Participatory assessment of farm level outcomes and impact of crops pests and diseases management

An application to the Plantwise programme in Rwanda and Ghana

Silvia Silvestri, Richard Musebe

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Authors

Silvia Silvestri, Senior Socio-economist, **Richard Musebe,** Socio-economist

CABI Africa
Canary Bird, 673 Limuru Road
Muthaiga, PO Box 633-00621
Nairobi
Kenya
T: +254 (0)20 2271000/20

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Executive summary

This study assesses the impact of the Plantwise programme through the measurement of the changes at economic and human capital level within selected farming communities. The impact is measured through the use of qualitative methods in the form of focus groups discussions (FGDs) and key informant interviews (KIIs).

This study finds that farmers that use plant clinics have increased their awareness, knowledge and capacity to identify and manage pests and diseases with respect to non-users of plant clinics. In particular:

- Clinic users have better capacity to identify signs of pests and diseases and can provide a more detailed list of signs.
- In terms of adoption of practices, in both countries plant clinic users appeare to have a wide range of responses for decision making possibly due to greater access to more control options. Yet, clinic users have more informed decisions when implementing an intervention and in general are able to articulate the rationale behind their choices.
- Crop rotation, timely planting, use of resistant varieties are some of the practices that farmers have more regularly adopted after consultation with plant clinics in Rwanda. In Ghana, Integrated pest management in form of use of organic pesticide seems to be prerogative of clinic users, together with early planting, use of resistant varieties and time of weeding.
- Efficient use of pesticides, knowledge of pesticides and use of the right dosage of pesticides is declared by key informants to be have been largely improved by clinic users after consultation with clinics. Yet, clinic users have also reduced the use of pesticide in favour of use of non-chemicals, such as ashes and neem for example.
- In Rwanda the overall assessment of all clinic users and non-clinic users revealed that clinic users performed better with respect to productivity of rice, maize and beans. There was a statistically significant difference in **the yield** of maize (8.5tons/ha vs 4.8tons/ha) and a highly significant difference in the yield of rice between users and non-users (8.1tons/ha vs 5.6tons/ha); in Ghana non-users perform better for groundnut (0.3tons/ha vs 0.4tons/ha) and cowpea (0.3tons/ha vs 0.6tons/ha), whilst users perform better for maize (1.4tons/ha vs 1.0tons/ha).
- In Rwanda for maize (2,467USD/ha vs 860 USD/ha) and rice (2,241USD/ha vs 1,561USD/ha) we found statistically significant differences between the **net value per ha** of clinic users vs clinic non-users, with the last ones that have lower net value per ha. No significant difference is recorded when looking at the performance of women and men separately; in Ghana for cowpea (322.2USD/ha vs 405.1USD/ha), groundnut (164.3USD/ha vs 264.7USD/ha), and maize (127.0USD/ha vs 273.3USD/ha), the net value per ha was higher for non-users than for users, however this difference was not statistically significant.

From a methodological point of view, with the use of qualitative methods we could capture the complexity of local dynamics behind differences between clinic users and non-users. However, additional research should be undertaken with quantitative methods to provide a more solid statistical basis for data collection and means of comparison between clinic users and non-users.

Introduction

Crops pests and diseases represent a common and important threat to the livelihoods of farmers in sub-Saharan Africa (Geddes, 1990; Rweyemamu et al., 2006), where farmers live mainly on subsistence agriculture (Thornton et al., 2008 and 2009). Ongoing strategies, interventions and programs exist in both Rwanda and Ghana that have tried to address the management of pests and diseases at national level. The Plantwise (PW) programme is one of these. The PW programme, funded by a multi-donor group, started in 2011 with the aim to “increase food security, alleviate poverty and improve livelihoods by enabling male and female farmers around the world to lose less, grow more and improve the quality of their crops”. In order to achieve this, PW gathers, organizes, manages and disseminates agricultural extension information to farmers through plant clinics, plant health rallies, institutional linkages and the knowledge bank. The expectation is that farmers and their families will benefit from the PW programme in terms of: changes in knowledge about pests and diseases and improved yield. Furthermore, the increase in production due to the new knowledge could in turn be utilized by the household and therefore increase food security and have livelihood impact. Alternatively, if increases in income derived from sales of crops allows for investments in health, education, or income generation, this would represent an impact on welfare. In this regard it is important to assess impacts of PW. However, assessing farm level impact of PW is complex as it requires a variety of methods, approaches and designs to assess changes, direct and indirect, expected and unexpected, that contribute to farm-level and other improvements. Yet, understanding of farmers’ decision making is a prerequisite to achieve longer-term sustainability. Impact assessment based on participatory approaches can help to reveal the diversity of farmers’ decision making among different socio-economic categories of families and also within families according to gender, age, etc. (Cromwell *et al.* 2001).

Impact assessment of interventions and programmes usually include assessment of the following components: environmental impact, which focuses on analysing impacts at ecological level; impact on human capital, which measures changes in farmers’ knowledge and skills for decision making; economic impact, that measures benefits for farmers in terms of increase in yield, income and welfare; and impact on social capital, that measure changes in social networks, access to information and collective actions as result of the implementation of a programme and/or interventions.

The aim of this study is to assess the impact of the PW programme through the measurement of the changes at economic and human capital level within selected farming communities, by establishing causality of observed impact and identifying contextual influences. In doing so this study aims to answer the following research questions: i) how has the PW programme impacted the knowledge of the farmers (men, women and youth)? ii) how has the PW programme impacted the skills of the farmers (men, women and youth)?; iii) how has the PW programme impacted farmers’ decision making in pest and diseases management?; iv) how has the PW programme impacted the livelihood and welfare of the farmers (men, women and youth)?; v) what are PW programme’s attributions (what are the programme factors that contributed to the change in the impact indicators and what is their importance)?

Methodology

Site characteristics

In both Rwanda and Ghana three study sites were selected and in each study site two different communities were involved in the study.

In Rwanda the study was conducted in the following sites (see Table 1 and figure 1): Ngororero in Western Province, Bugesera in Eastern Province, and Kamonyi and Huye in Southern Province.

In Ghana the study was conducted in the following sites in the region of Brong Ahafo (see Table 1 and figure 1): Kintampo North, Tano South and Techiman Municipal.

Table1. Description of study sites and main crops brought to the clinics with associated pests and diseases in Rwanda and Ghana.

Site name	Agro-ecological zone	Main crops*	Main pests and diseases**
Rwanda			
Eastern province, Bugesera district, Ruhuha sector	Savanna characterized by dry climate, with average temperature between 26 and 29°C. Two dry periods and two rainy periods. Min rainfall 850 max rainfall 1000 mm.	Banana	*Bananas xanthomonas wilt*
		Rice	Rice yellow mottle virus
		Cassava	Cassava mosaic disease Powdery Mildew
		Tomatoes	Tomato mosaic Tomato virus
Western province, Ngororero district, Ngororero and Sovu	Tropical type climate with four seasons. Altitude ranges from 1460 to 2883 m above sea level. Average annual rainfall of 1400 mm. The average annual temperature is 18ºC which varies with altitude.	Cassava	Cassava mosaic disease
		Maize	Maize streak virus
Southern Province, Huye and Kamonyi District, Rusatira Sector	It is characterised by sub-equatorial temperate climate with an average temperature of 20ºC. It has an annual rainfall of 1160 mm and four climatic seasons with heavy rainfall of 1400 mm per year.	Tomatoes	Bacterial wilt
		Maize	Maize stalk borer
Ghana			
Brong Ahafo region Kintampo North district Badu Krom community	Tropical continental or Interior Savannah type of climate. Mean annual rainfall between 1,400 mm-1,800mm and occurs in two seasons. Altitude 60-150m above sea level. The average temperature is 27ºC.	Groundnut	Rosette disease Termites Small borers
		Maize	Maize steam borer Termites Maize weevil
Brong Ahafo region Tano South district Owen Nkwanta community	Semi-equatorial climatic zone with two rainy seasons. Rain between 1,250mm and 1,800mm. The average temperature is 28ºC. Altitude 270 to 760m.	Cocoa	Maize stem borer Akate (capsid) Black pod
		Maize	Maize stem borer Termites Maize weevil

Site name	Agro-ecological zone	Main crops*	Main pests and diseases**
Brong Ahafo region Techiman Municipal district	Semi-equatorial and savanna climates with annual rainfall ranges between 1260mm and 1660mm. The average temperature is 25ºC. The elevation is 425m.	Maize	Maize steam borer Termites Maize weevil
		Cowpea	Aphids Pod borer Weevil

* based on frequency of crops brought to the clinics and selected for the FGDs

**based on declarations of farmers and cross-checked with PW dataset

Figure 1. Map of Study sites in Rwanda and Ghana.

Team

In both countries the team that conducted the study comprised of four local enumerators and a national facilitator, and the CABI staff. The national coordinator helped to ensure that: i) time for data collection was suitable for the different groups; ii) suitable enumerators were identified to interview different gender groups; iii) suitable key informants were identified.

Protocol

The two qualitative methods used to assess the outcome and impact of Plantwise programme were focus groups discussions (FGDs) and key informant interviews (KIIs). The protocol was developed through a review of published literature, online searches, and consultation with expert plant pathologists. The protocol was used flexibly, responding to conditions in the field and to the ways different groups of farmers responded, rather than a rigid framework for eliciting and organizing information.

For the FGDs, a form was developed to record participants names, ages, education levels, occupation (other than farming). This ensured that the information about the age was used by the note taker when recording responses from the participants.

Recruitment

For each of the field sites the team made prior arrangements with local collaborating institutions to recruit farmers for the FGDs.

Participatory approaches do not allow the same level of control in recruitment (and therefore sample composition) that is afforded by formal survey methods. Focus groups sessions were held outdoors, so that participants could be able to join or leave, making the group boundary rather fluid.

Language

The FGDs were held in local language: in Rwanda, Kinyarwanda was used during the FGDs with farmers, whilst KIIs were either held in English, French or Kinyarwanda with the help of translation from the national coordinator. In Ghana, Asante Twi was used with farmers, whilst a combination of English and Asante Twi, this last one with support of translation from enumerators, was used for the interviews with the KIIs.

Implementation

In both countries, FGDs were conducted with beneficiary (treatment) farmers, who are users of plant clinics, and with non-beneficiaries (control) farmers, who are non-users of plant clinics. A total of six communities, three of non-users and three of users, was selected in each country.

The following criteria were applied for the selection of the communities: similarity of AEZ, a necessary condition because elements such as soil, temperature and rainfall are important drivers of production; similarity of crops grown; similarity of pests and diseases. We ensured that there was no spillover effect into the non-clinic user area.

We conducted focus groups separately with men and women. A total of 24 heterogeneous focus groups were conducted, 12 in each country. Men and women have different roles and responsibilities determined by social norms. They may attach different values to services/information and benefits derived from them. Consequently, their demand for and access to services/information and their behaviours differ (Dayal et al, 2000). Yet, usually women cannot easily express themselves in a mixed group and hence the need for separate groups in such situations (Kelemework, 2003). In turn this helped to collect gender disaggregated data. Efforts were taken to capture as much information as possible about the youth from the men and women group discussions.

In Rwanda we interviewed 174 farmers, who included 88 men and 86 women. In Ghana the total number of farmers involved in the focus group discussions was 187, with 96 men and 91 women. Eleven KIIs were conducted in Rwanda and 9 in Ghana.

KIIs were implemented with: plant doctors, senior agricultural officers, input dealers and community leaders to provide an independent view of the outcomes and impact of Plantwise.

The selection of key informants was based on their knowledge of agricultural production as well as involvement in agricultural production activities at higher levels including policy level. In addition, the key informants were required to have experience in crop protection practices as well as supply and/sales of inputs. They needed to be dealing with farmers at various levels for example developing policy, providing input and information. The selection process was conducted in such a way as to ensure good representation of the key informants.

During the FGDs items were listed on a flipchart as farmers brainstormed. The flipchart list was transcribed and copied into an excel file. At the same time team members were taking notes. The analysis focused on the frequency of occurrences (how many times each item occurred) and on percent of occurrences (proportion whereby each item occurred among all counts – this provided a measure of the salience of each variable for women, men and youth).

Tools

The guiding questions developed for the focus groups discussions were organized in different sessions (see Appendix I):

- livelihood strategies (to collect information about most important crops grown in the farm for consumption and sale, crops labour allocation, crops areas, crops production and price);
- knowledge and skills (to gather information on human capital indicator); adoption; sources of information for crops pests and diseases

In Ghana an additional question on support received from farmers for pests and diseases control beyond information was added to this session;

- welfare (to assess implications for changes in management of pests and diseases);
- measurement of performances (to collect information about farming activities, type of inputs used and their cost).

This information was organized in two main indicators: human and financial capital (Table 2).

Impact on human capital

In order to measure the impact on human capital, prior to the FGDs a set of indicators of knowledge/skills, and decision making was defined.

Table 2. Indicators of human and financial capital

Impact	Indicators		
Human capital	Knowledge / skills • knowledge of signs of pests and diseases and skills to implement pests and diseases management practices	Decision making • Reasons given by farmers for implementing a practice	
Financial capital	• Welfare • Income (net value per ha) • Household asset	• Productivity • Yield	• Adoption of pests and diseases control practices

Indicator of knowledge/skills

Knowledge of control practices and skills to implement pests and diseases management practices was derived by:

i) recording the number of farmers that know what type of intervention to apply for a specific pest/disease

ii) and recording information on signs on crops that the farmers are able to associate to the presence of pests and diseases.

Indicator of decision making

The indicator of decision making was defined by recording the reasons provided by farmers for implementing a specific practice.

Impact on financial capital

The impact on financial capital was captured through assessment of: welfare, productivity and adoption.

Indicator of welfare

The indicator of welfare embedded both ‘income’ and ‘household asset’.

The proxy for income was the net value per ha, which was derived through the use of participatory budgeting. We collected information on quantities harvested and market price, together with information on activities, type, quantity and cost of input used (seeds, fertilizer, spray, etc.) for the last cropping season. The information was collected for two main crops for three farmers for each group of users and non-users.

Welfare was assessed in a participatory manner with the communities of farmers through the use of a causal diagram. Causal diagrams can help establish causality of the observed impact and identify contextual influences. A causal diagram similar to that developed by Galpin *et al*. (2000) and Doward *et al*. (2007) was used. Farmers where asked to indicate what they considered in deciding to change practices, what they believe are implications on welfare for their household, and what benefits they can derive from the implementation of control measures. The relative importance of each of the causal factors and/or impact was further assessed by asking farmers to assign a weight to each of the factors.

Indicator of productivity

The indicator of productivity was derived by collecting information on yield of crops for users and non-users of plant clinics. The information was collected for two main crops for three farmers.

Indicator of adoption

The indicator of adoption was derived by recording number of farmers that have adopted specific pest and disease control practices.

Sources of information

We collected evidence on what sources of information farmers access for management of crop pests and diseases. For each mentioned source we asked farmers what information was provided. This information was also integrated with the feedback from the key informants.

Challenges

In Rwanda, there were a number of challenges during the study. In one case after conducting the FGDs and moving to the subsequent station it was established that there was no appropriate comparison group and the research team was forced to drop the initial group to establish a new comparison group. The difference was occasioned by differences in agro-ecological zones and hence differences in crops grown. It was however addressed when our collaborator quickly identified an ideal group

In most districts the information collected about the education level of farmers did not show a big discrepancy between communities of users and non-users. However in Ghana a different level of literacy between the community of users and non-users in Tano South was found. The community of non-users that was interviewed in Tano South lives in a remote area with minimum access to education. Therefore this has possibly introduced a bias, considering that various sources indicate that there is a positive relationship between education level and adoption (Igoden et al 1990; Lin 1991; Silvestri et al 2012).

Findings for Rwanda

At the time of the study in 2016, there were 65 plant clinics in Rwanda, which included both 10 e-plant clinics and 55 ordinary plant clinics. E-plant clinics are those where plant doctors are provided with tablets for recording data and these data are transmitted directly to a server where they are captured in the Plantwise Online Management System. The tablets are also used to access information on plant pests and diseases on-line while conducting diagnosis of the plant specimens delivered by farmers. In the ordinary plant clinics data is hand written on the record sheets and later send to the management system.

Impact on human capital

Indicator of knowledge/skills

Farmers were asked whether they think they have or had their crops affected by pests and diseases. In Fig. 2 we report a comparison in % between users and non-users in terms of accumulated answers.

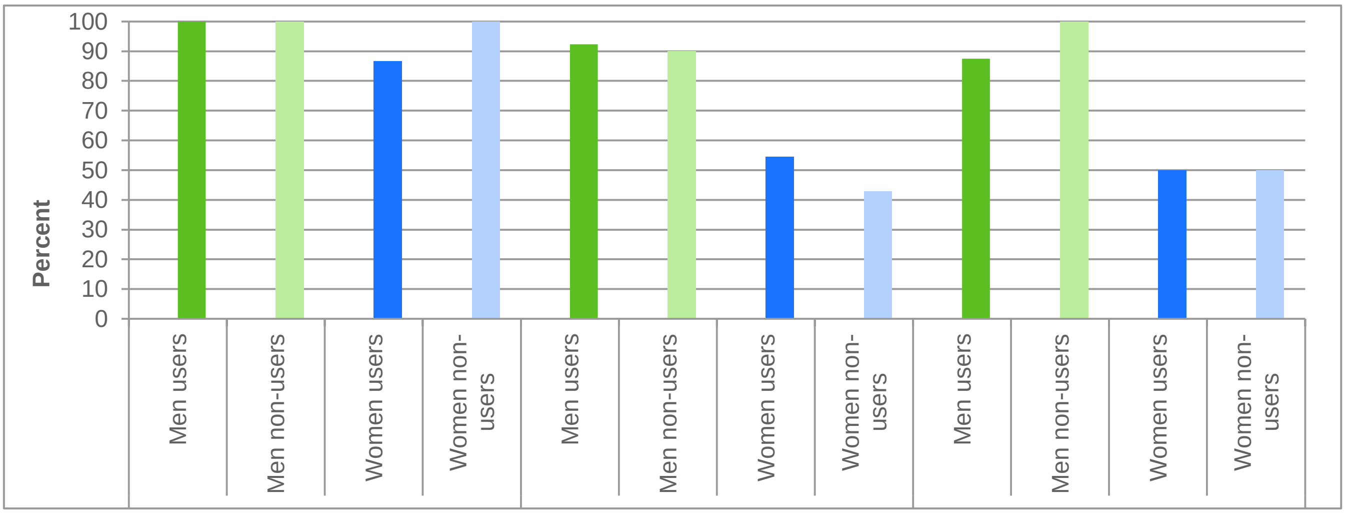


Figure 2. Knowledge of pests and diseases in crops by users and non-users of PW (%)

In terms of capacity to recognize signs of maize stalk borer, users of clinics could provide a more detailed list of signs, including among others, leaf yellowing, holes and insects in the stem, weak stem at a young stage and at flowering and death of the young plant in most instances. Non-users were not all able to identify in those signs the presence of a disease in the plant.

In the case of beans farmers reported signs such as black insects on the leaves, leaf curling, leaves yellowing and the bottom of the stem becoming dry, the bean plant becoming stunted and when it reaches the middle stage it is drying and the leaves have holes. These were reported as signs of bean aphids. There was better correlation between signs known by the plant clinic users with the correct signs of pests and diseases as described by the plant doctors.

The KIIs highlighted an improvement in capacity of identifying and controlling pests and diseases by clinic users. Another difference that the KIIs highlighted is the reduction in use of pesticide for controlling for example cassava pests and diseases on the part of clinic users compared to their use before accessing the clinics. Input dealers argue that knowledge and identification of pests and diseases has improved. There is efficient use of pesticides, knowledge of pesticides and use of the right dosage of pesticides. There is increased farmer knowledge and skills about pests and diseases and their control. More information is available on pests and diseases. More control options are made available. Community leaders also reported that there is increased awareness, knowledge and capacity to identify pests and diseases. The materials provide suitable pesticides and advice to the farmers (cause, effects, and control of pests and diseases). The information materials are detailed and very useful. The Senior Agriculture Officer reports that more knowledge is obtained by the plant doctors and farmers. Good agricultural practices are undertaken by farmers (timely planting, pest control, fertilizer application, etc.). The Rwanda Agricultural Board (RAB) gets information about pests and diseases from Plantwise in specific areas. Plant doctors reported increased pest and disease information, improved control of pests and diseases in the sector and capacity to identify pests and diseases (e.g. bacteria, fungi, viruses, etc.) and plant nutrition problems. In the case of E-clinics it was reported that in the tablets they have photographs that they use to compare with the plant samples brought by farmers.

Indicator of decision making

We compared the capacity of users and non-users in justifying practices implemented to address problems with pests and diseases. A summary of the reasons provided for implementation by users and non-users is provided in Table 3.

The key decision making processes of the farmers were influenced in the initial instance by the drive to increase crop yield, which would translate to improved food self-sufficiency and increased marketed surplus. Subsequently farmers controlled pests and diseases using different methods based on resource base, efficacy and time required to control the pests and diseases effectively. In this respect many methods were used by the farmers in their quest to control pests and diseases. Male farmers used methods that had higher financial implications such as pesticides as opposed to cultural practices that were used by women farmers to a great extent. There were no distinct differences in decision making between male and female youth. On the other hand plant clinic users appeared to have a wide range of responses for decision making possibly due to greater access to more control options.

The practice that stands out as the one that does not seem to be recognized by non-users in terms of contributing to control pest and diseases is crop rotation. This last one is in fact applied by non-users but there is no awareness of its potential for disease control.

One plant clinic user reported: "*I practiced crop rotation because I went to plant clinic and they advised me to do it. I put beans after harvesting maize and then replant maize after 5 months. I do crop rotation to see if crops will grow well without diseases*."

Table 3. Adoption and decision making by plant clinic users and non-users (%).

Crop	Diagnosis by plant doctor	Recommendation by the plant doctor	Reasons given by farmers for implementation	Clinic users adopters	Clinic non-users adopters
Maize	Maize stalk borer	Crop rotation	To avoid pests staying in the soil to attack same crops Non-clinic users provided no reason	54% of men [n=30 (8)]	86% of men [n=28 (0)]
			Because crops need nutrients in order to grow, many farmers rotate between rice, and maize Non-clinic users had no reasons	18% of women [n=28(2)]	11% women [n=29 (10]
		Uprooting	In order to avoid contamination of other crops	27% of men [n=30 (8)] 50% of women [n=28 (2)]	60% of men [n=28 (7)] 48% of women [n=29 (10)]

Crop	Diagnosis by plant doctor	Recommendation by the plant doctor	Reasons given by farmers for implementation	Clinic users adopters	Clinic non-users adopters
		Spraying pesticides	It acts fast on pests and diseases	47% of men [30 (n=8)] 61% of women [n=28 (2)]	67% of men [n=28(0)] 48% of women [n=29 (10)]
		Use certified seed	Advised by agronomists was the reason given by both clinic users and non-clinic users.	100% of men [n=30 (8)] 21% of women [n=28 (2)]	46% of men (n=28 (7)] 24% of women [n=29 (10)]
Rice	Rice yellow mottle virus	Use of resistant varieties	Helps to get crops that are strong	10% of men [n=30 (11)] 63% of women [n=27 (4)]	32% of men [n=28 (7)] 38% of women (n=29 (10)]
		Uprooting	To protect other plants that have not yet been attacked,	43% if men [n=30 (11)] 15% of women (n=27 (4)]	14% of men (n=28 (7)] 0% of women [n=29 (10)]
		Spaying pesticides	The disease can be removed easily; they spray in order to get good production.	20% of men [n=30 (11)] 59% of women [n=27(4)]	32% of men [n=28 (7)] 17% of women [n=29 (10)]
		Applying fertilizer	To increase yield and then be able to sell more in order to get money	0% of men [n=30 (11)] 37% of women [n=27 (4)]	0% of men (n=28 (7)] 0% if women [n=29 (10)]
		Use of certified seed	The rice crop is normally strong and healthy.	47% of men [n=30 (11)] 0% of women	7% of men [n=28 (7)] 0% of women
Banana	*Banana Xanthomonas Wilt*	Uprooting	Remove the pest and disease host and hence avoid pests from the same plant	17% of men [n=30 (11)] 19% of women [n=27 (4)]	27% of men [n=30 (7)] 10% of women [n=29 (9)]
		Early flower cutting	To remove infected flowers and avoid re-infestation	26% of men [n=30 (11)] 11% of women [n=27 (4)]	34% of men [n=30 (7)] 10% of women [n=29 (9)]
		Resistant varieties	The varieties stop fight pests and diseases on their own Cut the life of pests in the soil to avoid repeated attacks on the banana	10% of men [n=30 (11)] 44% of women [n=27 (4)]	23% of men [n=30 (7)] 7% of women [n=29 (9)]
		Crop rotation	Avoid depletion of nutrients for the banana crops, which can increase pest and disease attack	3% of men [n=30 (11)] 15% of women [n=27 (4)]	7% of men [n=30 (7)] 0% of women [n=29 (9)]

Note: The number in brackets indicate number of the youth who were present in the FGD

Farmers who uprooted noted that they practiced this method in order to reduce cross infection of other crops. This was especially in the case of maize stalk borer and rice yellow mottle virus. One farmer in the clinic users group reported that, "*I uprooted rice and burnt in order to eliminate rice yellow mottle virus and to avoid new contamination of other crops*". Other farmers uproot and bury especially for bananas. The pesticides that were reported to have been used include rocket, furidan and rava. Those who sprayed among the plant clinic users reported that they spray once per week for up to 8 weeks to control maize stalk borer. Farmers uprooted rice in the case of rice yellow mottle virus in order to avoid the contamination of other crops.

Results revealed that the plant clinic users were able to use a wide variety of pest and disease control methods compared to the non-plant clinic users. All plant clinic users were aware of the different approaches required for control of pests and diseases.

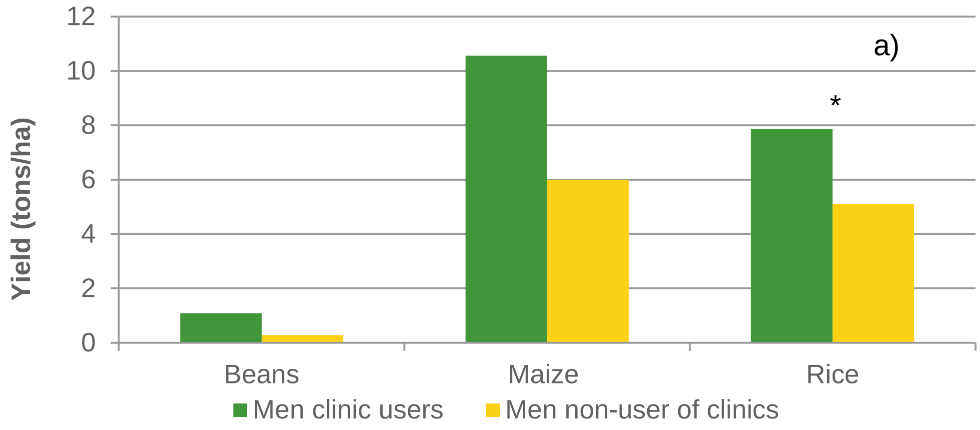
Impact on financial capital

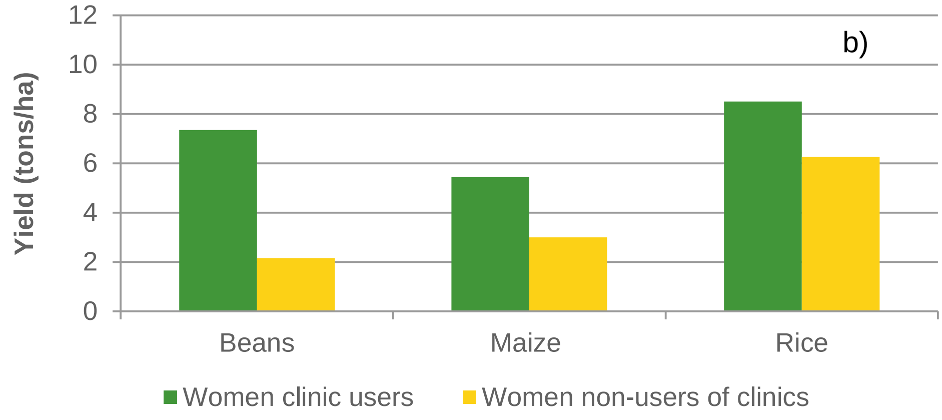
Indicator of productivity

Productivity was assessed for rice, maize and beans. The comparisons of users and non-users of plant clinics revealed that the men users of plant clinics had higher yield for all the crops taken into account, compared to the non-users of the plant clinics (see figure 3a). However, only the difference in the yield of rice was statistically significant ($t=21.14$, $p<0.05$).

Analysis was also conducted to assess differences between women clinic users and non-users (Fig. 3b). Women users of plant clinics had crop yield that was relatively higher than that of the non-clinic users. However, the difference was not statistically significant.

The overall assessment of all clinic users and non-clinic users revealed that clinic users performed better with respect to productivity of the selected crops (Fig. 3c). There was a statistically significant difference in the yield of maize and a highly significant difference in the yield of rice between users and non-users, however, the difference in the yield of beans was not statistically significant.





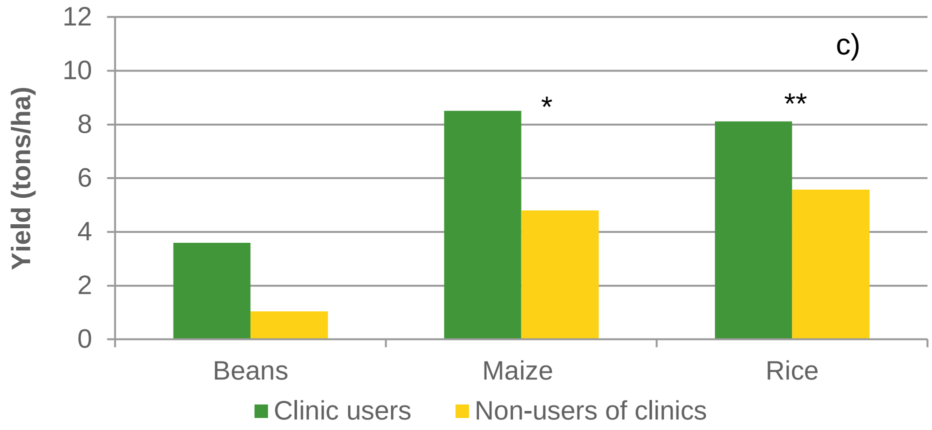


Figure 3. Comparison of yield of beans, maize and rice for (a) men users and non-users of clinics, (b) women users and non-users of clinics, (c) users and non-users of clinics. *p<0.05, **p<0.01

Indicator of adoption

In Table 3 we compare adoption of management interventions for crop pests and diseases control by users and non-users of plant clinics. The practice that stands out as the most applied by users and the least applied by non-users is the use of certified seed. Other practices show actually higher percentages of adoption by farmers non-users than users. These last ones apparently received considerable support from the extension officers working for Rwanda Agricultural Board (RAB) and the Ministry of Agriculture and Animal Resources (MINAGRI), the two main Rwandan governmental bodies working on agriculture.

Key informants were asked to identify those practices that they think farmers have implemented and those that they have dismissed as result of the consultation with plant doctors. As result of frequenting the clinics, farmers have adopted: i) better use of inputs; ii) planting in lines (correct spacing); iii) crop rotation; iv) timely planting; v) use of resistant varieties. Among the practices that farmers are no longer practicing are: i) using pesticide when not necessary; ii) feeding animals with crop residues affected by pests and diseases.

"There are some viruses for cassava for example, and farmers used to use pesticides. They thought that these viruses could be handled without the use of pesticides."

"Farmers used to keep crop residues and give them to livestock and help the pest to spread, they have now ended this practice"

"Farmers in general like to implement control measures that they think can give immediate result. If they see some insects they use pesticide, they spray, but after consulting plant doctors they have learned to better use inputs"

Dusengmina Arnoble – Plant doctor – Ngororero

Indicator of welfare

Income

The net value per ha was assessed for rice, maize and beans.

The costs were derived from the following activities reported by the farmers: land preparation, planting, weeding, application of fertilizer, and harvesting. In table 4 we report a comparison of the net value per ha between users and non-users of plant clinics for each of three crops analysed.

In the case of maize we found statistically significant differences between the net value per ha of clinic users vs clinic non-users, with the last ones that have lower net value per ha. No significant difference is recorded when looking at the performance of women and men separately. For beans, we recorded higher net value per ha for women, which is motivated with the fact that beans are considered a ‘women crop’. However, no significant difference was found between users and non-users both women and men. For rice, the overall comparison between users and non-users showed that users have higher net value per ha, however, when looking at men and women separately, this difference is not significant.

Table 4. Net value per ha for the different crops (USD)

User type		**Net value (USD per ha)**					
		Beans	**t-test**	**Maize**	**t-test**	**Rice**	**t-test**
Men	Users	362	t=1.72, p>0.1	3,199	t=2.75, p=0.1	2,136	t=3.83, p<0.1
	Non-user	71		1,039		1,384	
Women	Users	2,506	t=0.98, p>0.1	1,368	t=4.37, p=0.1	2,398	t=5.15, p=0.1
	Non-user	1,348		593		1,826	
Total	Users	1,220	t=1.45, p>0.1	2,467	t=2.92, p<0.05 *	2,241	t=5.60, p<0.05 *
	Non-user	582		860		1,561	

Note: 1 USD = RWF777.00

*p<0.05, **p<0.01

Assessment of economic benefits was cross checked through interviews with key informants. There appeared to be uniformity and agreement among the key informants regarding the benefits of Plantwise to the farmers in terms of increase in yield and income. Input dealers reported increased yield, income, knowledge and skills on pest and disease control, many pest and disease control options, quick access to specialized advice/services and farmers in the neighbourhood copying information from plant clinic users. Input dealers also argued that there is technical advice available to farmers on prevention and control of pests and diseases and reduced cost of pest and disease control. Community leaders also reported increase in knowledge about pests and diseases which in turns leads to reduction of crop failure.

Senior Agriculture Officers reported increased crop productivity, improving health of the crops, reducing the cost of agriculture activities through timely and efficient control of pests and diseases, reduction in poverty by increasing farm incomes and increasing the knowledge on good agriculture practices, prevention and control of pests and diseases. Plant doctor snoted reduced costs of pest and disease control (pesticide cost reduced), capacity building by providing information, increasing yield of crops, correct pests and disease management practices and readily available information about pests and diseases. There is increased income from improved crop yield and reduced cost of control.

“Plant clinics bring benefits to both farmers and local authorities. Thanks to the increase in production farmers can easily access health insurance and pay fee schools. The benefits are also spread to agro-dealers that have increased their income from the increased sales of inputs to farmers thanks to plant clinics advice.” -

Umulisa Marie Claire – Executive secretary of sector –Bugesera

"Consumers are benefiting since prices are reduced (as result of increased production), government is benefiting since it is easier for farmers to pay taxes, farmers are benefiting since their production increases, their income increases, they can manage to pay for health insurance."

Munezero Jean - Agro dealer –Ngororero

Household asset

In the following diagrams, we summarize the implications on welfare by farmers for not implementing pests and diseases control in their farm. Farmers attributed decisions associated with use of information to low crop yield as the main factor followed by the need for income to be used to address other household needs.

Women users

For women users, lack of food was a major factor that influenced whether or not decisions were made with respect to control of pests and diseases (Fig. 3). Further discussions revealed that lack of school fees, lack of health insurance as well as lack of household materials and domestic animals also influenced the decision making process. From the women's point of view food security was a critical factor that guided the need to control pests and diseases, which lowered yield that would be used for food and income generation.

Women noted that due to lack of food they could not do anything that demanded human power and as a consequence there was conflict in the family. Without money for paying fees the children do not go to school meaning that there is no hope for a better future and success in the family. Without farm income there are no livestock and hence no organic manure which is expected to lead to high crop productivity. Due to lack of health insurance the hospital costs were prohibitively high. Similarly when there is no money in the family problems cannot be solved in a peaceful way and as a consequence conflicts erupt in the families.

Women non-users

Women that did not use plant clinics also agreed that lack of food was key factor in influencing any decisions taken with respect to crop pest and disease control (Fig. 4). This was also explained by lack of health insurance and lack of school fees. The other factors that were attributed to low crop productivity and hence low farm incomes were family conflicts, malnutrition of the children and lack of household assets.

More specifically the women non-users of the plant clinics, who were involved in maize production reported:

- Lack of food: Farmers reported that they could not do anything without eating. Without food it was not possible to cultivate. It was also not possible to take children to school without eating.
- Lack of school fees: No good future for children and their families because they cannot contribute to the country's development
- Lack of health insurance: when you don't have health insurance the cost of medicine is very high which leads to the worries of going to the hospital
- Family conflicts: if there is no cash, the communication becomes so bad and the children may leave their home
- Lack of household materials like clothes, soap, body lotion, pads, telephones, handbags without them you can't cook food; wash your body and clothes.

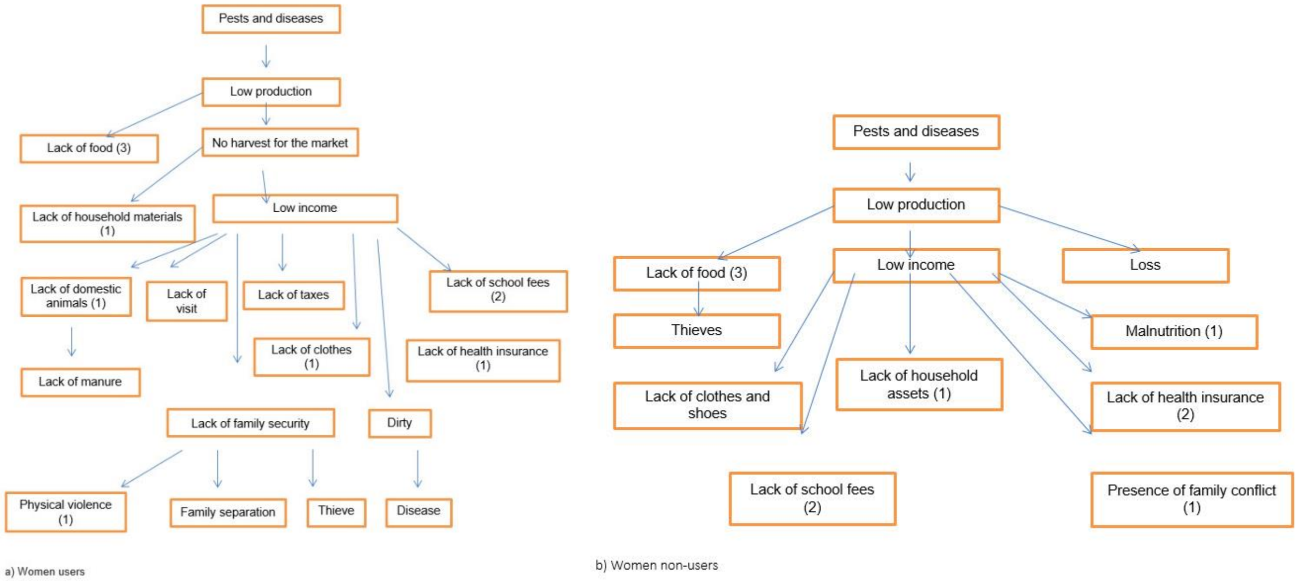


Figure 4. Causal diagram for women users and non-users of plant clinics.

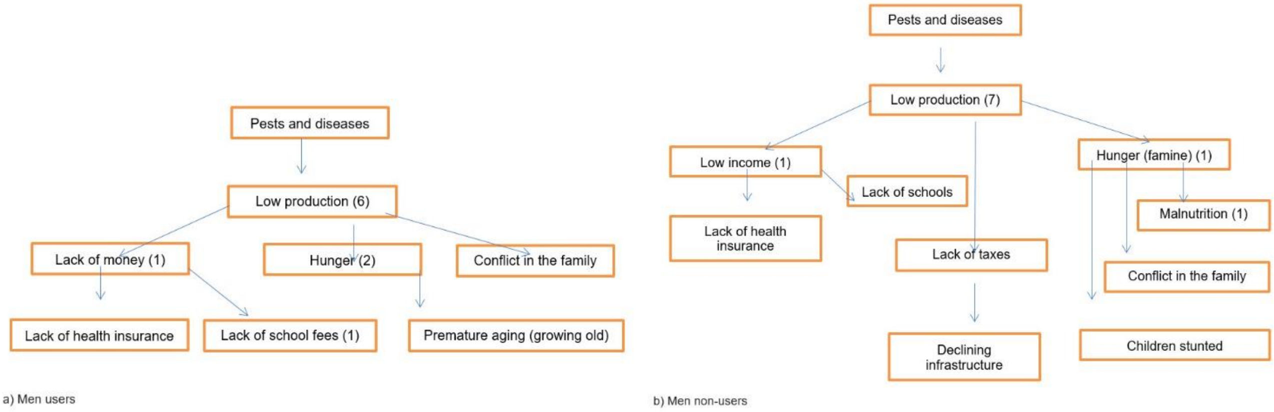


Figure 5. Causal diagram for men users and non-users of plant clinics.

Men users

Men users of plant clinics that were involved in maize production reported that the major factor that influenced their decision to control pests and diseases was low crop yields as a result of pest and disease attack on crops (Fig. 5). Low crop production led to hunger (food shortage) and lack of money to be used to address household needs. It emerged men controlled pests and diseases to increase crop yield and hence farm incomes that could be used for other household needs.

The men further argued that when there was no money then the consequence would be lack of school fees, hunger and low production. Farmers noted that low production was the main cause of the need for action against pests and diseases. They stated that it was pests and diseases that cause low production that is the main cause of almost all farmers' problems. This is because when there is low production farmers are unable to feed their children who as a result get malnourished and also get sick from different diseases.

Men non-users

Men non-plant clinic users also argued that the key factor that influences their decisions with respect to pest and disease control was low production that led to low incomes (Fig. 6). In this respect both plant clinic users and non-users agreed on the need to increase productivity in order to increase crop incomes. They also argued that as a result of low production there was lack of food self-sufficiency.

Insights from key informants on the impact of plant clinics

Assessment of the impact of plant clinics was cross checked through interview with key informants. It was noted that the provision of information on pest and disease control leads to reduction in pest and disease infestation levels, which in turn leads to an increase in production. Plant clinics also provides information on surveillance hence timely control leading to low expenditure on pest and disease control and provide promotion of reduction in the use of pesticides which leads to reduction in costs of production.

Capacity building was also indicated as another important impact reached by plant clinics, by increasing the awareness of farmers and their capacity to recognise and handle pests and diseases.

According with key informants, there is margin to improve the impact of plant clinics by:

- increasing the number of days for clinic operations;
- working with farmer promoters;
- increasing facilities and/or equipment;
- starting new clinics in villages (areas) that have no clinics;
- develop ways for involving women that increase access to plant clinics, such as create sensitization and do training on complementarity between man and women.

Sources of information on pests and diseases for farmers

The sources of information for crop pests and diseases management for farmers are summarized in Fig. 6. The graphic shows an unbalanced access to sources of information for men and women, with women obtaining information in general more from the network of friends and family members than directly from agro-dealers, extension officers, books/pamphlets and farmers promoters. These last ones actually seem to be prerogative of men users and non-users of clinics.

Men seem to have access to all sources of information, with agro dealers as the source that is more accessed by users of plant clinics with respect to non-users. This could be also explained by the fact that plant clinics give farmers indications about inputs to use and provide a prescription that they can show to agro-dealers. In this way farmers feel more confident in accessing agro-dealers shops and buying products from them. In addition, whenever farmers raise questions about pests and diseases issues, agro dealers refer them to the plant doctors for specialized advice. Agro-dealers also are able to look for the recommended pesticides prescribed by plant doctors that are not available locally or in their shops and make these available to farmers.

In Rwanda there is also an extensive network of extension officers (see section ‘Additional insights from discussions with key informants’) which work in collaboration with RAB and MINAGRI and they are widely accessed by farmers users and non-users of clinics. Often extension officers, even if not directly trained as plant doctors, consult plant doctors to gather the information they need. In this sense there is a kind of indirect spillover effect with information provided by plant doctors.

NGOs are informing predominately men clinic users, followed by women non-users of clinics. NGOs reported by farmers as useful in terms of providing information about how to manage crop pests and diseases included CEFAPEK and TUBURA. Another initiative that delivers information to farmers is IFDC. However, the information provided is more general and less focused on specifically addressing crop pests and diseases.

Radio also has good reach with farmers, with men gathering agricultural information from this source more than women. This might be also due to the control that men might have within the household over this asset.

With respect to radio, some women users reported: "*I listen to Huguka radio, in its programme of cassava disease and how to control it*" and "*I listen to radio Raia Rwanda talking about crop management, but I have already used the practices and control measures advices"; the radio only reminds me*".

Farmers' promoters (see section 'Additional insights from discussions with key informants') are also indicated as a source of information by farmers, with one men declaring to access this source. Farmer field schools (FFS) are also providing information to farmers but more on a general basis on good agronomic practices.

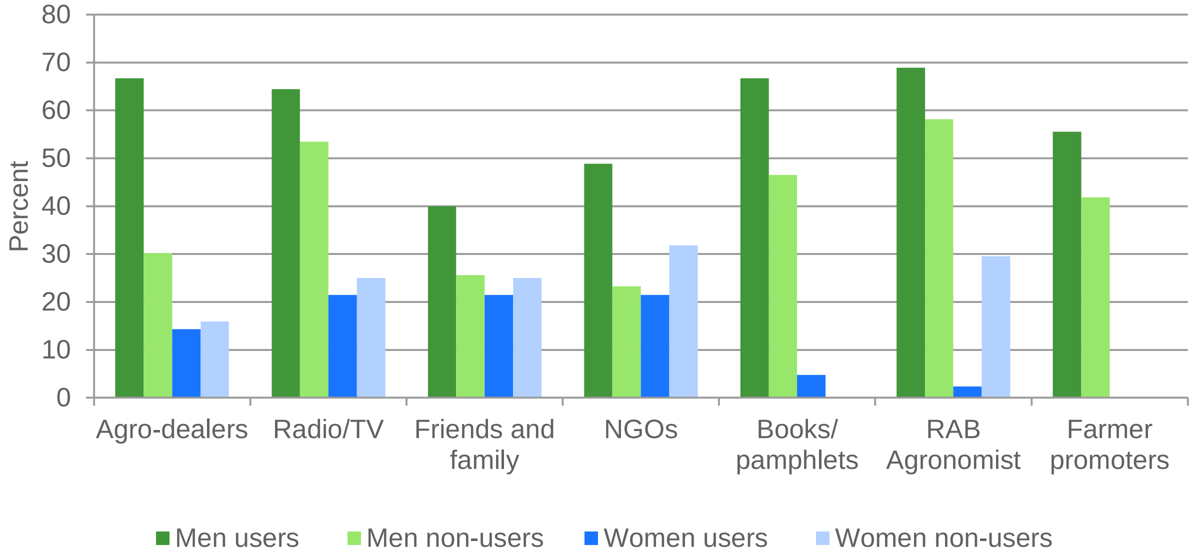


Figure 6. Percentage of farmers reporting use of different sources of information

Additional insights from discussions with key informants

Table 5 shows a summary of the numbers of key informants interviewed for each category.

Table 5. Number of key informants interviewed across the three study sites.

Category of key Informant	District			Total no. per category
	Bugesera	Huye	Ngororero	
Community Leader	1	1	-	2
Input Dealer	1	1	1	3
Plant Doctor	1	1	1	3
Senior Agricultural Officer	1	1	1	3
Total respondents	4	4	3	11

In Fig. 7 we report the organogram of the extension service in Bugesera Sector. Although this organogram is specific for Bugesera district a similar structure can be found across other districts where Plantwise has trained the main agronomist of the sector. In fact RAB and MINAGRI organize farmers promoters and farmers facilitators respectively, to provide support to farmers on crop management.

Each sector is composed of cells and each one of the cells is represented by one agronomist and one socio-economist. One of the cells is managing the entire sector. The agronomist of the cell managing the entire sector has been trained by PW. The agronomists in the other cells refer to the main agronomist in case of need. The cells are composed of villages and each village was represented by both farmer promoters and farmers facilitators.

Key informants were asked about the sustainability of the PW program from the point of view of governmental support. The Rwandan government has started a program called Kwigira (‘take care of you’) which could allocate some inputs, for example give free fertilizer, making a credit and when the farmer has gained some money from the sale of the crops he can pay back the credit received. The move towards sustained government support could be through raising awareness about the importance of Plantwise at the national level. There are already efforts by the government to incorporate Plantwise activities in other agriculture activities and also to initiate new plant clinics. However no clear policy options exist to ensure continuity. Other options are the use of existing clubs to run plant clinics with minimum government support. Plant doctors envisage a situation where arrangements are made for the farmers to pay part of the allowances for the plant doctors and at the same time PW activities need to be aligned with similar activities in the government. In addition, there is need for collaboration with NGOs in the same sector. The plant doctor view is in line with the current thrust to have diagnostic clinics to help address difficult cases.

All the key informants are of the view that government support is necessary to assure continuity of the benefits and institutions under Plantwise. There appear to be divergent views on private-public-partnerships. This is attributed to the fact that the private sector is for profit. The general understanding therefore is that involvement of different sectors and actors would be critical for continuity and by implication sustainability.

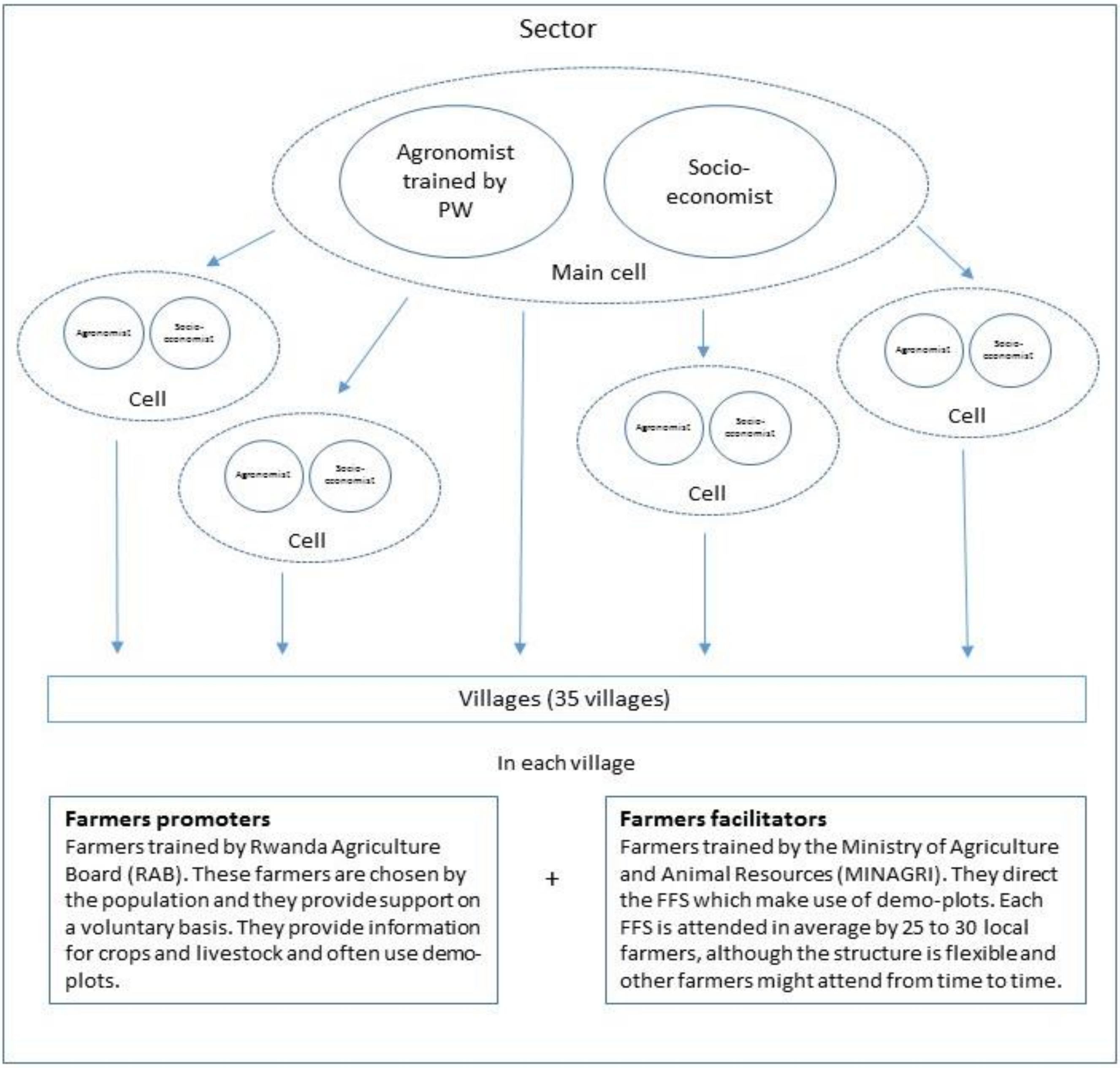


Figure 7. Locally managed agricultural extension in Bugesera District, Rwanda.

Findings for Ghana

At the time of the study, in 2016, there were 99 plant clinics in Ghana. We report the results from the focus groups discussions with farmers users and non-users and with the key informants.

Impact on human capital

Indicator of knowledge/skills

This section focuses on diseases for maize and groundnut. In general, we observed a different capacity of recognizing signs of pests and diseases between users and non-users, with reduced awareness in non-users.

Different level of awareness and capacity to recognise signs of for example of maize steam borer and to identify appropriate interventions was found in both men and women users in Tano South.

The community of women non-users in Tano South mentioned that they do not have many problems with pests and diseases. However, when asked whether they have seen signs such as yellow and green streaks on the leaves in maize, which indicate presence of maize streak virus, farmers declared they thought these signs were due to excess of exposure to sun. Similarly, they could not associate the presence of brown leaves, holes in the plant and discoloured grains with a disease, but rather with some general weakness of the plant. As a consequence of that there was no intervention done for maize stem borer, and maize streak borer for example.

The men in this community were able to recognize the presence of holes in the plant of maize as a sign of presence of a diseases (stem borer), but half of them did not know what kind of intervention to implement. Similarly to women, the yellowing of the maize was thought to be due to drought and not to a disease.

Men and women users in Techiman Municipal could recognize the various phases of the maize steam borer. They could associate the presence of strips on the leaves of maize with the presence of a disease and admitted that before consulting plant doctors, they used to confuse the strips with the excess of exposure to sun.

Men and women non-users located in Techiman Municipal could associate yellow strips on the leaves of maize with the presence of a disease (maize streak) but could not identify the type of disease precisely and therefore were not doing anything. Non-users could recognize symptoms of maize stem borer but apart from cutting down the plant and in few cases spraying, they did know what else to do.

In Kintampo both communities of users and non-users, women and men, presented the knowledge of the signs of maize steam borer, maize streak and groundnut rosette.

Indicator of decision making

We compared the capacity of users and non-users in justifying practices implemented to address pests and diseases. A summary of the reasons provided for implementation is showed in Table 6.

Farmers users have more informed decisions when implementing an intervention and in general are able to articulate the rationale behind their choices. For practices such as use of neem, early planting, time of weeding, the reason behind the lack of implementation by non-users farmers is essentially explained by the lack of knowledge that these practices can be used for pest and disease control.

Table 6. Adoption and decision making by plant clinic users and non-users (%).

Crop	Pest/disease	Intervention	Clinic users (CU)	Clinic non-users (CNU)	Reasons for implementation
Maize	Maize steam borer	Uprooting	√	√	Affected plants are removed and burned (CU) Affected plants are thrown away (CNU)
		Spraying chemicals	√	√	Apply in the morning when the plant pores (stomata) are open for maximum absorption (CU)
		Spraying neem	√	Not applied	It is produced locally and it is cheap (CU)
		Plant resistant varieties	√	Not applied	Not provided
		Early planting	√	Not applied	This would have been a valuable option but rains are not reliable (CU)
Groundnut	Groundnut rosette virus	Uprooting	√	√	Removal of infected plants to avoid re-infestation and destruction (CU, CNU)
		Spraying chemicals	√	√	It is the most effective method (CU, CNU)
		Weeding	√	Not applied	Time of weeding: weeding is not done after the rain (CU)
		Crop rotation	Not applied	√	When rotated with maize the plant becomes more resistant (CNU)
Cowpea	*Aphids*	Spraying neem	√	Not applied	Spray in the morning when the insects are available (CU)
		Spraying chemicals	√	√	Some farmers declare to use also the pesticide they use for cashew (CNU)
		Use of hermetic bags	√	√	Use of three layers of hermetic bags.
		Storage with chemicals	√	Not applied	It allows to keep the cowpea immune from pests and diseases (CU)
Cocoa	Capsid	Spraying chemicals	√	√	Insects are killed (CU, NCU)
		Hand picking	√	Not applied	Insects are removed from the plant (CU)
		Weeding	Not applied	√	Not provided
		Pruning	Not applied	√	Applied but not with the intention of manage pests (CNU)

Impact on financial capital

Indicator of productivity

Productivity was assessed for groundnuts, cowpea and maize. In figure 8 we show the comparison of the yields produced by men, women users and non-users and aggregated results for clinic users and non-users. For cowpea and groundnuts, yield of non-users are higher than the yield of users and the difference is statistically significant for yield of cowpea grown by men. Yield of maize are higher for both men and women users than non-users but this difference is not statistically significant. Overall, non-users perform better for groundnut and cowpea, whilst users perform better for maize. A possible explanation for this might be the fact that whilst cowpea and groundnut diseases are relatively well recognized and addressed by both users and non-users, maize related diseases are more difficult to identify for non-users of clinics and therefore it is more challenging for non-users to know what intervention to apply. This in turn might translate in reduced interventions and crop failure.

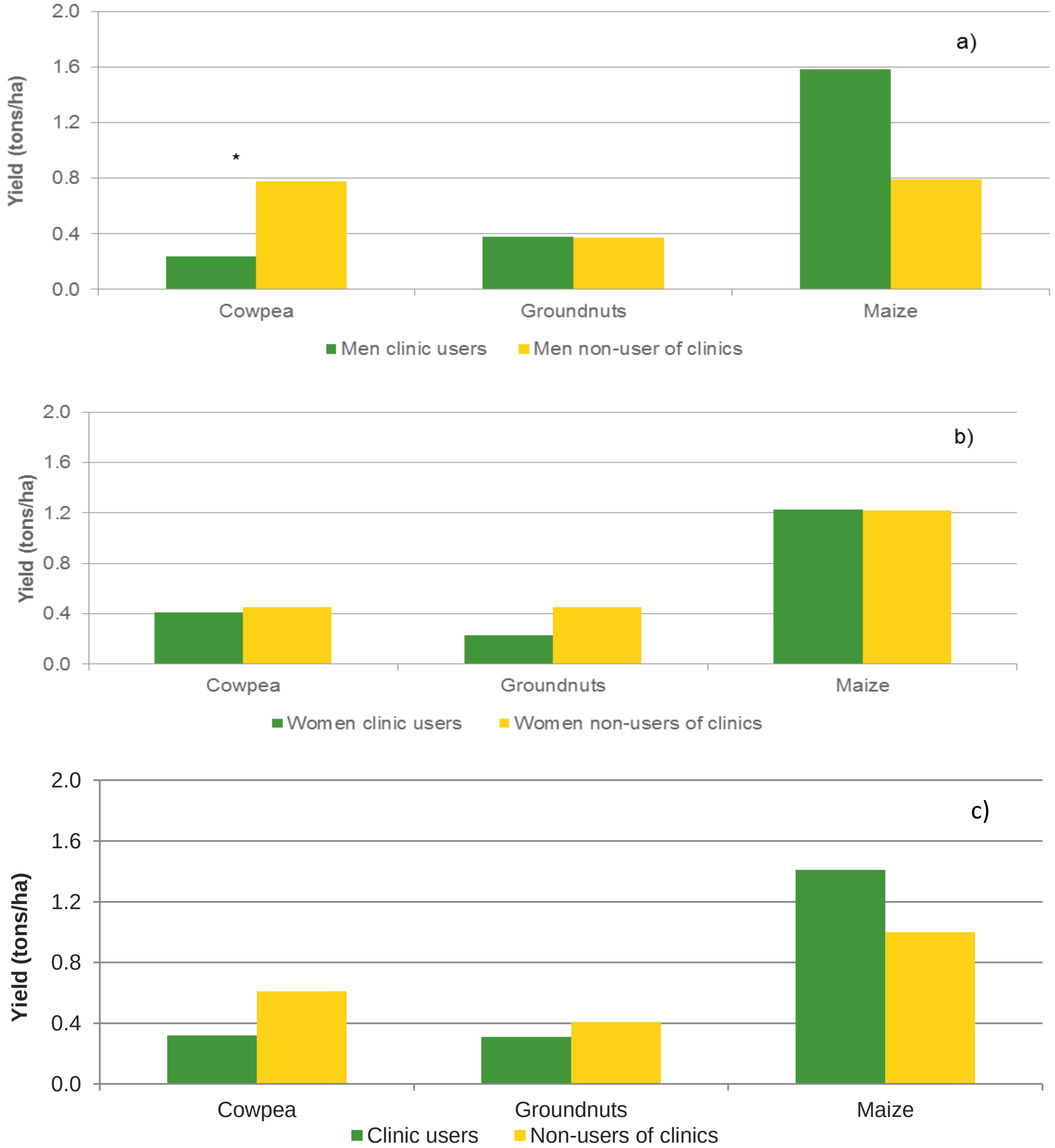


Figure 8. Comparison of yield of cowpea, groundnuts and maize for (a) men users and non-users of clinics, (b) women users and non-users of clinics, (c) users and non-users of clinics. *p<0.05

Indicator of adoption

In Table 6 we compared adoption of management interventions for crop pests and diseases control by users and non-users of plant clinics.

One pest/disease for each crop is listed together with the practices in place to manage it and the associated rationale for implementation. One of the practice that seem to be in place exclusively with clinic users is the application of integrated pest management (IPM) with the use of natural insecticide, neem, which is extracted from the leaves of the neem tree, *Azadirachta indica*. This practice is applied for treatment of maize stem borer and aphids on cowpea. Another main difference between users and non-users is the lack of adoption for by non-users of early planting and the use of resistant varieties. Early weeding also is applied by users for the treatment of rosette in groundnut.

From the consultation with the key informants, the use of natural insecticide, together with certified seeds, early weed control, use of low cost technologies, such as ashes, have been introduced by farmers, or their application has increased after consultation with plant clinics. Farmers have learned how to correctly implement seed selection and not to plant seed if they are not healthy. They have also learned to apply timely planting together with correct spacing and row planting.

When asked about practices that farmers have dismissed, key informants mention that farmers were using pesticides and insecticides indiscriminately, but after consultation they became more aware of what to use and how to use it, especially with respect to the quantity of water needed to be used with pesticide. Farmers have learned to apply non-chemical control in the nurseries and to sterilize the nurseries using hot water and fire without recurring to the use of pesticide.

Users have also stopping applying products designed for a certain crop on other vegetables (whilst we found that some non-users were applying for example cocoa products on vegetables)., Farmers are now using protective gloves and have learned the correct time for spraying of pesticides. They have learned to introduce crop rotation and to remove sick plants and burn and bury them. When looking at the treatment for maize steam borer, some of the non-users for example mentioned that they cut down the plant, but do not mention full removal of the plant through uprooting and subsequent burn and bury. When asked about interventions that farmers wanted to implement but did not, they mainly mentioned the wish to promptly control pests and diseases, but highlighted that this would require funds immediately available to buy inputs and proximity of points of sale for inputs.

Indicator of welfare

Income

The net value per ha was assessed for cowpea, groundnut and maize. The costs were derived from the following activities reported by the farmers: land preparation, planting, weeding, application of fertilizer, and harvesting.

Table 7. Net value per ha for the different crops (USD)

User type		**Net value (USD per ha)**					
		Cowpea	t-test	Groundnut	t-test	Maize	t-test
Men	Users	234.9	$t=4.66, p<0.05$	165.7	$t=2.13, p>0.1$	116.0	$t=1.30, p>0.1$
	Non-user	564.7		172.7		172.7	
Women	Users	409.6	$t=1.68, p>0.1$	163.0	$t=1.03, p>0.1$	138.1	$t=2.75, p>0.1$
	Non-user	249.4		297.9		373.8	
Total	Users	322.2	$t=0.70, p>0.1$	164.3	$t=1.62, p>0.1$	127.0	$t=2.45, p<0.1$
	Non-user	405.1		264.7		273.3	

Note: 1 USD = 3.94

In table 7 we report a comparison of the net value per ha between users and non-users of plant clinics for each of three crops analysed.

For all the three crops the net value per ha is higher for non-users than for users. Considering that yield of maize of users were higher than the ones of non-users (figure 8), this could be justified by higher input costs by farmers users.

Contributing toward higher yields and increase in income are some of the benefits of plant clinics listed by key informants. However, key informants reported that farmers use different types of pesticides and insecticides at the same time, even when not necessary, with the consequence of increasing the costs of production.

In figure 9 we show the results of a participatory budgeting exercise that was done with women non-users in Tano South. The same approach was used across the other communities to record time and costs of activities and inputs.

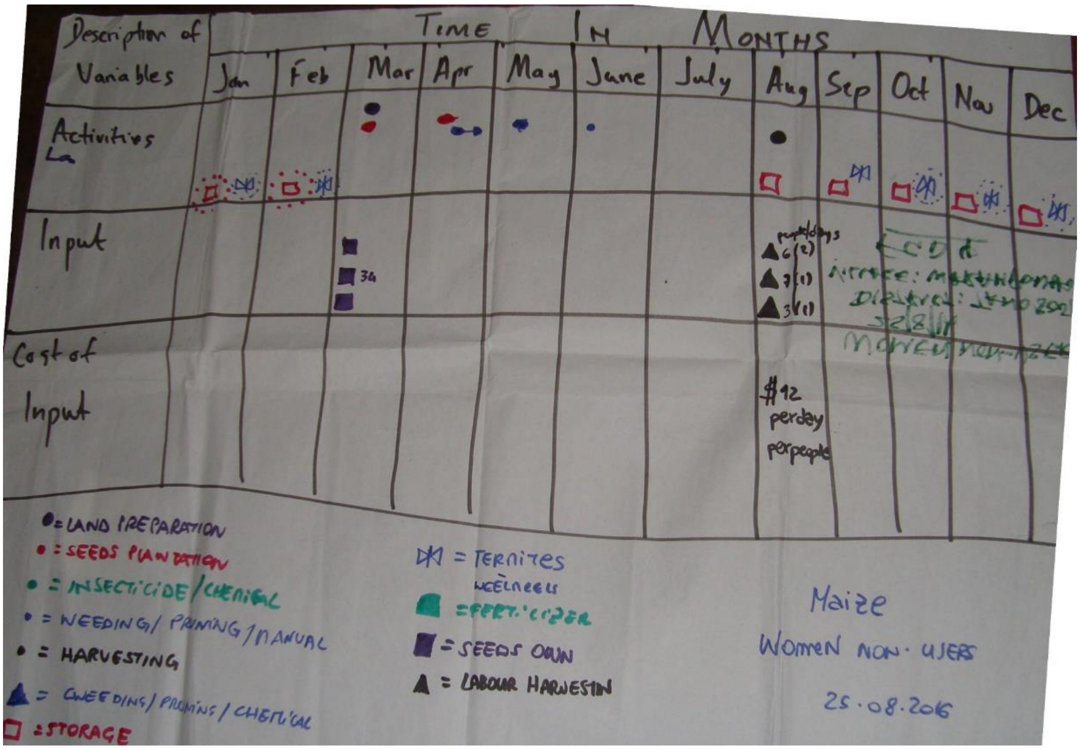


Figure 9. Participatory budgeting for maize for women non-users in Tano South.

Household asset

In figure 10 and 11 we present the results of the casual diagrams that show what farmers believe are implications on welfare for not implementing pest and disease control in their farm. Farmers believe that the main impact will be perceived at level of yield, which in turn will impact household income that can address other household needs.

Women said in general they cultivate different crops from men and can decide about the land they manage. They mentioned the impact on quality of the produce as a consequence of the lack of interventions on crops affected by pests and diseases. The impact on food security is also highlighted, although we found different dynamics within the different communities, with women in Techiman

Municipal for example, more prone to share what they harvest with other members of the community in case of crop failure.

There is awareness of the need to prevent pests and diseases to secure opportunities for reinvestment for the next cropping season, in terms of being able to secure seeds and therefore do not have to reduce the size of land for lack of material to plant.

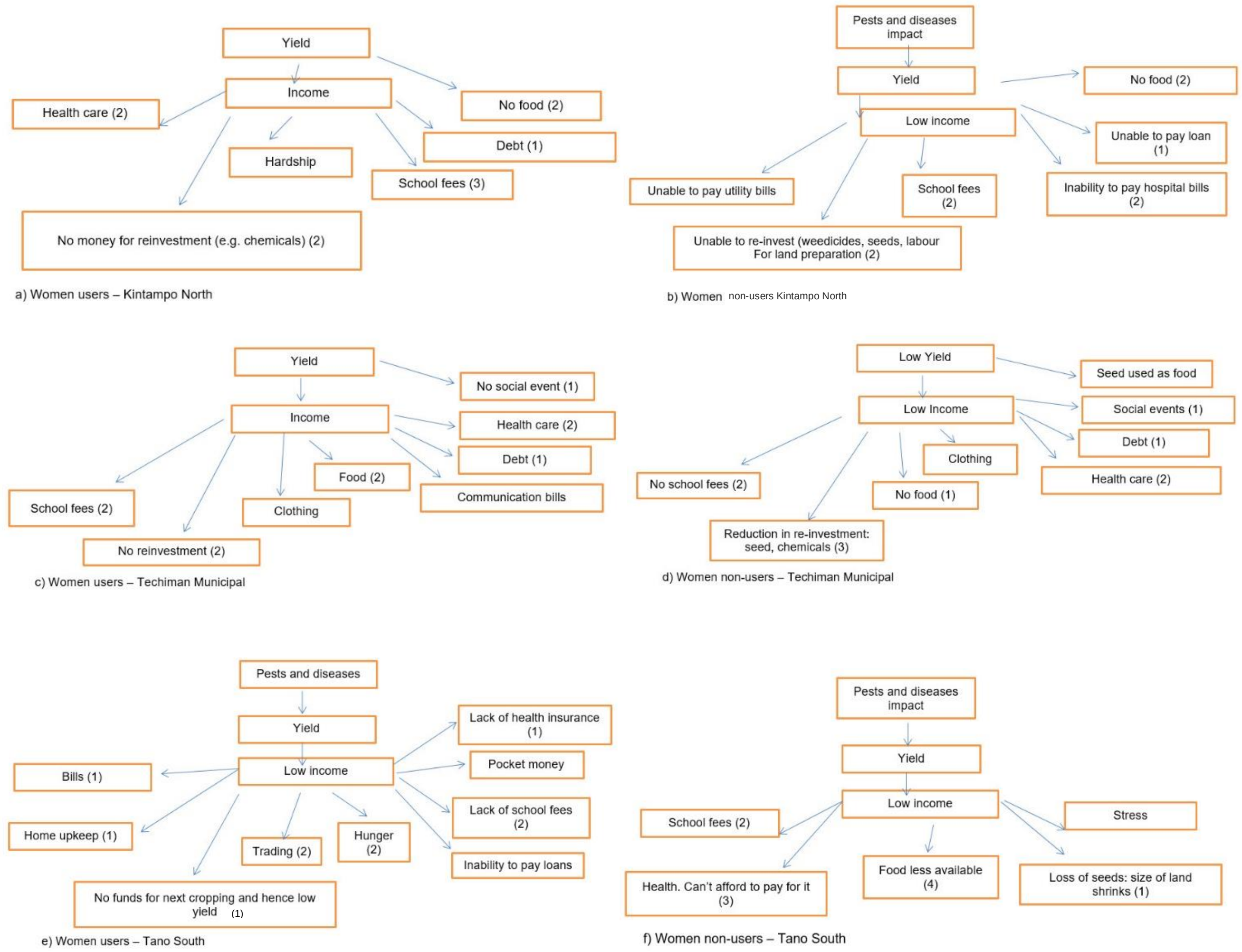


Figure 10. Causal diagram for women users and non-users: a) Kintampo North, users; b) Kintampo North, non-users; c) Techiman Municipal, users; d) Techiman Municipal, non-users; e) Tano South, users; f) Tano South, non-users.

For men particular emphasis was given to the need to be able to re-invest in purchase of seeds, insecticide, weedicide and land preparation to ensure high yields and secure the upcoming farming season. Purchasing inputs in advance is thought to enable farmers a prompt intervention in case of appearance of pests and diseases. Farmers also showed awareness that pests and diseases can lead to low quality of the product which in turn translates in low market value.

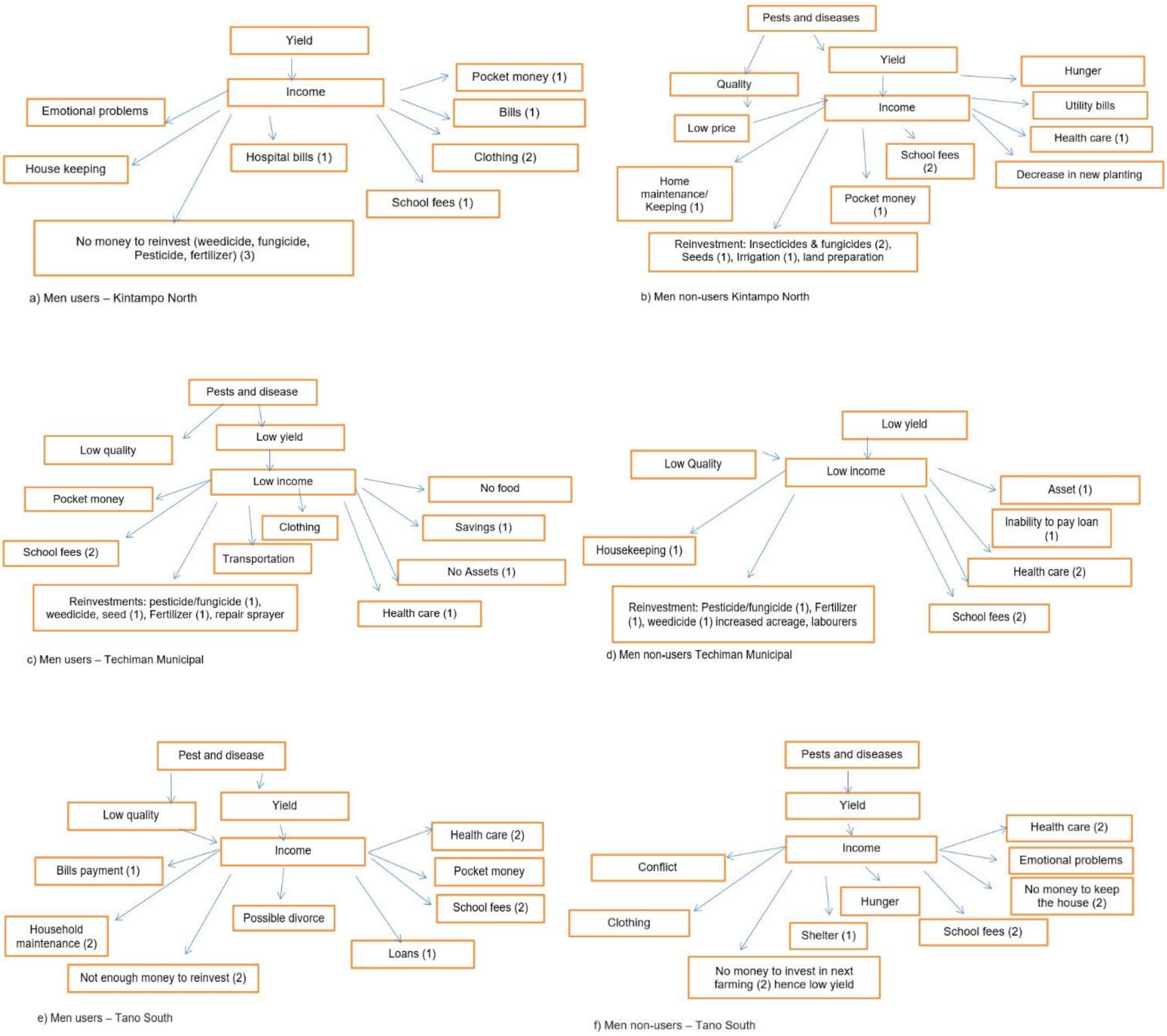


Figure 11. Causal diagram for men users and non-users. a) Kintampo North, users; b) Kintampo North, non-users; c) Techiman Municipal, users; d) Techiman Municipal, non-users; e) Tano South, users; f) Tano South, non-users.

Assessment of the impact of plant clinics was cross checked through interviews with key informants. It was noted that the provision of information on pest and disease control favours the production of more healthy crops. This is due to the fact that farmers learn the use of integrated pest management, and therefore reduce use of chemicals in favour of natural products.

Sources of information on pests and diseases for farmers

The sources of information for crop pests and diseases management for farmers are summarized in Fig. 12. The main difference that emerges is that most of the women, both users and non-users seem to seek agricultural information much less than men users and non-users.

NGOs are least used by farmers and they are not at all mentioned by women. The discussions with key informants highlighted the presence of different NGOs acting across the study areas. The main point is that NGOs members are usually introduced to the communities through plant doctors or through extension officers and therefore most of the farmers are not able to make a distinction. Most NGOs offer trainings and support for good agricultural practices, have small focus on pests and diseases, and often target one specific crop. This might be some of the reasons why they were mentioned by many farmers as a source of information for pests and diseases.

In Tano South the NGO CEFA is active in providing broad agricultural advice to farmers. In Kintampo North, key informants reported the presence of: Concern Universal that provides information on sorghum; AGRA that addresses cashew and mango and organizes trainings on good agricultural practice and provides seeds to farmers; the Crop Research Institute in Kumasi that works with farmers especially on promoting techniques related to yam. In Techiman Municipal GIZ carries out trainings at village level for maize through the use of demonstrations, and explains about good agricultural practices; they also address pests and diseases but not in detail.

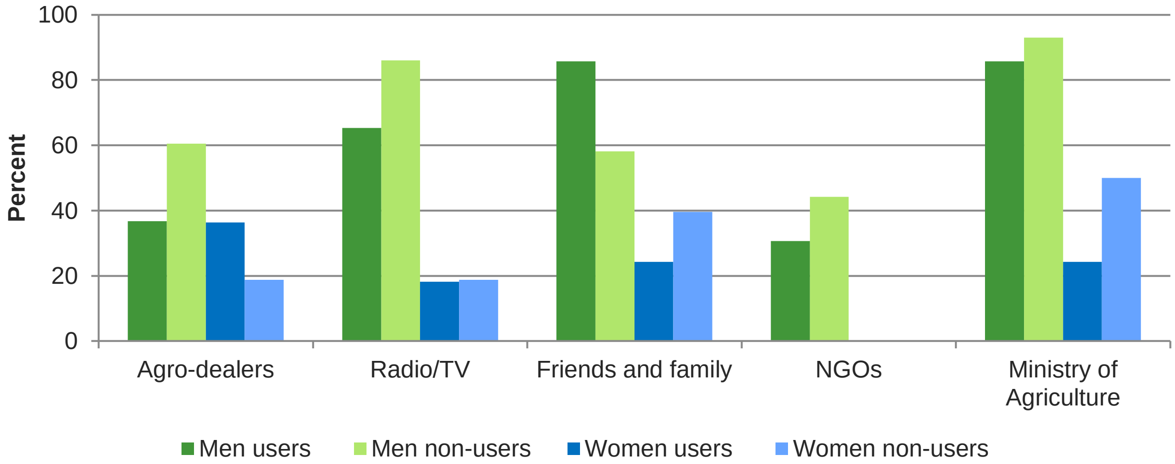


Figure 12. Percentage of farmers reporting use of different sources of information

Radio is used by more than 60% of male users and non-users and by less than 20% of women as a source of information for pests and diseases. This is most probably due to household dynamics on ownership and control over assets. Farmers listen to the radio to receive information about: seed selection, improved varieties, time of planting, use of fertilizer, and storage. Some radio programs target specific crops, such as the one promoted through 'Astar FM' that focuses on maize.

Agro-dealers are used mainly by men non-users and women users to get information on the use of inputs, type, timing and rates, in particular for pesticides.

The ministry of agriculture has agricultural extension officers that regularly visit farmers to provide advice on good agronomic practices. However, when planning a visit to the farmers, the agricultural officers inform them via sms. Women declared was that they have very limited use of the phone and are usually not informed by the husbands about an upcoming visit of the extension officers. This would explain why this source of information is low for both women users and non-users.

Friends and family are also listed as sources of information for pests and diseases, with major adopters among men users and women non-users. Knowledge spillovers among farmers was mentioned by key informants as one of the main benefits from the presence of plant clinics.

Conclusions

This study shows that farmers that use plant clinics have increased their awareness, knowledge and capacity to identify and manage pests and diseases with respect to non-users of plant clinics. In particular:

- Clinic users have better capacity to identify signs of pests and diseases and can provide a more detailed list of signs.
- Clinic users are more skilled in the identification of the appropriate interventions to address pests and diseases.
- In terms of adoption of practices, in both countries plant clinic users appeared to have a wide range of responses for decision making possibly due to greater access to more control options. Yet, clinic users have more informed decisions when implementing an intervention and in general are able to articulate the rationale behind their choices.
- Crop rotation, timely planting, use of resistant varieties are some of the practices that farmers have more regularly adopted after consultation with plant clinics in Rwanda. In Ghana, Integrated pest management in form of use of organic pesticide seems to be prerogative of clinic users, together with early planting, use of resistant varieties and time of weeding.
- Efficient use of pesticides, knowledge of pesticides and use of the right dosage of pesticides is declared by key informants to be have been largely improved by clinic users after consultation with clinics. Yet, clinic users have also reduced the use of pesticide in favour of use of non-chemicals, such as ashes and neem for example.
- For what concerns yields: in Rwanda the overall assessment of all clinic users and non-clinic users revealed that clinic users performed better with respect to productivity of rice, maize and beans. There was a statistically significant difference in the yield of maize and a highly significant difference in the yield of rice between users and non-users; in Ghana non-users perform better for groundnut and cowpea, whilst users perform better for maize.
- For what concerns the net value per ha: in Rwanda for maize and rice we found statistically significant differences between the net value per ha of clinic users vs clinic non-users, with the last ones that have lower net value per ha. No significant difference is recorded when looking at the performance of women and men separately; in Ghana for cowpea, groundnut and maize the net value per ha was higher for non-users than for users, however this difference was not statistically significant.

It was not possible to gather sufficient information for youth since their participation in the focus groups discussions was limited in general to one – three individuals per each focus group.

From a methodological point of view, with the use of qualitative methods we could capture the complexity of local dynamics behind differences between clinic users and non-users. However, additional research should be undertaken with quantitative methods to provide a more solid statistical basis for data collection and means of comparison between clinic users and non-users.

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Appendix 1. Focus Group Discussion Checklist

INTRODUCTION **(10 minutes)**

Greetings, introduction of the team and the project

Explanation of the program and participant list

Communities of users

Consent request (to be read by the facilitator): "*This focus group discussion (FGD) is conducted by CABI and its program Plantwise. The purpose of the FGD is to help us understand how farmers benefited or not from the information provided through the plant clinics. The information will be helpful in giving us information on adoption of the recommendations and what benefits farmers derived from it. The information will not be reported as individual, and thus will be fully anonymous, without identity revealed. Do you wish to continue with the FGD? __ 1=Yes 2=No".*

Communities of non-users

Consent request (to be read by the facilitator): "*This focus group discussion (FGD) is conducted by CABI. The purpose of the FGD is to help us understand how farmers manage their pest and diseases and make the way they make choices with respect to pest management. The information will not be reported as individual, and thus will be fully anonymous, without identity revealed. Do you wish to continue with the FGD? __ 1=Yes 2=No".*

1. Identification **(1 minute)**

1.1 Date of the FGD ---

1.2 Name of group ---

1.3 FGD gender composition (No. of men / women) --

1.4 Village name ---

1.5 District --

1.6 Names of the FGD facilitators ---

2. Livelihoods strategies **(45 minutes)**

2.1 What are the most important crops **grown in your farm** for household **consumption** (name up to 5 in the order of importance - record answers of youth and adult separately).

Crop name	How many people	Ranking

Why is the crop ranked 1 above considered very important for food consumption?

2.1.1 Ask about food preferences --

2.2 What are the most important crops **grown in your farm** for **sales** (name up to 5 in the order of importance - record answers of youth and adult separately)?

Crop name	How many people	Ranking

2.2.1 Why is the crop ranked no. 1 the most important crops for sale? (Record answers of youth and adult separately)

2.3 What are the crops that take most of the labour in your farm? (name up to 5 in the order of importance - record answers of youth and adult separately)?

Crop name	How many people	Ranking

2.3.1 Why is the crop ranked no. 1 taking most of the labour? (Record answers of youth and adult separately).

2.4 What are the crops that take most of the **space in your farms** (name up to 5 in the order of importance)? (Record response, if there are different responses coming out, record this).

Crop name	How many people	Ranking

2.4.1 Why is the crop ranked no. 1 taking most space?

2.5 For the two main crops, would you know what is the **area/space** that they occupy in your farm?

A record from three farmers is taken. Ensure youth answers are included. Once we ask one farmer what is the area for a crop we ask also for the production and price (Use table below).

2.6 For the two main crops, what was the average **production** per household (kg) for the last season (make sure you capture quantity for the last cropping season and have homogeneous units, for example if a farmers mentions he harvest a certain quantity per week, ask for how many weeks)? (use table below)

2.7 At what **price** do you manage to sell in the market these crops? (Rational is that preventive practices are expected to lead to higher quality and can therefore been sold at higher price) (Use table below).

Farmer no.	Crop 1	2.5 Area	2.5 Unit of Area (e.g. ha, m, etc.	2.6 Production	2.6 Unit of production (e.g. kg, tones, etc.)	2.7 Price per unit	2.7 Currency (e.g. US$, GHS, etc.)
1	-------------						
2	-------------						
3	-------------						

Farmer no.	Crop 2	2.5 Area	2.5 Unit of Area (e.g. ha, m, etc.	2.6 Production	2.6 Unit of production (e.g. kg, tones, etc.)	2.7 Price per unit	2.7 Currency (e.g. US$, GHS, etc.)
1	-------------						
2	-------------						
3	-------------						

(If there are differences in production per unit and or price per unit among the farmers ask farmers what they think is the reason for this. Record answer of youth and adult.

Section 3: Knowledge and skills (45 minutes)

3.1 Do you have or did you have in the past in your farm problems with pests and diseases for these crops ____________& ____________ (Record frequency of 'yes' and 'no' per each crops and record separately answers from youth and adult).

3.2. What are the signs of presence of pests and diseases in these crops ____________________& __________________________? Record each recognized signs, why they think it is due to pests and diseases and record frequency for each sign; record separately answers from youth & adult

Crops	**3.1 Pests/diseases**		**3.2 Signs of disease/pest**	**3.3 Interventions by farmers**
	yes	not		

3.3 What have you done in your farm to address pests and diseases for these crops -------------------?

Ask farmers: what they have done, how they have done it (e.g. if using spray, frequency of spraying, product used, where and what they were spraying), why they have done it (what was the rationale for doing it). If some of the recommendations are not mentioned, ask farmers if they have implemented them, how and why and record answers.

Crop	**Diagnosis**	**Recommendation type**	**Frequency Spontaneous answers**	**Frequency Non spontaneous answers**
Plantains	Black Sigatoka			
	Fusarium wilt			
Cassava	Cassava mosaic virus			
Mango	Fruits flies			
Tomatoes	Tomato mosaic			
	Tomato virus			
Maize	Maize stem borer			
	Maize streak virus			
Garden eggs	Insects			
	Caterpillars			
	Stem borers			
Cocoa	Black pod disease			
	Black pod of cocoa			
	Cocoa stem borer			
	Mirids			
	Stink bug			
	Termites			
Okro	Insects			
	Flea beetle			
	Aphids			
Oranges	Angular leaf spot			
	Fruit flies			
Rice	Brown spot			
	Rice yellow mottle virus			
	Termites			
Tomatoes	Late blight			
	Fusarium wilt			

3.4 Is there anything that you wanted to implement but did not? If so, what was this and what were the reasons for not implementing it (e.g. lack of money, far from places where to purchase input, etc.)? Record separate answers for youth and adults.

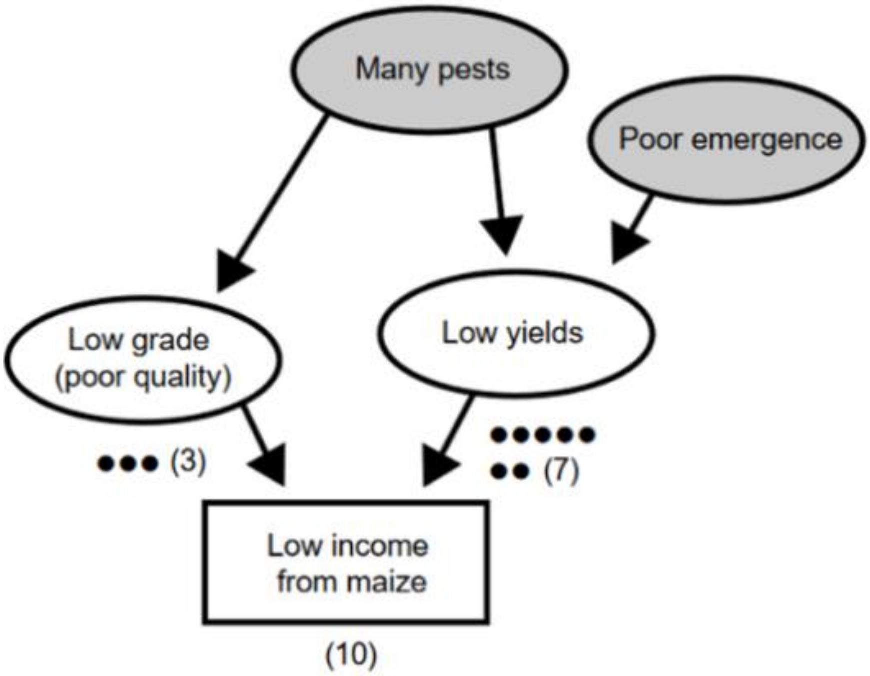
3.5 What are your main sources of information for the management of pest/diseases (plant clinics, radio, friend or family, NGO, agro-dealers, religious organizations, etc.). Ask also what type of information is received, with what modality, etc. (e.g. if radio, what programs, what contents, etc.; if NGO what NGO, what information, etc.). Record answers from farmers

Source of information	**Frequency**	**Explanation (type of information)**
plant clinics		
agro-dealers		
Radio		
religious organizations		
friend or family		
NGO		
Other (specify)_____________		

Section 4: Welfare **(45 minutes)**

4.1 If you changed some of your practices, what were your considerations for the change? Did you feel the quality of your product was changing? Your production was changing? And as result of your production, what else? Your income? The possibility of feeding the family, the possibility of paying fee schools? Create a tree of answers.

Once the tree of answer is ready, ask farmers we have now 10 (we decide this together) little rocks can you distribute them to show what of all you have listed as consequence of the lack of intervention is more and less important for you?



Section 5: Measurement of performances **(45 minutes)**

5.1 Can we reconstruct the activities you have done last season for this crop _______________.

Have you used any input (inputs are for example seeds and fertilizer)? Would you recall how much of it did you use? Would you recall how much did it cost you? In which month did you plant? And when did you harvest? Did you do any other activity in between?

Description of variables	**Time in months**											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Activities												
Inputs												
Cost of inputs												
Outputs	Already recorded with the first questions.											
Value of output	Derived this once the FGD is finished, by using price declared in the first questions.											
Cash Balance/ profits	Derive this once FGDs is finished, using price declared in first questions & costs declared here.											

Appendix 2. Key Informants Interview Checklist

Consent request: To be read by the enumerator

"This survey is conducted by CABI Africa. The survey is to study farm level outcomes and impact of Plantwise in Rwanda. This is in order to understand the changes in livelihood and welfare of the farmers attributable to Plantwise program with special reference to plant clinics and plant health rallies. The study will generate information to facilitate improvement of the expected benefits form Plantwise program in the target countries. The information will not be reported as specific to organizations and thus will be fully anonymous, with no individual identity revealed. Do you wish to continue with the interview? _1_ 1=Yes 2=No"

Section 1: Identification

Country --------------------------------------- Zone/Province/County ---

District --- Administrative post /Sector ---

Name of plant clinic if applicable --

Date of interview: --

Name of the KII (respondent): --

Name of organization/institution represented: --

Position/role in the institution/organization: ---

Education level of the respondent:--

Gender of the respondent ---

Tel. No (*if willing to*): ------------------------------ Email address (*if willing to*): ---------------------------------

N.	Questions	PD	SAO	CL	ID
1	How do you work/collaborate with Plantwise	x	x	x	x
Section 2: Causality and contextual influences of PW program					
2	Are you aware of other initiatives similar to PW? If so, could you list them?	x	x	x	x
3	In what ways PW complements these initiatives?	x	x	x	x
4	What would you consider as added value of Plantwise with respect to other initiatives/what is PW adding to other initiatives?	x	x	x	x
5	To what extent are plant clinics benefiting your sector?	x	x	x	x
6	How has the plant health training /information materials impacted pest information and control?				
Section 3: Indicators of outcome and impact of Plantwise program					
6	Who/what are beneficiaries of PW? Please list.	x	x	x	x
7	Can you list in order of importance up to 5 benefits of PW for farmers? (impact indicators)	x	x	x	x
8	How is PW contributing to the change of the mentioned impact indicators for farmers?	x	x	x	x

Section 4: Utilization of information					
9	What information provided by PW to farmers do you think is more useful?	**x**	**x**	**x**	**x**
10	What do you think are the most implemented practices by farmers as result of the consultation with plant doctors (example: use of resistant varieties, rotation, spacing, rogueing and burning, timely planting, solarisation, early ploughing, nutrient management and other cultural methods)?	**x**	**x**	**x**	**x**
11	What do you think are practices that farmers have dismissed as result of the consultation with plant doctors?	**x**	**x**	**x**	**x**
12	How have you used the Plantwise online management system (POMS)?				
Section 5: Sustainability of PW program					
	What is the usefulness of plant clinics for the government (how strategic PW is)?	**x**	**x**		
	What is the usefulness of plant clinic data in the government operations (how strategic PW is)?		**x**		
	How can the performance of the Plantwise approach be improved (opportunities)?	**x**	**x**	**x**	**x**
	Is the government able to pay the costs currently catered for by CABI? 1=yes, 2=no ----		**x**		
	How can the institutions supported through the Plantwise programs and the benefits realized be maintained and continue after the end of the program? ----------------------------------		**x**		
PD: Plant doctors SAO: Senior agricultural officers CL: Community leaders ID: Input dealers					

contact CABI

europe

CABI Head Office
Nosworthy Way, Wallingford, Oxfordshire, OX10 8DE, UK
T: +44 (0)1491 832111

CABI
Bakeham Lane, Egham, Surrey, TW20 9TY, UK
T: +44 (0)1491 829080

CABI
Rue des Grillons 1, CH-2800 Delémont, SWITZERLAND
T: +41 (0)32 4214870

asia

CABI
C/o Internal Post Box 56, Chinese Academy of Agricultural Sciences,
12 Zhongguancun Nandajie, Beijing 100081, CHINA
T: +86 (0)10 82105692

CABI
2nd Floor, CG Block, NASC Complex, DP Shastri Marg, Opp. Todapur Village,
PUSA, New Delhi – 110012, INDIA
T: +91 (0)11 25841906

CABI
PO Box 210, 43400 UPM Serdang, Selangor, MALAYSIA
T: +60 (0)3 89432921

CABI
Opposite 1-A, Data Gunj Baksh Road, Satellite Town, PO Box 8, Rawalpindi-PAKISTAN
T: +92 (0)51 9290132

africa

CABI
CSIR Campus, No. 6 Agostino Neto Road, Airport Residential Area, PO Box CT 8630, Cantonments Accra, GHANA
T: +233 (0)302 797202

CABI
Canary Bird, 673 Limuru Road, Muthaiga, PO Box 633-00621, Nairobi, KENYA
T: +254 (0)20 227 1000/20

americas

CABI
UNESP- Fazenda Experimental Lageado, Rua: José Barbosa de Barros, 1780
Botucatu – SP, CEP: 18610-307, BRAZIL
T: (14) 3882 - 6300 / 3811 - 7127

CABI
Gordon Street, Curepe, TRINIDAD AND TOBAGO
T: +1 868 6457628

CABI
875 Massachusetts Avenue, 7th Floor, Cambridge, MA 02139, USA
T: +1 617 3954051