	0.709***	-0.42	-58.67
Maize	1855	0.0166	0.364	0.35	95.44
Niebe	1855	1.229***	0.908***	-0.32	-35.35
Sesame	1855	0.101	0.0938	-0.01	-7.68
Bissap	1855	0.775***	0.770***	-0.01	-0.65
Peanut	1855	0.409	0.356	-0.05	-14.89
Pulses	1855	1.229***	0.908***	-0.32	-35.35

Table A3.3 Spillover analysis results on input use indicators

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias (%)
Input use indicators					
Fertilizer use (kg/ha, log)	1855	0.210	0.489***	0.279	57.055
Organic fertilizer use (kg/ha, log)	1855	-0.0606	0.258	0.319	123.488
Inorganic fertilizer use (kg/ha, log)	1855	0.234	0.413***	0.179	43.341
Pesticide use (kg/ha, log)	1855	0.0114	0.0194	0.008	41.237
Quantity of seeds used (kg, log)	1855	0.0958	0.0932	-0.003	-2.790
Quantity of pesticide used (kg, log)	1855	-0.00262	0.0178	0.020	114.719
Seed expenditure (XOF, log)	1855	0.268	0.269	0.001	0.372

Table A3.4 Spillover analysis results on income and asset indices

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias
Income					
Total gross income (XOF, log)	1855	0.114	0.136	0.02	16.18
Crop income (XOF, log)	1855	0.727***	0.534***	-0.19	-36.14
Livestock income (XOF, log)	1855	-0.192	0.409	0.60	146.94

Wage income from agricultural (XOF, log)	1855	-0.0248	0.0552	0.08	144.93
Wage income from non-agricultural work (XOF, log)	1855	-0.102	0.157	0.26	164.97
Self -employment income (XOF, log)	1855	-0.810**	-0.364*	0.45	-122.53
Transfer income (XOF, log)	1855	0.459	0.238	-0.22	-92.86
Tropical livestock unit	1855	-0.0428	-0.0382	0.00	-12.04
Asset indices					
Overall asset index	1855	-0.0873*	-0.0108	0.077	-708.3
Housing asset index	1855	-0.00569	0.00426	0.010	233.6
Durable asset index	1855	-0.130*	-0.0156	0.114	-733.3
Productive asset index	1855	-0.0847	0.00418	0.089	2126
Livestock asset index	1855	-0.0505	-0.0588	-0.008	14.116

Table A3.5 Spillover analysis results on poverty indicators

Poverty indicators	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias
Above the overall asset-based poverty line, 40th percentile	1855	-0.041	-0.013	0.03	-202.99
Above the overall asset-based poverty line, 60th percentile	1855	-0.023	-0.016	0.01	-43.95
Above the durable asset-based poverty line, 40th percentile	1855	-0.033	-0.003	0.03	-1136.8
Above the durable asset-based poverty line, 60th percentile	1855	-0.039	-0.029	0.01	-35.54
Above the productive asset-based poverty line, 40th percentile	1855	-0.029	0.006	0.03	612.54
Above the productive asset-based poverty line, 60th percentile	1855	-0.003	0.009	0.01	130.08
Above the livestock asset-based poverty line, 40th percentile	1855	-0.014	0.002	0.02	810.66
Above the livestock asset-based poverty line, 60th percentile	1855	0.039	0.013	-0.03	-203.91
Above the housing asset-based poverty line, 40th percentile	1855	-0.025	0.005	0.03	578.60
Above the housing asset-based poverty line, 60th percentile	1855	0.007	0.032	0.03	79.25

Table A3.6 Spillover analysis results on market participation

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias
Market participation indicators					

Harvest sold to market operator (Yes=1)	1855	0.0257	0.0300*	0.004	14.333
Market participation - millet (Yes=1)	1855	0.0913***	0.0955***	0.004	4.398
Market participation - maize (Yes=1)	1855	0.0118	0.0236**	0.012	50.000
Market participation - sorghum (Yes=1)	1855	-0.0100	0.00272	0.013	467.647
Market participation - niebe (Yes=1)	1855	0.0293	0.0314*	0.002	6.688
Market participation - bissap (Yes=1)	1855	0.0692***	0.0710***	0.002	2.535
Market participation - peanut (Yes=1)	1855	0.00461	0.0170	0.012	72.882

Table A3.7 Spillover analysis results on quantity and value of crop sold

	N	ATE with neighborhood effect	ATE without neighborhood effect	Bias	Percent bias
Market access indicators					
Quantity of crop sold - millet (kg, log)	1855	0.492**	0.525***	0.03	6.29
Quantity of crop sold - maize (kg, log)	1855	0.0824	0.154**	0.07	46.49
Quantity of crop sold - niebe (kg, log)	1855	0.119	0.146*	0.03	18.49
Quantity of crop sold - sesame (kg, log)	1855	0.0266	0.0398	0.01	33.17
Quantity of crop sold - bissap (kg, log)	1855	0.351***	0.355***	0.00	1.13
Quantity of crop sold - peanut (kg, log)	1855	0.0341	0.0692	0.04	50.72
Value of crop sold - millet (XOF, log)	1855	0.975***	1.019***	0.04	4.32
Value of crop sold - maize (XOF, log)	1855	0.141	0.268**	0.13	47.39
Value of crop sold - sorghum (XOF, log)	1855	-0.101	0.0334	0.13	402.40
Value of crop sold - niebe (XOF, log)	1855	0.275	0.322*	0.05	14.60
Value of crop sold - sesame (XOF, log)	1855	0.0634	0.0891	0.03	28.84
Value of crop sold - bissap (XOF, log)	1855	0.754***	0.777***	0.02	2.96
Value of crop sold - peanut (XOF, log)	1855	0.140	0.191	0.05	26.70

Table A3.8 Spillover analysis results on resilience and food security indicators

	N	ATE with	ATE without	Bias	Percent

		neighborhood effect	neighborhood effect		bias (%)
Income diversification index (count)	1855	0.0447	0.105	0.06	57.43
Income diversification index (margalef)	1855	0.0447	0.105	0.06	57.43
Income diversification index (shannon)	1855	-0.00722	0.0152	0.02	147.50
Crop diversification (count)	1792	0.193***	0.218***	0.03	11.47
Crop diversification (berger parker)	1792	0.108**	0.0971***	-0.01	-11.23
Crop diversification (margalef)	1792	0.0251***	0.0283***	0.00	11.31
Crop diversification (shannon)	1792	0.0748***	0.0789***	0.00	5.20
Household dietary diversity score	1850	-0.329*	-0.319**	0.01	-3.13
FIES	1855	0.360*	0.138	-0.22	-160.8
Ability to recover from all shock	1250	-0.240	-0.00155	0.24	-15384
Ability to recover from the 5 major shocks	1070	-0.129	0.0785	0.21	264.3
Resilience index (PRIME), normalized	1250	0.222	0.664	0.44	66.5

Table A2.1 Distribution of POs by commune

Region	Commune	PAFA	Control within	Control outside	Total
Diourbel	Baba Garage	4	0	0	4
Diourbel	Dalla Ngabou	0	0	1	1
Diourbel	Dankh Sene	0	0	1	1
Diourbel	Darou Nahim	0	0	2	2
Diourbel	Dinguiraye	2	0	0	2
Diourbel	Gawane	1	0	0	1
Diourbel	Kael	0	0	1	1
Diourbel	Keur Ngalgou	0	0	1	1
Diourbel	Lambaye	2	0	1	3
Diourbel	Madina	0	0	1	1
Diourbel	Missirah	0	0	1	1
Diourbel	Ndangalma	0	0	1	1
Diourbel	Ndindy	3	0	0	3

Diourbel	Ndondol	1	0	0	1
Diourbel	Ngogom	0	0	1	1
Diourbel	Ngohe	5	0	0	5
Diourbel	Ngoye	1	0	2	3
Diourbel	Patar	4	0	0	4
Diourbel	Refane	1	0	0	1
Diourbel	Taiba Tieckene	0	0	1	1
Diourbel	Taif	0	0	2	2
Diourbel	Thiakhar	3	0	0	3
Diourbel	Tocky Gare	2	0	0	2
Diourbel	Touba Fall	0	0	1	1
Diourbel	Toure Mbonde	1	0	0	1
Fatick	Colobane	2	0	3	5
Fatick	Diagane Barka	0	0	1	1
Fatick	Diaoule	0	0	2	2
Fatick	Diossong	0	0	1	1
Fatick	Djilor	0	0	1	1
Fatick	Mbar	3	0	0	3
Fatick	Ndiene Lagane	0	0	1	1
Fatick	Ndiob	2	0	7	9
Fatick	Niakhar	4	0	1	5
Fatick	Nioro Alassane Tall	1	0	0	1
Fatick	Ouadiour	1	0	1	2
Fatick	Patar Lia	2	0	4	6
Fatick	Thiare Ndialgui	0	0	2	2
Fatick	Toubacouta	4	0	2	6
Kaffrine	Birkelane	0	0	1	1
Kaffrine	Boulel Goumack	1	0	0	1
Kaffrine	Diamagadio	6	0	2	8
Kaffrine	Dianke Souf	2	0	1	3
Kaffrine	Fass Thiekene	0	0	2	2
Kaffrine	Gainthe Pathe	0	0	1	1

Kaffrine	Gniby	0	0	1	1
Kaffrine	Kahi	1	0	1	2
Kaffrine	Kathiote	0	0	3	3
Kaffrine	Mabo	0	0	2	2
Kaffrine	Maka Yopp	4	0	0	4
Kaffrine	Medinatoul Salam Ii	0	0	2	2
Kaffrine	Missirah Wadene	1	0	0	1
Kaffrine	Ndioum Ngainth	0	0	1	1
Kaffrine	Nganda	2	0	2	4
Kaffrine	Ribot Escale	0	0	2	2
Kaffrine	Sagna	2	0	2	4
Kaffrine	Saly Escale	1	0	0	1
Kaolack	Dabaly	1	0	0	1
Kaolack	Gagnick	0	0	1	1
Kaolack	Gainthe Kaye	1	0	0	1
Kaolack	Kayemor	1	0	1	2
Kaolack	Keur Baka	1	0	0	1
Kaolack	Keur Maba Diakhou	0	0	1	1
Kaolack	Keur Soce	1	0	0	1
Kaolack	Khelcom Birane	0	0	3	3
Kaolack	Latmingue	6	0	0	6
Kaolack	Mbadakhoune	0	0	2	2
Kaolack	Ndiago	0	0	4	4
Kaolack	Ndiebel	1	0	0	1
Kaolack	Ndiedieng	1	0	0	1
Kaolack	Ndoffane	0	0	2	2
Kaolack	Ndrame Escale	0	0	1	1
Kaolack	Ngathie Naoude	0	0	1	1
Kaolack	Ngayenne	3	0	0	3
Kaolack	Nguelou	0	0	1	1
Kaolack	Wack Ngouna	0	0	1	1
Louga	Gassane	0	6	0	6

Tambacounda	Bamba Thialene	0	9	0	9
Tambacounda	Malem Niani	0	1	0	1
Tambacounda	Payar	0	9	0	9
Thies	Cherif Lo	0	2	0	2
Thies	Fissel	0	3	0	3
Thies	Sandiara	0	3	0	3
Thies	Sessene	0	2	0	2
Thies	Tassette	0	2	0	2
Thies	Thiadiaye	0	5	0	5
Thies	Thienaba	0	3	0	3
Thies	Touba Toul	0	6	0	6

Table A2.2 - Households sample distribution by treatment and control, by Region and Commune

Region	Commune	Treated POs		Control POs		Total
		SPAM beneficiaries	Non SPAM beneficiaries	Households within PAFA regions	Households outside PAFA regions	
Diourbel	Baba Garage	49	29	0	0	78
Diourbel	Dalla Ngabou	0	0	8	0	8
Diourbel	Dankh Sene	0	0	8	0	8
Diourbel	Darou Nahim	0	0	16	0	16
Diourbel	Dinguiraye	20	13	0	0	33
Diourbel	Gawane	10	0	0	0	10
Diourbel	Kael	0	0	8	0	8
Diourbel	Keur Ngalgou	0	0	8	0	8
Diourbel	Lambaye	21	17	8	0	46
Diourbel	Madina	0	0	8	0	8
Diourbel	Missirah	0	0	8	0	8
Diourbel	Ndangalma	0	0	8	0	8
Diourbel	Ndindy	29	16	0	0	45
Diourbel	Ndondol	12	8	0	0	20
Diourbel	Ngogom	0	0	8	0	8
Diourbel	Ngohe	42	23	0	0	65

Diourbel	Ngoye	10	7	16	0	33
Diourbel	Patar	41	19	0	0	60
Diourbel	Refane	10	4	0	0	14
Diourbel	Taiba Tieckene	0	0	6	0	6
Diourbel	Taif	0	0	16	0	16
Diourbel	Thiakhar	27	26	0	0	53
Diourbel	Tocky Gare	20	19	0	0	39
Diourbel	Touba Fall	0	0	8	0	8
Diourbel	Toure Mbonde	11	4	0	0	15
Fatick	Colobane	20	12	16	0	48
Fatick	Diagane Barka	0	0	8	0	8
Fatick	Diaoule	0	0	15	0	15
Fatick	Diossong	0	0	8	0	8
Fatick	Djilor	0	0	8	0	8
Fatick	Mbar	33	16	0	0	49
Fatick	Ndiene Lagane	0	0	8	0	8
Fatick	Ndiob	19	1	53	0	73
Fatick	Niakhar	39	25	8	0	72
Fatick	Nioro Alassane Tall	9	8	0	0	17
Fatick	Ouadiour	10	7	9	0	26
Fatick	Patar Lia	18	2	31	0	51
Fatick	Thiare Ndialgui	0	0	16	0	16
Fatick	Toubacouta	39	2	15	0	56
Kaffrine	Birkelane	0	0	8	0	8
Kaffrine	Boulel Goumack	9	1	0	0	10
Kaffrine	Diamagadio	57	13	15	0	85
Kaffrine	Dianke Souf	18	18	8	0	44
Kaffrine	Fass Thiekene	0	0	16	0	16
Kaffrine	Gainthe Pathe	0	0	8	0	8
Kaffrine	Gniby	0	0	8	0	8
Kaffrine	Kahi	10	7	8	0	25
Kaffrine	Kathiote	0	0	23	0	23

Kaffrine	Mabo	0	0	16	0	16
Kaffrine	Maka Yopp	40	20	0	0	60
Kaffrine	Medinatoul Salam Ii	0	0	16	0	16
Kaffrine	Missirah Wadene	9	1	0	0	10
Kaffrine	Ndioum Ngainth	0	0	8	0	8
Kaffrine	Nganda	18	8	17	0	43
Kaffrine	Ribot Escale	0	0	16	0	16
Kaffrine	Sagna	18	0	16	0	34
Kaffrine	Saly Escale	8	0	0	0	8
Kaolack	Dabaly	10	0	0	0	10
Kaolack	Gagnick	0	0	8	0	8
Kaolack	Gainthe Kaye	10	0	0	0	10
Kaolack	Kayemor	10	0	8	0	18
Kaolack	Keur Baka	10	0	0	0	10
Kaolack	Keur Maba Diakhou	0	0	8	0	8
Kaolack	Keur Soce	11	9	0	0	20
Kaolack	Khelcom Birane	0	0	24	0	24
Kaolack	Latmingue	57	1	0	0	58
Kaolack	Mbadakhoune	0	0	16	0	16
Kaolack	Ndiago	0	0	27	0	27
Kaolack	Ndiebel	10	4	0	0	14
Kaolack	Ndiedieng	9	12	0	0	21
Kaolack	Ndoffane	0	0	15	0	15
Kaolack	Ndrame Escale	0	0	8	0	8
Kaolack	Ngathie Naoude	0	0	8	0	8
Kaolack	Ngayenne	32	9	0	0	41
Kaolack	Nguelou	0	0	8	0	8
Kaolack	Wack Ngouna	0	0	8	0	8
Louga	Gassane	0	0	0	48	48
Tambacounda	Bamba Thialene	0	0	0	72	72
Tambacounda	Malem Niani	0	0	0	8	8
Tambacounda	Payar	0	0	0	72	72

Thies	Cherif Lo	0	0	0	2	2
Thies	Fissel	0	0	0	23	23
Thies	Sandiara	0	0	0	24	24
Thies	Sessene	0	0	0	16	16
Thies	Tassette	0	0	0	16	16
Thies	Thiadiaye	0	0	0	39	39
Thies	Thienaba	0	0	0	24	24
Thies	Touba Toul	0	0	0	43	43

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