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Full Length Research Paper

Socio-economic impact of the coconut lethal yellowing disease on Ivorian smallholder coconut farm families

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Côte d'Ivoire lethal yellowing (CILY) disease has devastated coconut plantations over the past ten years in the Grand-Lahou in the south littoral of Côte d'Ivoire. This paper used primary data collected from 338 coconut farming households of Grand-Lahou to assess the socio-economic impact of CILY for smallholder farmers. Using the propensity scores matching method, the Average Treatment effect on the Treated was calculated to assess the impact of the disease on the household. To characterize the welfare of coconut farming households, five socio-economic parameters where estimated; income, food expenses, non-food related expenses, health and school expenses. Food and non-food related expenses, including health expenses increase for CILY-affected households compared to their counterfactual. Inversely, households' total income and spending children's schooling expenses decreased. The survey data evidenced the inequality of gender roles in Grand-Lahou, emphasizing the limited access to resources for women farmers. Based on the findings, recommendations were made to address gender inequities and to promote awareness for smallholder farmers in preventing disease spread; and approaches for better education access. Informing farmers that CILY is associated with an increase of food- and non-food related expenses may encourage their engagement at mitigating the impact of the disease and improving disease management.

Key words: Coconut lethal yellowing, Grand-Lahou, awareness, education, smallholder farmers, gender, socio-economic impact, socio-economic parameters, household expenses.

Abbreviations used: Côte d'Ivoire lethal yellowing (CILY), Propensity Scores Matching (PSM), Double Difference (DD), Instrumental Variables (IV), Regression Discontinuity (RD), Average Treatment effect on the Treated (ATT), Average Treatment Effect (ATE), Nearest-Neighbor Matching (NN), Kernel Matching (KM), Franc CFA (FCFA).

INTRODUCTION

Pests and diseases are one of the main constraints in agriculture; direct yield losses are estimated between 20-40% of global agricultural productivity (Savary et al., 2012). However, estimating the entire economic impact of pests and diseases can be complex and go beyond the immediate impact on the directly affected agricultural producers (FAO, 2001). Frequently, studies focus on the losses of productivity and agricultural income at the farm specific level. The most direct economic impact is the loss or reduced efficiency of agricultural production, which reduces farm income. The severity of the economic impact will depend on the specific circumstances. If the farm economy is relatively diversified and other income opportunities exist, it will be more resilient. Conversely, if the local economy is heavily dependent on one or a few vulnerable commodities, as is frequently the case with smallholder farmers, the burden may be severe and local food security impaired.

Coconut (*Cocos nucifera* L.) is the most important crop along West Africa's coastal belt. In Côte d'Ivoire, coconut palm is cultivated on approximately 50,000 ha. The country is the top African exporter to Europe and West Africa of copra coconut oil, desiccated coconut, copra, and nuts (Arocha Rosete et al, 2014), with a yearly production of 55,000 tons of copra (equivalent to 550 million of nuts/year). Coconut is an important source of employment for men and women farmers in the Ivorian coastal region of Grand-Lahou. It is the main source of income of more than 12,500 smallholder families, and the source of livestock feed, nutritious milk and water. Income generated is used for the payment of children's food, schooling and clothing.

Coconut-producing countries have been severely impacted by lethal yellowing-like diseases over the past forty years, which have killed millions of coconut palms in Central America and the Caribbean and Africa (Sullivan and Harrison, 2013). Over the past ten years, Côte d'Ivoire Lethal Yellowing disease (CILY) has caused losses of 12,000 tons of copra/year in the Ivorian coastal areas (Arocha Rosete et al., 2016). The 2013 outbreak destroyed over 400 hectares of coconut palm trees in Grand-Lahou. This equates to a loss of 240 million FCFA (533,334 $US) of income per year for around 200 smallholder farm families. At the present time, CILY is threatening over 7000 ha of the coastal coconut groves of Grand-Lahou.

Level of education and disease awareness affect agricultural production, food security, marketing, farmers' livelihoods (Godwin-Egein et al., 2015a). For most poor farmers, there is inadequate knowledge disease and the existence of control measures, which results in heavy crop losses. Lack of awareness greatly influences farmers' behavior in solving some of their production constraints in developing nations (Nangoti et al., 2004). Indeed, it is well established that no agricultural intervention would succeed if the community is not well informed on major disease problems and their impact. Farmer groups, and in particular women's groups, provide a unique access point to rural farming communities for agricultural extension and farmer-led innovation and adoption of disseminated information (Brownhill and Njuguana, 2016).

It is also well established that gender equality is crucial to agricultural development (World Bank, 2009). Many studies have demonstrated the link between women's empowerment and building resilience in food security (Deere & Doss, 2006; Quisimbing & McCafferty, 2006). In Côte d'Ivoire women play an essential role in agriculture, producing and marketing up to 60–80% of the Nation's food (USAID, 2013). While women farmers typically achieve lower yields than men, not because they are less skilled, but because they operate smaller farms and have poor access to resources such as fertilizers, improved seeds and tools. Côte d'Ivoire's constitution affirms gender equality before the law, as does their 1998 Rural Land Law, however, the customary system of land tenure, in which women have no land ownership rights and their access to land is limited, accounts for 98% of the rural land of Côte d'Ivoire (USAID, 2013). According to FAO (2011), if women in rural areas had the same access to land, technology, financial services, education and markets as men, agricultural production would be increased and the number of hungry people reduced.

The purpose of this study is to assess the socio-economic impact of CILY on smallholder coconut farm families affected by the disease in Grand-Lahou. This study goes beyond the commonly measured direct indicators of economic impact: production and income levels. Based on the Propensity Score Matching (PSM) method, this study estimates the impact of CILY on five socio-economic parameters (income, food expenses, non-food related expenses, health and school expenses), which characterize the welfare of coconut farming households. Based on the impact of the disease identified by these socio-economic parameters, gender-responsive recommendations to address disease spread and management, and to enhance the adaptive capacity of the smallholder farmers, are discussed.

METHODOLOGY

Impact evaluation methods

Several approaches can be used to evaluate a program's impact but the main challenge across different types of impact evaluation is to find a good counterfactual—namely, the situation a participating subject would have experienced when he or she had not been exposed to the program (Khandker et al., 2010). A program could be a project, a public policy, or in the case of this study, a disease, and the impact evaluation consist of studying whether changes in well-being are due to the program and not to other factors (Gertler et al., 2011).

As indicated by Khandker et al. (2010), quantitative impact evaluations can be done before (ex-ante) or after (ex-post) the introduction of the program. Ex-ante evaluation predicts program impacts using data before the program intervention, whereas ex-post evaluation examines outcomes after a program have been implemented. Our study focused on the impact of CILY disease which began ten (10) years ago in Grand-Lahou which makes this a case of ex-post quantitative impact assessment.

The different quantitative impact evaluations methods used in research are randomized evaluations, Propensity Score Matching (PSM), Double Difference (DD), Instrumental Variables, Regression Discontinuity (RD) and pipeline approaches. These methods vary by their underlying assumptions regarding how to resolve selection bias in estimating the program's treatment effect (Ravallion, 2003; Khandker et al., 2010).

Randomized evaluations involve a randomly allocated initiative across a sample of subjects (communities or individuals); the progress of treatment and control subjects exhibiting similar pre-program characteristics is then tracked over time. Randomized experiments have the advantage of avoiding selection bias at the level of randomization. DD methods assume that unobserved selection is present and that it is time invariant; the treatment effect is determined by measuring the difference in outcomes across treatment and control units before and after the program intervention. DD methods can be used in both experimental and non-experimental settings. IV models can be used with cross-section or panel data, and in the latter case, allow for selection bias on unobserved characteristics to vary with time. In the IV approach, selection bias on unobserved characteristics is corrected by finding a variable (or instrument) that is correlated with participation but not correlated with unobserved characteristics affecting the outcome; this instrument is used to predict participation. RD can be viewed as a special case of the IV assumptions (Hhan et al., 2001). The RD is applied in quasi-experimental design in which the probability of receiving a treatment changes discontinuously as a function of one or more underlying variables. For example, in situations where a treatment is led by an administrative rule. Intuitively, individuals closed to the discontinuity (cut-off) can be considered as randomly assigned to the treatment. Pipeline methods construct a comparison group from subjects who are eligible for the program but have not yet received it.

In this study on the impact of CILY on coconut farm families in Grand-Lahou, the randomized selection method is not applicable due to the non-randomly assignment of CILY disease across the population of units represented by coconut farm families. The DD method is not applicable either due to the lack of baseline data on coconut farm families before the outbreak of the disease in the CILY-affected region. The IV and RD methods are unsuitable assuming that selection bias is only based on observed characteristics. The PSM method, which typically relies on observed characteristics to construct a comparison group, was determined to be the most appropriate quantitative evaluation method for this study.

As previously mentioned, a key issue in evaluating a program is to find the adequate counterfactual. In our case, the 'subject', identified as the farm household is observed for either CILY-impacted or non CILY-impacted households. Indeed, for those households affected by the CILY, it is difficult to estimate their economic welfare or income before the occurrence of the disease. PMS is a very helpful tool in finding an appropriate comparison group under certain restrictions.

PSM consists of computing propensity scores ranging from 0 to 1 that summarize all of the observed characteristics of the units; as they influence the likelihood of being enrolling in the program (being affected by CILY). The PSM method (a quasi-experimental method) tries to mimic the randomized assignment to treatment and comparison groups by choosing for the comparison group those units that have similar propensities to the units in the treatment group.

PSM has been applied in a very wide variety of research fields (Heinrich et al., 2010) and specially in studies on agriculture (Pufahl and Weiss, 2009; Wu et al., 2010; Bravo-Ureta et al., 2011; Cavatassi et al., 2011; Rejesus et al., 2011; Gonzales-Flores et al., 2014; Villano et al., 2015).

As with all econometric methods, PSM has some limitations or disadvantages. PSM relies on an underlying assumption, which presumes, that all potential variables are observed. In this study, potential variables called 'cofounding variables' refer to the characteristics of the farmers or the lands) that would both 1) affect the outcomes of interests (households' welfare), and 2) make one zone more likely to be affected by the CILY disease rather than another one. The present study controls for a wide range of observed characteristics (Table 2), therefore, a number of important unobserved cofounding variables that would create significant bias in our results are not clearly seen. A second issue that may be a concern is the fact that PMS requires a relatively large sample, while the sample size of our study is modest, however, it provides some reasonably significant results.

Propensity scores matching method

In order to identify a valid indicator group for comparison, we used a quasi-experimental research design with PMS to establish a valid counterfactual group

According to Ravallion (2003), the underlying concepts of PSM are based on the identification of two groups, one that takes part in the intervention (denoted as $T_i = 1$ for household *i*), and another one that does not participate in the intervention (denoted as $T_i = 0$). Differences in the outcomes between the two groups are attributed to the 'intervention', which refers to 'CILY disease' in our study. Coconut farming households with CILY-affected farms are identified as the intervention group, 'treatment' and households with non CILY-affected coconut farms, the non-participating group, 'control'. Following Crépon and Jacquemet (2014), the econometric model to assess the impact of CILY in the study is specified as in the Equation 1.

$$y_i = a + bT_i + u_i$$

(1)

Where,

T is the Treatment and *i* the coconut farming household

$T_i \in \{1,0\}$

$T_i = 1$ if a household with 'CILY-affected coconut farm'

$T_i = 0$ if a household with 'non CILY-affected coconut farm'

a is the constant, b the coefficient and u the error term

Then the impact is mathematically calculated as in the Equation 2.

$$\Delta_i = y_{i1} - y_{i0}$$

(2)

The difference Δ_i corresponds to the simultaneous difference of outcomes between the situation of a household (*i*) with a CILY-affected coconut farm, and the situation of the same household (*i*) if the coconut farm was not affected by CILY. Expressing the counterfactual problem as a household or an individual does not allow simultaneous observations for two different statuses (with and without intervention). Therefore, the matching methods endeavour to develop a counterfactual or control group that is as similar to the treatment group as possible in terms of observed characteristics (Gertler et al., 2011). Khandker et al. (2010) recommended to find from within a large group of non-participants, individuals who are observationally similar to participants in terms of characteristics not affected by the program/intervention. PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment, using observed characteristics. It is mathematically described as in Equation 3:

$$P(X_i) = Prob(T_i = 1|X_i) \; (0 < P(X_i) < 1)$$

(3)

Where,

Prob is the Probability of being affected by CILY

T is the Treatment and X_i a vector of pre-intervention control variables

The vector X_i of pre-intervention control variables is based on the knowledge of the program under evaluation, and on the social, economic, and institutional theories that may influence participation in the intervention. To calculate the program treatment effect, one must first calculate the propensity score P(X) based on all the observed covariates X that jointly affect participation and the outcome of interest. The validity of PSM depends on two conditions: conditional independence (namely, that unobserved factors do not affect participation), and sizable common support or overlap in propensity scores across the participating and non-participating samples (Khandker et al., 2010). In this study, the outcomes of interest in coconut farming households include the annual income, food-related, and non-food related expenses. Non-food related expenses are house expenses (house renting, electricity, water, telephone, cooking energy, soap, toothpaste and cosmetics); home construction and repair expenses; fuel, transportation and travel expenses; household appliances; agricultural equipment (hoe, machete, nets, fish, traps); clothing; alcohol (including local drinks); tobacco, taxes, insurance and other expenses (marriage ceremonies, dowry, jewelry , baptisms, religious gifts, donations).

Observed characteristics (X) fall into three categories; demographic, farm-related and village-related. Propensity scores for each household in the sample were estimated using logistic regression modelling. Matched pairs of households were established based on the proximity of estimated propensity scores generated from the logit model. Unmatched counterfactual households were dropped from the analysis in order to remove bias and to increase robustness (Heckman et al., 1997; Ravallion, 2003). As recommended by Heckman et al. (1997) and Khandker (2010), the test of balancing was performed to verify that in each quantile, the mean of the distribution of propensity scores was equal to the mean of the variable X. The average treatment effect of CILY is calculated as the mean difference of outcomes across the treated and counterfactual groups. This effect will be calculated by using the Average Treatment Effect for the Treated (ATT) according to Heckman et al. (1997) as the Average Treatment Effect (ATE) might not be of relevance to policy makers since it includes the effect on persons for whom the program was never intended. The ATT measures the average causal difference in selected outcome variables between the households with CILY-affected coconut farms (treated group) and the households with non CILY-affected coconut farms (control or counterfactual group). The ATT is calculated as in Equation 4.

$$ATT = \frac{1}{T}\left[\sum_{i \epsilon T} Y_i^T - \sum_{j \epsilon C} \omega(i,j) Y_j^C\right]$$

(4)

Where,

Y_i^T is the outcome of the i^{th} household with 'CILY-affected coconut farm'

Y_j^C is the outcome of the j^{th} household with 'non CILY-affected coconut farm' matched with the i^{th} household with 'CILY-affected coconut farm'

T is the total number of households with 'CILY-affected coconut farm'

C is the total number of households with 'non CILY-affected coconut farm'

$\omega(i,j)$ is the weight function for aggregate outcomes of matched 'non CILY-affected' households

The ATT is estimated without any assumptions about functional forms and error distributions as PSM does not require a parametric model to link program participants to outcomes (Ravallion, 2003), which overcomes the non-experimental regression-based approaches (Kachale and Mapila, 2010). Non-parametric matching estimators commonly used are the Nearest-Neighbor Matching (NN) and the Kernel Matching (KM). These are consistent methods under the conditional independence and commonly supporting assumptions. In this study, the ATT was estimated by using the robust KM method (Lacroix, 2014), which uses a weighted average of all non-participant items to construct the counterfactual match for each participant. If P_i is the propensity score for the participant *i* and P_j is the propensity score for the non-participant *j*, and if the notation in Equation 4 is followed, the weights for KM are as in Equation 5.

$$\omega\ (i,j)_{KM} = \frac{K\left[\frac{P_j - P_i}{a_n}\right]}{\sum_{k \epsilon C} K\left[\frac{P_k - P_i}{a_n}\right]}$$

(5)

Where,

P_i is the propensity score of the household *i* with 'CILY-affected coconut farm'

P_j is the propensity score of the household *j* with 'non CILY-affected coconut farm'

$K(.)$ is the Kernel function and a_n is the bandwidth parameter

C is the total number of households with 'non CILY-affected coconut farm'.

The Kernel Matching used in our study is widely discussed in Heckman et al. (1997) and Heckman et al. (1998). Note that the PSM method is now available in a wide range of statistics packages like Stata, SAS and R. This allows any empirical researchers to easily apply this method or replicate our results. For instance Sianesi (2001) provides an easy step-by-step PSM implementation method using STATA.

Variables used in the Logit model

To implement the PSM procedures, several variables were used in the Logit model, see Table 1. The Logit model is a binary choice model used to generate a propensity score for each coconut farming household. These scores represent the probability of being affected by CILY. Propensity scores were used for matching treated (CILY-affected) and non-treated (non CILY-affected) groups. Based on theoretical and empirical foundations, we selected variables that jointly affect the participation (probability of being affected by CILY) and the outcome of interest (Khandker et al., 2010).

Variables that could significantly influence the total income of the household include socio-demographic characteristics (size of the household, ethnic group, age, level of education and marital status of the householder); type of agricultural workers, and areas of agricultural production (Kuepie, 2004; Chia et al., 2006; Cissé et al., 2011).

According to Tiehi (2012), health expenses should be determined by socio-demographic characteristics (age, sex and level of education of the householder) and the total income of the household. High-income households, including those led by young farmers, women, or a higher-educated individual, are more likely to visit the hospital and pay for health fees. Munyamahoro and Ntaganira (2012) revealed that households whose members do not visit modern hospitals are poor-resourced farmers. Kone (2013) found that higher education levels reduce the risk for mothers to practice self-medication for infants and young children. Moreover, Amooti and Nuwama (2000) indicated that the physical distance from home to childbirth centres is also a factor influencing hospital visits. For example, in Uganda a long distance to the healthcare facility is the number one reason for home childbirth. This is also a trend in Côte d'Ivoire. Seke (2007), Adjiwanou (2005), Glaeser et al., (2002), Grootaert (1998), Pilon (1995), Clignet (1994), Jacoby et al. (1993), Jamison and Lockheed (1987), found that socio-demographic characteristics (size of the household, sex, standard of living, level of education, activity or profession, and religion of the householder) determine children's school attendance. Women-led households, as well as households with higher-educated members, support children attending school. When the standard of living declines, a change is evident; children's school attendance dramatically decreases.

Explanatory variables included socio-demographic characteristics of the household such as family size (TailleMen2 TailleMen3), sex (SexM1), age (AgeCatCM2 AgeCatCM3) and education Level (NivInstCM1, NivInstCM2) of the householder; farm characteristics such as area of the coconut farm (SUPERFCOC1), non-coconut crop areas (SupOtreCult), labor force used in coconut farming (MbreTRAVCOC); village characteristics such as the standard of living (nivovie), availability of electricity, potable water, or well water; health characteristics such as the number of sick members (NbreMalade), the health and school infrastructures like nursing center (infirmerie), childbirth center (maternit) or hospital (Hpital), primary school (ecolprim), secondary school (ecolsec) or preschool (ecolmat), and distance to the nearest health center or school (distMoyen, distecolprimvil, distecolsecond). In estimating the impact of CILY on family expenses, the variable total income (RevTotal) was included as an explanatory variable according to the economic theory introduced by the Ernst Engel's law stating that household expenses are related to the income (Zimmerman, 1932). This theory states that the percentage of income allocated for food purchases decreases as income rises. As the household's income increases, the percentage of income spent on food decreases, while the proportion spent on non-food related goods increases.

Data

Primary data was collected from baseline surveys of 338 randomly selected coconut farming households, which represents 69% of households identified in 39 villages of the six CILY-affected zones in the south littoral of the Grand-Lahou Department of Côte d'Ivoire (Table 2). CILY–affected farming households were represented by 234 out of the selected families (treated group). Non CILY-affected farming households accounted for 104 out of the 338 families (control group). Data collected included the characteristics of the household's village (main economic activities, standard of living, school and health infrastructures, water and electricity availability, and farmers' associations) (Table 3); household socio-demographic characteristics (sex, age, education level, head of household background, household size); farm's characteristics (area of the coconut farm, mode and cost of land acquisition) (Table 4); and the financial situation of the coconut farm family (income, food-related and non-food related expenses including health and education). Descriptive statistics of characteristics of villages and households were calculated (Table 3 and Table 4).

RESULTS AND DISCUSSION

Characteristics of coconut farmers' villages in Grand-Lahou

The main activities in Grand-Lahou villages for the coconut farm families (Table 3) are fishing (93.85%), which includes fish, crabs and freshwater shrimps; agriculture (83.98%), which refers to both perennial crops (coconut and palm tree) and food crops (cassava, plantain, maize and yam); animal husbandry associated with cattle, sheep, goats and poultry (55.90%); and commercialization, which is mostly related to coconut products, cassava, freshwater shrimps, crabs and dried fish (51.03%). Gardening (12.22%) is the growing of vegetables for family's own consumption and commercialization, and includes the African eggplant, leafy vegetables, okra and pepper. Tourism refers to guided visits to Grand-Lahou. Comparison between villages with CILY-affected farms and villages with non CILY-affected farms reveal the same priority order and type of activities.

The average proportion of villages with access to potable water (8.20%), well water (23.24%) and electricity (22.27%) is very low. Villages with CILY–affected farms have limited access to potable water (9.81%), well water (21.11%) and electricity (26.64%). Villages with non CILY-affected farms have only access to well water (33.33%), and no access to potable water and electricity.

Primary schools are present in several villages (67.97%), however, there are no preschools (0%) nor secondary schools (0%) located in any of the villages**.** The mean distance from the villages to the nearest school ranges from 3.07 km for primary schools to 25.25 km for preschools, and 29.41 km for secondary schools. Preschool and secondary schools are only located in the urban center of Grand-Lahou, which is located the farthest from the CILY–affected villages.

Health infrastructure identified in the villages of Grand-Lahou includes nursing and childbirth centers (Table 3). The nearest health centers are located in urban centers, with a mean distance of 32.70 km between the villages and the hospital; 20.33 km between the villages and the nursing center; and 20.59 km between the villages and the childbirth center. Analysis of the survey results indicate the longest distances to health centers are from the CILY–affected villages.

The standard of living of the majority of coconut farming households in the villages is either medium-income families (57.03%) for incomes ≥ 500 FCFA per adult; or low-income families (42.97%) for incomes < 500 FCFA per adult. This applies for both CILY-affected and non CILY-affected farms. The standard of living was measured on the basis of the poverty line equal to 500 FCFA (1 US $) per day per adult in Cote d'Ivoire (Mahyao et al., 2009).

Socio-demographic characteristics of coconut farm families

The majority (84.11%) of coconut farm families are men-led, whereas 15.89% are women-led farms (Table 4). Similarly, CILY-affected households are mostly men-led (82.81%) compare to those led by women (17.19%). For non CILY-affected farms, 87% were men-led, and only 13% were led by women. This revealed that women-led households with CILY-affected farms are in higher proportion than those with non CILY-affected farms. Women's agricultural associations have recently been created in CILY–affected villages (29.91%).

The age of the coconut farm heads of household ranges from 21 to 87 with an average of 53.88 years old. More than 50% of the heads of household are older than 60 years old for both the CILY-affected and non CILY-affected households. The majority of the coconut farm heads of household are native from Grand-Lahou (52.24%), with household sizes varying from 5 to 10 members (60.75%).

Non CILY-affected households are all led by natives (100%), as opposed to CILY-affected households, which have a mixed composition of natives (48.39%), allochthons (22.58%) and non-natives (29.03%). 'Natives' refer to the local ethnic group (Avikam) from Grand-Lahou. 'Allochthons' are a mixture of different ethnic groups such as Baoule, Dida, and Bete from other regions or departments of Cote d'Ivoire. 'Non–natives' refer to people originally from neighboring countries (Ghana, Mali).

The level of experience for the head of household in coconut farming varies from 1 to 80 years with an average of 31 years. The analysis revealed that the heads of CILY–affected households possess much less experience (14.68 years) than heads of non CILY–affected households (31.24 years). The average area of coconut farms owned by smallholder families in Grand-Lahou varies from 0.25 to 20 ha with a mean of 3.56 ha, and the possibility to extend to 2.5 or 2.77 ha to cultivate other crops. The different modes of land acquisition include heritage (77.07%), donation (16.67%) or renting (12.26%). The cost of land in Grand-Lahou ranges from 10,000 to 500,000 FCFA per hectare with a mean of 270,000 FCFA per hectare.

Socio-Economic Impact of CILY on coconut farming households

Results on the impact of CILY on the coconut farming households for five socio-economic parameters are summarized in Table 5. The PSM procedure to assess the CILY impact on the household income showed a region of common support of Propensity Scores (PS) in the interval between 0.55 and 0.99. The density of PS is presented in Figure 1. This procedure yielded a total of 318 matched observations with 220 for CILY–affected households and 98 for non CILY–affected households. The KM with bootstrapping of standard errors resulted in a difference of total income of 16,295 FCFA/year between matched treated (792,373 FCFA/year) and their counterfactual (776,078 FCFA/year). This difference represents an increase of 2.09%. The negative difference of coconut income (-19,416 FCFA) resulting in the difference of matched treated (254,866 FCFA/year) and matched controls (274,282 FCFA/year) represents a decrease of 7.07%.

The PSM procedure for CILY impact evaluation on family expenses, including the total income (RevTotal) in explanatory variables, reveal regions of common support of propensity scores in the interval between 0.34 and 0.98; 0.26 and 0.98; 0.27 and 0.98 for food-related and non–food related expenses. The densities of PS are presented in Figure 2, Figure 3 and Figure 4. The procedures yield a total of 249 matched observations with 174 CILY–affected households and 75 non CILY-affected; 241 matched observations with 164 CILY–affected households and 77 non CILY–affected; 254 matched observations with 176 CILY–affected and 78 non CILY–affected households, respectively.

Results showed that smallholder farmers with CILY-affected farms have incurred higher expenses compared to those with non CILY-affected farms. The CILY-affected farmers report a significantly higher monthly cost for food (83.25%) and non-food related expenses (81.43%) such as annual health (99.47%) and schooling (29.22%) (Table 5). Factors that may be associated with the increase in food-related expenses may be the low level 'gardening' found (6.52% in CILY-affected farms versus 30.95% in non CILY-affected farms) (Table 3). Spending more time on 'commercial' activities could result in less time available for growing food for their own consumption, therefore, more money is spent on food for the family. The impact of CILY on the total revenue and the coconut farming income was not significant (Table 5). However, there was a significant difference in what impacted and non-impacted farmers indicated were their main activities. CILY-affected farmers reported spending time on 'tourism' (9.38%), non CILY-affected farms did not report any time spent on 'tourism' (Table 3). Time spent on 'commercialization' also varied (56.58% for CILY-affected farms versus 30.95% for non CILY-affected farms).

As CILY-affected farmers have lost a significant percentage of their coconut production, it appears they have shifted to 'commercialization', for example cultivating cassava and selling 'attieké', or investing more in fishing and selling dried fish.

CILY-affected farms incur in more non-food related expenses than non CILY-affected farms (Table 5). Heads of household may be required to hire extra laborers for field work and will have to provide them with salary and food, which increases expenses for food, electricity and water. Bagnol and Mariano (2009) found that ecological degradation as well as plant and animal diseases affect men and women differently both in terms of their risk of infection and their level of socio-economic impact. Farmers from CILY-affected farms invest in more land compared to non CILY-affected farms (Table 4) with a mean of 270,000 FCAF, which also increases the non-food related expenses. The need for more land to cultivate alternative crops could be one reason for this increase.

The increase in health expenses may be associated with the distances to health centers (nursing and childbirth facilities), which are the farthest from the CILY–affected villages (Table 3). As mentioned by Samba (2010), the farther a village is from the nearest school or health centre, increases transportation expenses and/or physical effort due to the long distance families must travel. In addition, farmers working in CILY-affected farms spend longer hours for plot maintenance, weeding and disease surveillance. Consequently, fatigued farmers may be more susceptible to health problems. The higher number of laborers working in the field may generate more work accidents, and subsequently increase need for medical attention.

CILY-affected farms reported spending less money (-29.22%) on school compared to those with non CILY-affected farms (Table 5). Discussions with farmers and village chiefs revealed that revenue from coconut had typically been used for paying for school; once the outbreak of CILY impacted the area, many households

Table 1. Variables used in the Logit model.

Variables	Description	Label	Modality
Sex	Sex of the HH[a]	SexM1	1 : Man, 0 : Woman
Age	Class 1 for Age of the HH	AgeCatCM1	1 : < 40 years; 0 : if not
	Class 1 for Age of the HH	AgeCatCM2	1 : 40 to 60 : 0 : if not
	Class 1 for Age of the HH	AgeCatCM3	1 : > 60 years; 0 : if not
Education	Level 1 of the HH	NivInstruCM1	1 : Illiterate; 0 : if not
	Level 2 of the HH	NivInstruCM2	1 : Primary ; 0 : if not
	Level 3 of the HH	NivInstruCM3	1 : Secondary ; 0 : if not
Background	Background 1 of the HH	OriginCM1	1 : Allochton; 0 : if not
	Background 2 of the HH	OriginCM2	1 : Non-native ; 0 : if not
	Background 3 of the HH	OriginCM3	1 : Native; 0 : if not
Size of household	Size 1 of the household	TailleMen1	1 : <5 members ; 0 : if not
	Size 2 of the household	TailleMen2	1 : 5 to 10 ; 0 : if not
	Size 3 of the household	TailleMen3	1 : > 10; 0 : if not
Labor Force	Labor Force used in coconut farming	MbreTRAVCOCO	1 : Family; 0 : if not
Water and Electricity	Potable water	Water	1 : Water; 0: if not
	Electricity	Electricity	1 : Electricity; 0: if not
	Drilling water	Forage	1 : Forage; 0: if not
Health Infrastructures	Nursing center	Infirmerie	1 : Nursing ; 0: if not
	Childbirth center	Maternit	1 : Childbirth : 0; if not
	Hospital	Hpital	1 : hospital; 0: if not
School Infrastructures	Preschool	ecolmat	1 : Nursery ; 0: if not
	Primary school	ecolprim	1 : Primary; 0: if not
	Secondary school	ecolsecond	1 : Secondary; 0: if not
Standard of living	Standard of living	Nivovie	1 : Medium; 0 : Low
Farming Area	Coconut farm area	SUPERFCOCO1	ha
	Other farming area	SupOtrCult	ha
Health	Number of sick members	NbreMalade	Persons
	Distance to nearest center	DistMoyen	Km
School	Distance to nearest center	distecolprimvil	Km
		distecolsecond	Km

[a]Head of Household.

could not afford to send their children to school. CILY-affected farm families, on average, are farther from pre-school and secondary schools, compared to non CILY affected households; greater distances to school facilities increases education costs (Samba, 2010), making the schools more unaffordable.

Observations and discussion on gender inequalities and disease awareness towards reducing the impact of CILY

Survey data reveals low education levels for coconut farmers in Grand-Lahou, which may have influenced the increase of CILY incidence. Heads of households indicated a high rate of illiteracy with 89.14% for those from CILY-affected farms and 97% for those from non CILY-affected farms (Table 4).

When compared to non CILY-affected farms, CILY-affected farms surveyed exhibit very poor weeding conditions and no indications of any crop or disease management practices. At the same time, there is much less experience in coconut farming reported by the CILY-affected households surveyed (mean 14.68 years) compared with the farming experience of non CILY-affected households (mean 31.24 years) (Table 4). Lack of weeding and good field practices are factors directly related with the increase of lethal yellowing diseases in coconut worldwide (Been, 1995; Myrie et al., 2011). Moreover, family members from women-led farms showed a lower education level than those from men-led farms.

These findings illustrate the need for interventions to educate farmers, raise disease awareness within the community of Grand-Lahou to reduce CILY incidence and to prevent disease spread, and to expand agricultural knowledge and practices in general.

In most of Africa, rural farmers do not have the most up to date information on modern agriculture (Sokoya et al., 2014).To improve agricultural productivity, increase resilience in smallholder households, and thus ensure food security, access to information and increased awareness is imperative. There is consensus that more education results in a positive impact on agricultural productivity. It has been found that the more educated farmers adopt new ideas and inovations earlier (Padhy and Kumar, 2015). In addition to improvement in production efficiency, education increases market efficiency; the ability of a farm to receive the highest net sale price for their outputs and pay the lowest net price for the inputs. In other words, education enhances the

Table 2. Coconut farming households interviewed in zones of Grand-Lahou, Côte d’Ivoire.

Zones	Villages	CILY-affected Farming households	Non CLIY-affected Farming households	Total interviewed	Total identified	% of Total Identified
Z1	Agoudamé1	7	1	8	2	
	Agoudamé2	0	3	3	1	
	Braffedon	6	9	15	24	
	Gbegueledon	1	0	1	1	
	Kébékro	2	0	2	3	
	Lakpehoun	0	2	2	1	
	Subtotal	16	15	31	32	97
Z 2	Amanikro	3	0	3	3	
	Badadon	13	0	13	55	
	Doudougbazou	12	0	12	13	
	Gbapo	1	0	1	2	
	Gbata	1	0	1	2	
	Likpilassié	14	0	14	22	
	V1	15	0	15	25	
	V2	13	0	13	26	
	V3	12	1	13	19	
	Yaokro	9	1	10	13	
	Subtotal	93	2	95	180	53
Z 3	Ablam	4	0	4	6	
	Adjadon	7	0	7	10	
	Dibou	10	1	11	14	
	Gredjibery	10	0	10	11	
	Groguida	15	0	15	30	
	Kokou	12	0	12	17	
	Kpoklotchom	1	0	1	1	
	Lahou Kpanda	15	0	15	64	
	Legrekon	3	0	3	3	
	Subtotal	77	1	78	156	50
Z 4	Djateket	2	10	12	10	
	N'Guessandon	0	14	14	7	
	Noumouzou	4	11	15	6	
	Toukouzou	1	12	13	8	
	Subtotal	7	47	54	31	174
Z 5	Allékédon	4	7	11	13	
	Beugrédon	4	9	13	10	
	Ebounou	4	2	6	11	
	Essonam	1	4	5	6	
	Zagbalébé	4	7	11	14	
	Subtotal	17	29	46	54	85
Z 6	Liboli	11	2	13	16	
	Mackey	10	1	11	12	
	Tioko	3	5	8	8	
	Tiokotchi	0	2	2	4	
	Subtotal	24	10	34	40	85
	Total	234	104	338	493	69

Source: Field survey, 2014.

ability of farmers to know when and where to buy and sell (Padhy and Kumar, 2015). Compounding these issues, farmers who are illiterate are unable keep written records of their production or thoroughly review a contract with a potential buyer or seller; and their capacity to access information, and to understand plant diseases and their

Table 3. Description of characteristics of villages surveyed in Grand-Lahou, Côte d'Ivoire.

Variables	CILY-affected Villages	Non CILY-affected Villages	Pooled
Main activities (%)			
Fishing	92.57	100.00	93.85
Agriculture	82.71	90.48	83.98
Animal husbandry	55.56	57.14	55.90
Commercialization	56.58	30.95	51.03
Gardening	6.52	30.95	12.22
Tourism	9.38	0.00	7.06
Crafts	0,00	0,00	0,00
Water and Electricity (%)			
Potable water	9.81	0.00	8.20
Well water	21.11	33.33	23.24
Electricity	26.64	0.00	22.27
School Infrastructures			
Preschool (%)	0.00	0.00	0.00
Mean Distance (Km)[a]	25.95	10	25.25
Standard deviation	(16.96)	(0.00)	(16.91)
Primary school (%)	35.71	74.30	67.97
Mean Distance (Km)[a]	3.30	1.52	3.07
Standard deviation	(5.08)	(0.87)	4.78
Secondary school (%)	0.00	0.00	0.00
Mean Distance (Km)[a]	29.83	25.29	29.41
Standard deviation	(15.93)	(8.74)	(15.44)
Health infrastructures			
Nursing center (%)	16.82	0.00	14.06
Mean Distance (Km)[a]	20.96	13.82	20.33
Standard deviation	(13.78)	(2.18)	13.33
Childbirth center (%)	16.82	0.00	14.06
Mean Distance (Km)[a]	21.29	13.82	20.59
Standard deviation	(14.05)	(2.18)	13.57
Hospital (%)	0.00	0.00	0.00
Mean Distance (Km)[a]	33.44	25.29	32.70
Standard deviation	(17.79)	(8.74)	17.31
Standard of living (%)			
High-income	0.00	0.00	0.00
Medium-income	57.01	57.14	57.03
Low-income	42.99	42.86	42.97
Association (%)			
Farmers Associations	0.00	30.95	5.08
Women Associations	29.91	0.00	25.00

Source: Field survey, 2014
[a] Distance to the nearest center.

control measures is limited. Education approaches to raise disease awareness are being implemented for farmers in Grand-Lahou with special attention to women. These include training programs and field schools on CILY and its current control methods, coconut biology and farming, and market efficiency (UNA, 2015).

Although the percentage of women-led farms (17.19%) in CILY-affected farms was significantly lower than the percentage of men-led farms (82.81%) (Table 4), Ivoirian women provide 80% of food production and 60% of marketing and labor within the coconut production chain (ANADER, 2013). Women farmers specialize in weeding, transplanting, selling and copra processing. However, in Côte d'Ivoire, coconut farming is considered a "man's work", so women's involvement is mostly underpaid, and their role is undervalued and constrained by limited access to resources, services and market opportunities. In addition to their farming work, women's responsibilities include cleaning the house, cooking, educating the children, and taking care of the family. Without electricity or running water, which is often the case in the villages of Grand Lahou, these tasks are even more onerous for women.

Intervention approaches to empowering women are imperative to address gender inequity and to efficiently increase farm productivity. Many Ivoirian women farmers inherited their farms from husbands and relatives who died in the recent civil war (ANADER, 2013). However, in Grand-Lahou, a recent study showed that women are denied access and control over farmland since they are socially forced to work in their husband's farms (UNA, 2015). Similarly in Sub Saharan Africa, women play a

Table 4. Description of characteristics of coconut farming households of Grand-Lahou, Côte d'Ivoire.

Variables	CILY–affected Households (N=234)	Non CILY–affected Households (N=104)	Pooled (N=338)
Household characteristics			
Sex of the HH[a]			
Men (%)	82.81	87	84.11
Women (%)	17.19	13	15.89
Age of the HH			
Mean (years)	53.86	55.26	53.88
Min	21	23	21
Max	87	86	87
Shapiro and Wilk normality test	0.06**	0.16	0.006*
Age category of the HH			
< 40 years	21.72	16.00	19.94
40 to 60 years	23.53	27.00	24.61
> 60 years	54.75	57.00	55.45
Level of education of the HH			
Illiterate (%)	89.14	97.00	91.59
Primary (%)	4.52	2.00	3.74
Secondary (%)	6.33	1.00	4.67
Origin of the HH			
Native (%)	48.39	100.00	52.24
Allochton (%)	22.58	0.00	20.90
Non-native (%)	29.03	0.00	26.87
Family size			
< 5 members	16.29	10.00	14.33
5 to 10 members	60.63	61.00	60.75
> 10 members	23.08	29.00	24.92
Coconut farm characteristics			
Experience in coconut farming (years)			
Mean	14.68	31.24	31
Min	3	1	1
Max	80	80	80
Coconut farm area (ha)			
Mean	3.53	3.82	3.56
Min	0.25	0.25	0.25
Max	20	20	20
Land cost (FCFA)			
Mean	270 000	-	270 000
Min	10 000	-	10 000
Max	500 000	-	500 000
Land acquisition mode			
Heritage (%)	66.51	81.00	71.07
Donation (%)	21.56	6.00	16.67
Other (%)	11.93	13.00	12.26

Source: Field survey, 2014
***, **, * = indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk levels respectively
[a] Head of Household.

dominant role in the production, processing and post-harvest storage of the food, and yet only 15% of them are landholders (Bagnol and Mariano, 2009).

Using only rudimentary hand tools, such as a machete, men farmers are responsible for the heavy-labour intensive task of land clearing and preparation. Most of female farmers must rely on male laborers for field preparation giving away 1/3 of the harvest and keeping only 2/3 for her family (ANADER, 2013). Women do not have large plots of land and are often heirs of old unproductive plantations, and bear the brunt of the consequences of lack of farm labor. During surveying, we observed that women-led farms tend to be weedy, produce little and are more prone to diseases, including CILY. Women, like men farmers, are affected by the geographical isolation of the farms and the lack of transportation from the farm to the village. Both women and men farmers require access to funds, resistant planting material, modern farming equipment and supplies, new technologies for disease control, and training to make their farms sustainable and profitable.

According to FAO (2011), investing in women and using

Table 5. CILY impact on coconut farming households in Grand-Lahou, Côte d'Ivoire.

Variables	Matched treated	Counterfactual	CILY impact			
	Mean	Mean	ATT[a]	Std Error[b].	t[c]	ATT (%)
Income (FCFA/year)						
Total income	792372.84	776077.87	16294.967	117352.9	0.139	2.09
Coconut farming income	254866.26	274282.36	-19416.102	47570.53	-0.408	- 7.07
Expenses						
Food (FCFA/month)	74095.058	40433.847	33661.211	11176.88	3.012	83.25***
Non-food (FCFA/year)	140903.81	77662.183	63241.625	22232.007	2.845	81.43***
Health (FCFA/year)	111285.49	55788.679	55496.807	17335.200	3.201	99.47***
School (FCFA/year)	150054.42	212019.49	-61965.063	52410.323	-1.182	- 29,22

Source: Field survey, 2014
***, **, * = indicates that the variables are statistically significant at 1.0% 5.0% and 10.0% risk levels respectively
[a] Average Treatment Effect on the Treated
[b] Standard Error
[c] Statistic of student

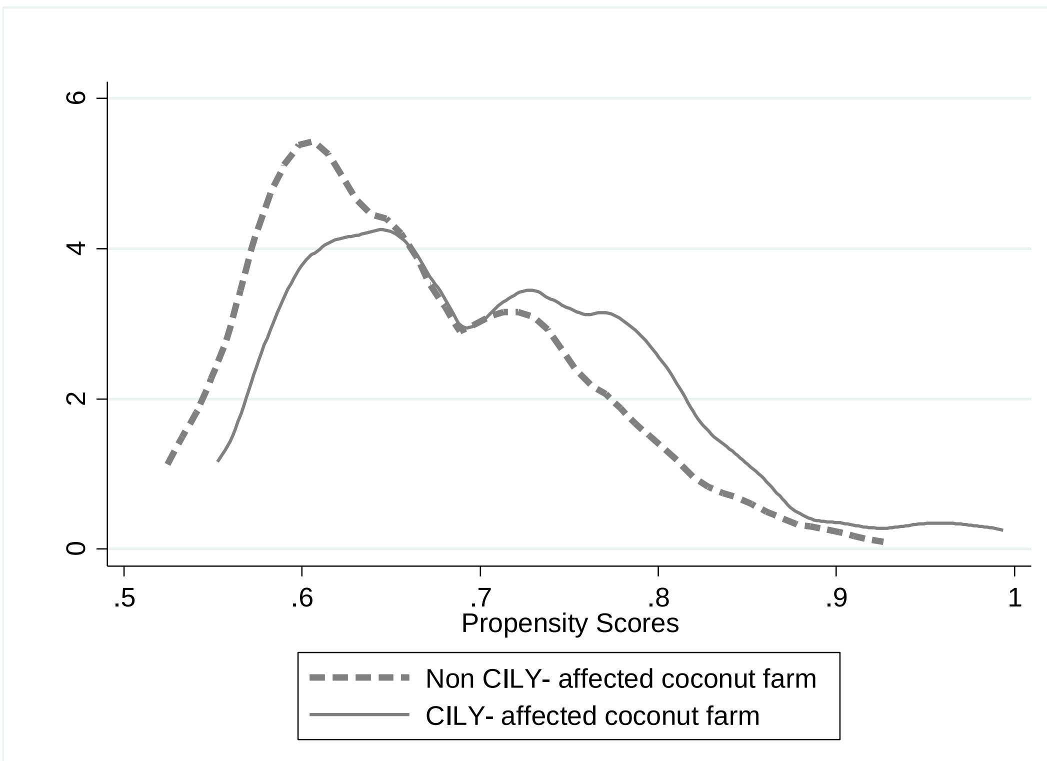

Figure 1. Density of the propensity scores for CILY-affected and non – affected farming households using variables affecting household's income.

gender-responsive approaches, leads to better program results. If women have the same access as men to productive resources, land, loans, training, market, and business and social organizations, they could increase yields on their farms by 20 to 30%. When women and girls earn income, they reinvest 90% of it into their families, compared to men who reinvest 30-40% (Fortson, 2003). When women are empowered to have more influence over economic decisions, their families allocate more income, food, health, education, children's

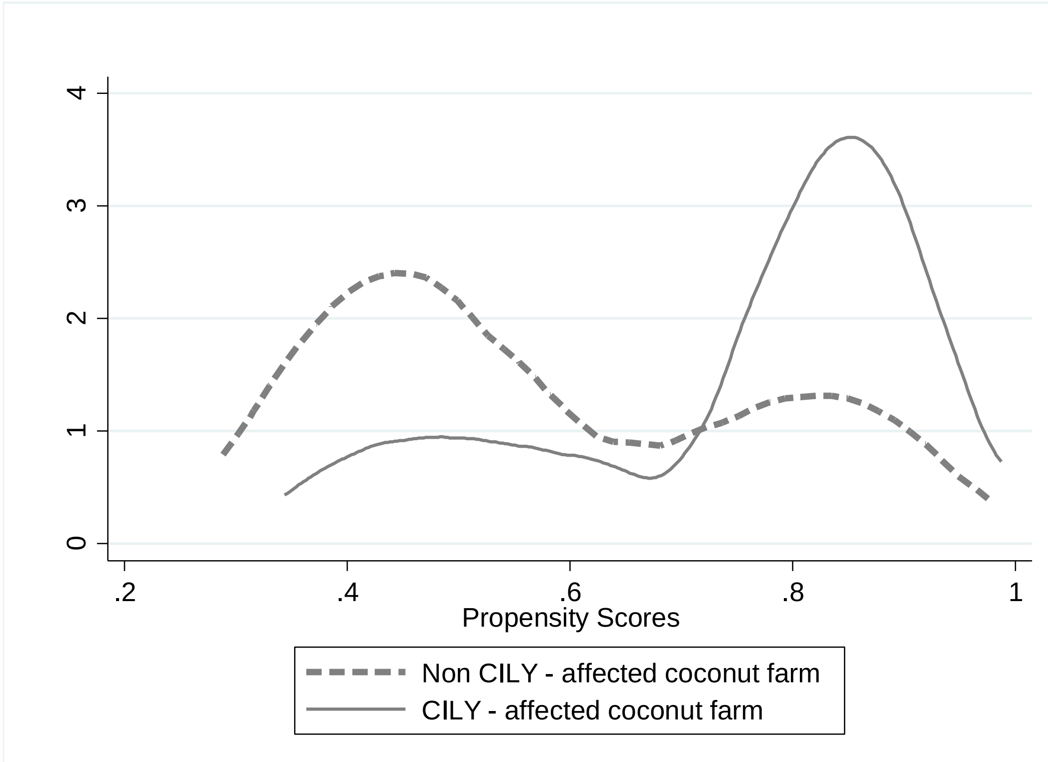

Figure 2. Density of the propensity scores for CILY-affected and non – affected farming households using variables affecting food and non-food expenses.

clothing and children's nutrition.

In Grand-Lahou, Women Groups are being created to address the main constraints for women within the coconut production chain (UNA, 2015). At the time of our survey Women Groups/Associations have only formed for those CILY-affected farms (Table 3). These Women Groups aim to gather women together for information and activities related to the processing and commercialization of agricultural products and products derived from coconut and other crops (UNA, 2015). Activities include the training in cassava and coconut farming; seeking funding to acquire machinery to process cassava, coconut oil and corn flour; seeking funding to acquire equipment for copra cleaning, shelling and drying; and field schools and gender workshops led by female agricultural extension agents.

One approach that would help farmers to make their coconut farms more profitable and resilient to CILY is intercropping; allowing smallholder farmers can make the most of their land space. Mensah and Ofosu-Budu (2012) developed a coconut-citrus intercropping system for farmers to provide insurance against total crop failure and loss of income due to Cape St. Paul Wilt disease (CSPWD) in Ghana. The introduction of new food crops can improve farmers' profits (since there may not be as much competition from other local producers) and the nutrients available to those who consume what they produce. In Nigeria, Godwin-Egein et al. (2015b) showed that intercropping pumpkin and maize significantly reduced the incidence of leaf spot disease.

CONCLUSIONS AND RECOMMNEDATIONS

Analysis of the survey conducted indicates that CILY impacts the livelihoods of smallholder coconut farmers in Grand-Lahou by dramatically increasing the household food-related and non-food related expenses, particularly for health. Identifying the causes of this increase in expenses requires further investigation. However, making farmers aware of such expense increases may be used as an information tool to raise disease awareness, and engage them in improving crop management and prevent disease spread.

Factors such as education level, lack of disease awareness, and gender inequalities can influence farmers' perception and behavior related to CILY disease control. These factors may increase the risk for farms to be more prone to CILY infection thus increasing the incidence of the disease across the coconut plantations in Grand-Lahou. Village-based implementation of educational programs and CILY training such as field schools and community workshops will help farmers increase their productivity and improve income and family nutrition.

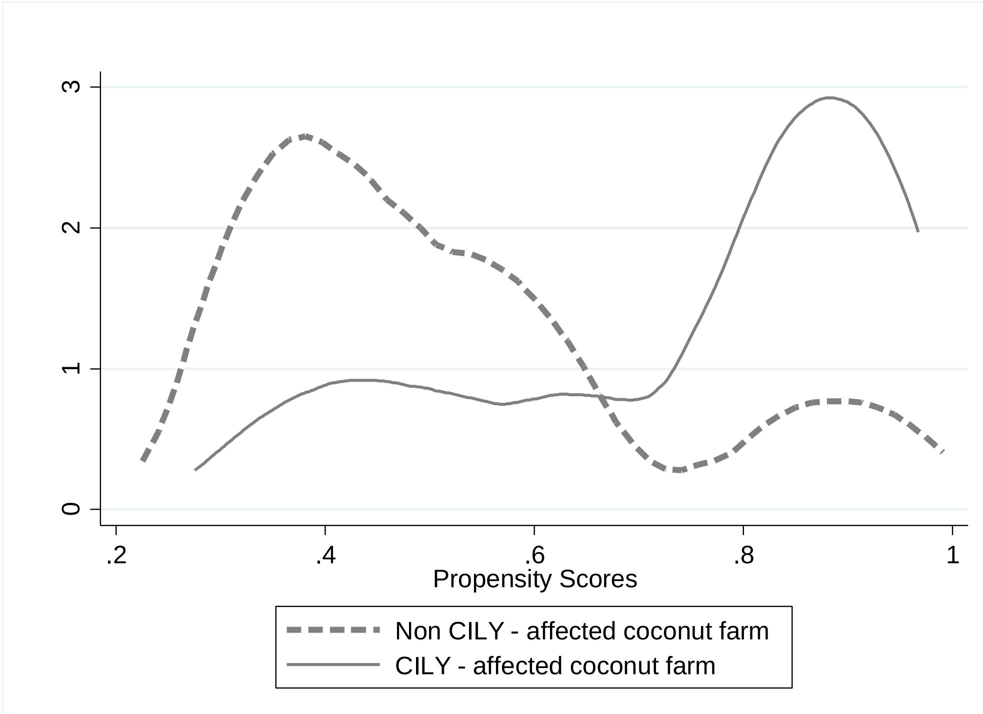

Figure 3. Density of the propensity scores for CILY-affected and non – affected farming households using variables affecting health expenses.

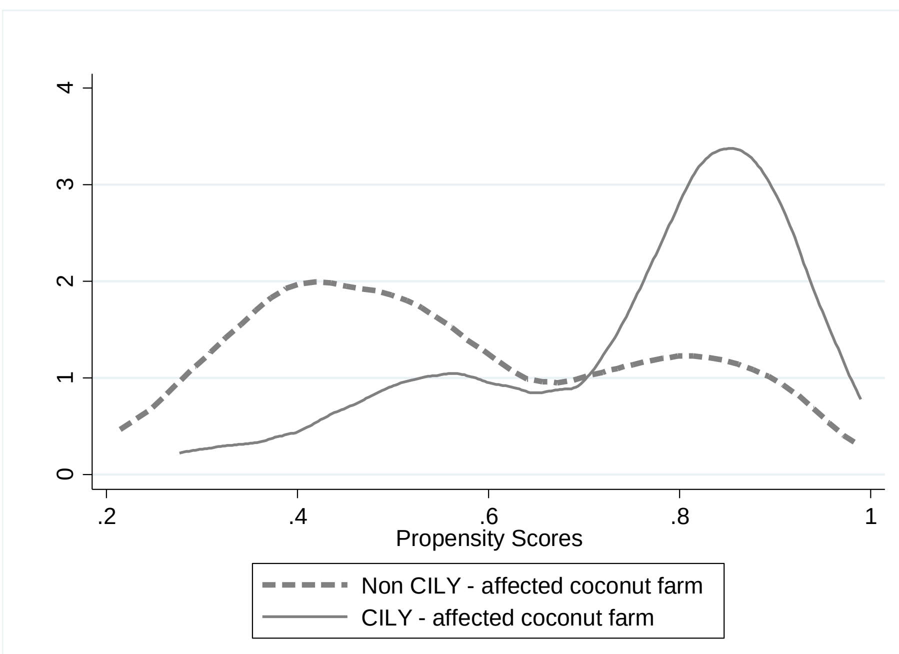

Figure 4. Density of the propensity scores for CILY-affected and non – affected farming households using variables affecting schooling expenses

As with all agriculture interventions, gender considerations must be a priority and gender equity a goal. Efficient information flow and better communication among agricultural stakeholders, researchers, policy makers, and farmers are critical in mitigating gender inequalities. Interventions to improve women's access to land and resources, education, agricultural extension services, mobility, and decision-making to enhance coconut produce and marketing are required.

Improving livelihood for coconut smallholder families should take into account actions to increase access to food, and health care and school centers for the community. A decrease in spending on school was observed in CILY-impacted households, which at the same time have high food and healthcare expenses, further illustrating the need for these actions so that obtaining an education is something all families can afford.

The implementation of coconut intercropping systems with alternative food and cash crops should be encouraged in Grand-Lahou to compensate losses due to CILY and help increase the resilience of coconut smallholder households.

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