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# **Evaluation of Plantwise–Kenya: Baseline Report *Executive Summary***

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## Contributors

The evaluation of Plantwise–Kenya is being conducted by American Institutes for Research (AIR) for CABI. The Principal Investigators for the overall evaluation are Juan Bonilla (AIR) and Paul Winters (American University). The overall team leaders of this report are Juan Bonilla (AIR), Andrea Coombes (AIR), and Paul Winters (American University), but many others made important contributions and are listed below in alphabetical order:

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## **Background, Study Design and Objective**

Plantwise is a global initiative that provides smallholder farmers with information on crop health maintenance. Plantwise began working in Kenya in 2010 to gather, organize, manage, and disseminate plant health information to smallholder farmers. Plantwise–Kenya (PW-K) is implemented through three interconnected activities. First, PW-K engages key stakeholders such as the Ministry of Agriculture, extension programs, researchers, input suppliers, and regulators to fortify plant health systems through encouraging collaboration and coordination of activities. Second, a “Knowledge Bank” database serves as a repository for plant health information that assists with monitoring pests and diseases, promotes strategies for climate change adaptation, and facilitates international trade. Third, through PW-K farmers are able to access trained plant doctors through a network of locally run plant clinics. Plant clinics provide smallholder farmers with low-cost access to plant health information and diagnoses of plant health issues.

American Institutes for Research (AIR) is conducting a mixed-methods evaluation of PW-K in collaboration with American University and Research Solutions Africa. On the quantitative side, both primary data collection and the analysis of PW-K administrative data are used. The primary data collection includes a farm-level survey as well as a knowledge assessment of plant doctors. To measure the impacts of PW-K at the farm level, AIR designed a multi-site, longitudinal randomised controlled trial (RCT) in 13 counties in the country, relying on the plant clinic expansion plan that PW-K is implementing from 2014 to 2018. On the qualitative side, information is being collected at the national and local (county) level through both key informant interviews (KIIs) and focus group discussions (FGDs). Baseline data and two rounds of follow-up data (at 12 and 36 months) will be collected. The evaluation collected baseline data in 2014; this document reports on this baseline data collection and corresponding data analysis.

A key purpose of this document is to report on whether the baseline data collection was successful in terms of gathering adequate data, and to describe the data that were collected. Since PW-K has been in operation for four years, a second objective is to offer preliminary insights into the study’s research questions, including (i) whether PW-K induces plant health system change, (ii) whether the process used in implementation influences its effectiveness, (iii) whether PW-K improves the wellbeing of farmers, and (iv) whether the benefits of PW-K justify its costs.

## **Plantwise–Kenya Theory of Change and Current Thinking**

The activities of PW-K can be divided into three general categories: (i) institutional strengthening, (ii) the Knowledge Bank, and (iii) field activities. Institutional activities include various methods to provide support to and increase collaboration among participants in the plant health system. The Knowledge Bank is a free and open-access online database of locally relevant plant health information. The field component involves establishing and maintaining a network of plant clinics, which act as a physical interface between farmers and crop protection experts. The clinics are staffed by extension agents who work for the Ministry of Agriculture (MoA), but receive special training from PW-K to be plant doctors. As part of the field activities, plant doctors staffing plant clinics provide prescriptions to farmers that diagnose plant health issues and provide recommendations for responding to these issues. In this process, information on pests and diseases that farmers are confronting are collected and maintained in the Plantwise

Online Management System (POMS). POMS data feeds into the Knowledge Bank and provides insight into chronic and emerging pest issues.

These three interrelated PW-K activities are intended to have a set of initial effects that can be broadly categorized into (i) changes in the overall system for managing Kenya's plant health, and (ii) changes that result from farmers altering their behaviour as a consequence of the plant clinics and general system changes. Taken together, these changes on the part of stakeholders and farmers are hypothesised to lead to stronger institutions for managing crop protection, higher quantity and quality of production from farms, and greater income and food security for farmers. To evaluate these changes, the four questions noted above are considered.

The design of PW-K includes two innovations that are of particular interest in addressing plant health issues. First, the delivery of agricultural extension through plant clinics differs from the approaches that have been dominant in recent decades, such as training and visitation or farmer field school approaches, in that farmers go to see the extension agents at designated locations rather than vice versa. The focus is strictly on pest management issues and not broadly on agronomic practices, and farmers only go if they have a particular plant health issue they need to address. The financial costs of this approach are likely to be lower than alternatives, with the disadvantage that there may be missed opportunities in reaching farmers.

Second, by virtue of the data gathering at plant clinics that is entered into the POMS, PW-K is implementing a unique pest monitoring system that can potentially be incorporated into an area-wide system of pest management. The data provide a snap shot of emerging pest issues and the severity of existing pest problems, as well as which pests farmers are struggling to control. If combined with an area-wide eradication plan or with farm-level support, the system of data collection can enhance total pest population management.

## **Assessing the Counterfactual and Plant Clinic Context**

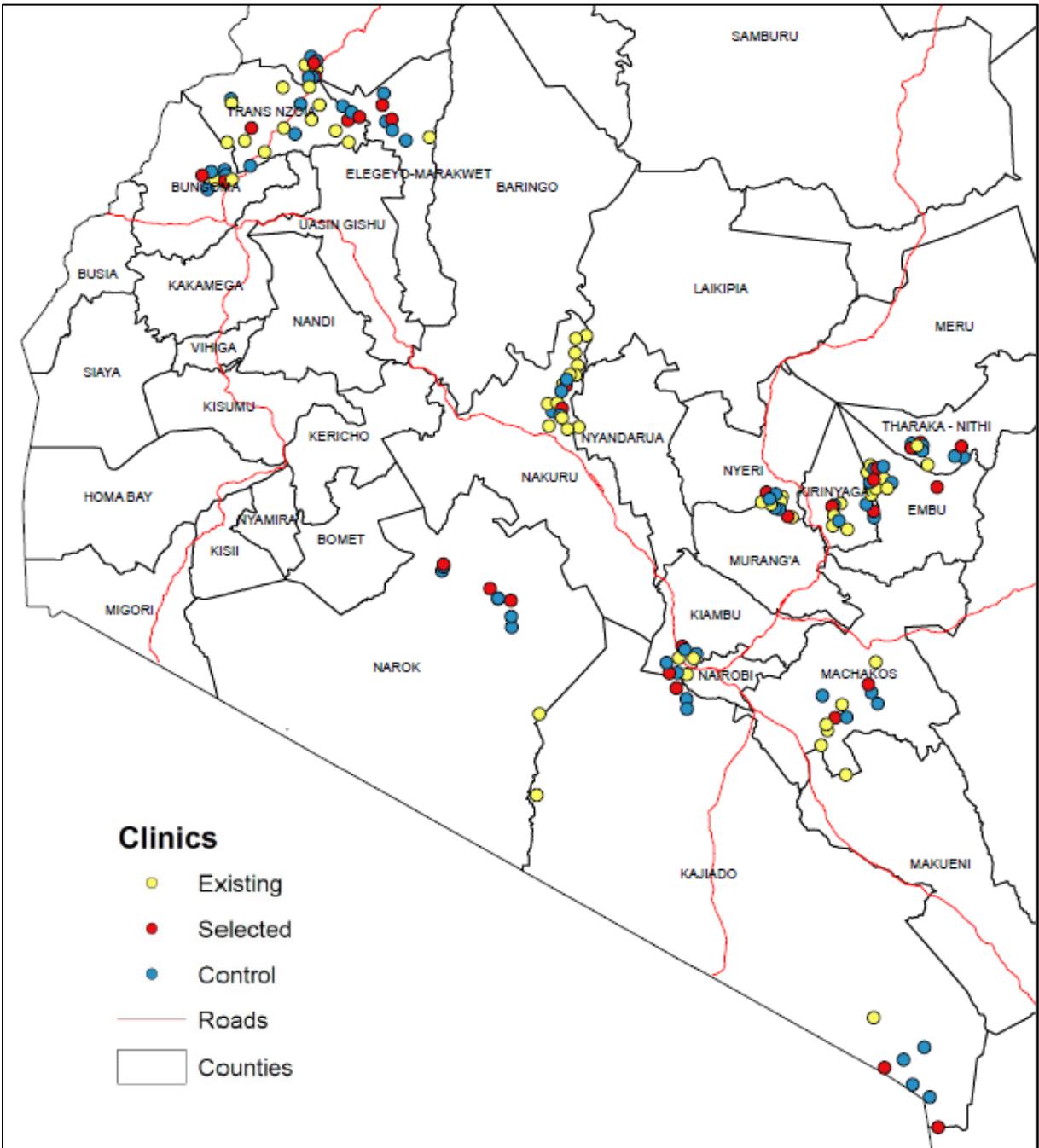
The analysis of the baseline data collection presented in the report point to a highly successful execution of the original evaluation design. The qualitative activities (KIIs and FGDs at the national and county levels) and quantitative activities (farm-level survey and plant doctor assessment) were successfully implemented and provided the anticipated data.

To measure the impacts of PW-K at the farm level, a randomised control trial (RCT) was designed to take advantage of the plant clinic expansion plan that PW-K is implementing from 2014 to 2018. To create the sample, 30 sets of three potential new plant clinic sites with similar characteristics were identified, for a total of 90 potential sites. From each set of three potential clinics, one site was randomly selected for inclusion in the programme starting in 2014, thus creating the initial 30 treatment sites and 60 comparison sites. Figure 1 shows a map of existing PW-K plant clinic sites along with the 30 initial treatment sites and 60 control sites. Additionally, the 59 existing clinic sites are noted.

The purpose of using an RCT is to create a reasonable counterfactual where the treatment and control groups are similar in terms of their observable and unobservable characteristics except that the treatment group received the programme, which allows straightforward assessments of impact. The effectiveness of an RCT in creating a reasonable counterfactual can be assessed by

determining whether the average characteristics of treatment and control groups are statistically equivalent at baseline.

**Figure 1. Location of Plantwise Clinics in Kenya**



Tables 1 and 2 present descriptive statistics for key household and crop variables as well as t-tests to compare treatment and control groups. For variables with p-values greater than 0.05, there is no statistically significant difference between treatment and control groups. Table 1

shows that the treatment and control groups are similar in their household characteristics, overall crop production, and their experience with farming in the last five years.

**Table 1. Assessment of Counterfactual with Selected Household Variables**

Variables	Control	Treatment	Balance Tests	
	Mean	Mean	Diff	p-value
<i>Household characteristics</i>				
Household size	4.05	4.14	0.10	0.56
Household head is male	0.81	0.80	-0.00	0.85
Household head age	46.60	46.61	0.03	0.98
Head education: primary	0.55	0.53	-0.02	0.60
Head education: secondary	0.36	0.38	0.01	0.61
Hours crop production: head	30.18	32.43	2.30	0.25
Years in farming	18.40	18.73	0.34	0.74
<i>Crop production</i>				
Area	2.25	2.23	-0.02	0.83
Crops produced	5.83	6.08	0.24	0.32
Crops produced (>1/32ac)	3.05	3.09	0.04	0.64
Value of harvest consumed	18,243	16,426	-1,715	0.49
Value of harvest sold	28,094	32,910	4,848	0.51
Value of total harvest	47,777	50,435	2,794	0.72
Gross margins	38,108	39,392	1,415	0.90
<i>In the last five years...</i>				
Crops produced changed	0.09	0.10	0.01	0.51
Amount rainfall changed	0.72	0.70	-0.02	0.64
Timing rainfall changed	0.84	0.86	0.02	0.49
Temperature changed	0.79	0.82	0.04	0.24
Number of insects increased	0.44	0.45	0.01	0.79
Number of diseases increased	0.41	0.44	0.03	0.56
Crop yields decreased	0.52	0.54	0.02	0.71
Pest information improved	0.13	0.09	-0.03	0.17

Notes: Standard errors clustered at the plant clinic level. Observations: Household – control 1880 and treatment 942. Crops – control 1872 and treatment 931. Last five years: control 1551 and treatment 785.

Table 2 shows that their use of inputs, cultural practices, and yields on both annual and perennial crops are similar. In fact, only four of the more than 140 variables analysed were statistically significantly different at the 5 percent confidence level. Overall, the baseline data collection establishes a clear counterfactual and should allow for unbiased estimates of programme impact in the subsequent analysis.

**Table 2. Assessment of Counterfactual with Selected Annual and Perennial Crop Variables**

Variables	Annual Crops				Perennial Crops			
	Control	Treat	Balance Tests		Control	Treat	Balance Tests	
	Mean	Mean	Diff	p-val.	Mean	Mean	Diff	p-val.
<i>Inputs</i>								
Organic fertiliser used	0.41	0.38	-0.03	0.11	0.50	0.49	-0.00	0.96
Inorganic fertiliser used	0.69	0.70	0.01	0.62	0.37	0.32	-0.03	0.56
Pesticide use	0.22	0.19	-0.03	0.12	0.21	0.19	-0.01	0.78
Family labour days	24.37	22.22	-2.34	0.06	27.58	28.60	0.38	0.90
Paid labour days	6.20	6.01	-0.19	0.72	5.65	6.43	0.82	0.50
<i>Practices</i>								
Rotate crops	0.29	0.26	-0.03	0.25				
Use resistant variety	0.32	0.32	-0.00	0.93	0.32	0.34	0.04	0.65
Improved planting material	0.66	0.68	0.01	0.63	0.41	0.40	-0.03	0.49
Certified planting material	0.73	0.74	0.01	0.72	0.39	0.40	-0.01	0.77
Residue removal	0.81	0.82	0.00	0.89				
Plant early	0.87	0.83	-0.03	0.03				
Intercrop	0.50	0.52	0.01	0.62	0.24	0.20	-0.04	0.58
Weed in timely manner	0.97	0.98	0.00	0.71	0.89	0.90	0.02	0.37
Remove infested material	0.69	0.70	0.01	0.64	0.68	0.69	-0.01	0.81
<i>Production</i>								
Value of total harvest	35,115	29,576	-4,753	0.25	54,277	80,666	22,730	0.33
Gross margins	24,750	19,935	-4,180	0.58	55,435	74,390	14,014	0.63

Notes: Only includes crops produced on an area of over 1/32<sup>nd</sup> an acre. Standard errors clustered at the plant clinic level. Observations: Annuals – control 1796 and treatment 903. Perennials – control 485 and treatment 251.

Since the baseline survey is a representative sample of the areas around a plant clinic, the data offer a wealth of information about the agricultural characteristics where plant clinics operate. From Tables 1 and 2, some notable characteristics are as follows:

**Table 3. Most Important Crops by County**

	County													National
	Bongoma	Elg/ Marakwet	Embu	Kajiado	Kiambu	Kirinyaga	Machakos	Nakuru	Narok	Nyeri	Tharaka-Nithi	Trans Nzoia	West Pokot	
<b>Beans</b>	21.4%	11.9%	10.7%	31.1%	16.7%	20.2%	17.5%	12.9%	22.4%	17.0%	11.7%	25.3%	28.3%	17.3%
<b>Improved maize</b>	24.3%	22.3%	15.7%	15.4%	12.7%	10.9%	15.2%	18.2%	17.4%	12.9%	8.9%	34.5%	24.7%	16.8%
<b>Local maize</b>	8.6%	11.2%	3.0%	20.2%	13.4%	18.2%	5.2%	2.5%	28.3%	11.5%	10.0%	11.7%	23.9%	11.3%
<b>Bananas</b>	9.3%	2.4%	15.3%	0.4%	4.8%	9.8%	3.5%	8.3%	0.2%	14.1%	13.1%	8.9%	4.9%	8.1%
<b>Potatoes</b>	0.0%	29.5%	2.7%	1.8%	10.4%	0.7%	0.2%	10.4%	8.5%	1.9%	1.1%	0.7%	3.0%	5.5%
<b>Coffee</b>	3.0%	0.0%	15.8%	0.0%	0.0%	1.8%	3.0%	1.1%	0.0%	18.2%	9.1%	0.3%	1.4%	5.2%
<b>Kale</b>	3.0%	5.6%	2.3%	7.7%	12.5%	1.8%	1.4%	11.6%	3.7%	2.0%	1.5%	2.5%	3.0%	4.4%
<b>Napier</b>	0.9%	2.1%	6.9%	0.0%	7.0%	2.6%	0.6%	4.1%	0.2%	8.0%	5.7%	2.5%	0.8%	3.6%
<b>Avocados</b>	6.5%	1.9%	2.7%	0.2%	1.1%	0.4%	2.0%	5.6%	0.0%	1.7%	1.1%	5.2%	2.2%	2.4%
<b>Tomatoes</b>	0.2%	0.0%	1.3%	13.6%	2.7%	5.7%	1.6%	0.6%	1.6%	1.1%	0.8%	0.0%	0.0%	1.9%
<b>Cowpeas</b>	2.3%	0.0%	0.1%	0.2%	0.0%	0.0%	8.1%	0.0%	0.0%	0.0%	6.3%	0.5%	0.3%	1.8%
<b>Pigeon peas</b>	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	14.5%	0.0%	0.0%	0.0%	3.0%	0.0%	0.3%	1.8%
<b>Mangoes</b>	3.3%	0.2%	0.7%	0.2%	0.0%	0.7%	8.7%	0.3%	0.2%	1.2%	0.0%	1.5%	0.0%	1.4%
<b>Tea</b>	0.0%	0.6%	6.1%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	3.9%	0.0%	0.0%	1.3%
<b>Sugar cane</b>	3.3%	0.4%	1.7%	0.0%	0.7%	1.1%	0.1%	3.0%	0.0%	1.6%	0.9%	0.7%	0.5%	1.2%
<b>Sweet potatoes</b>	4.9%	0.0%	2.4%	0.0%	0.7%	0.7%	0.8%	0.6%	0.0%	1.6%	0.5%	1.5%	0.5%	1.1%
<b>Onions</b>	0.5%	2.6%	0.2%	0.9%	0.5%	0.0%	0.1%	6.0%	0.4%	0.3%	0.4%	0.0%	0.5%	1.1%
<b>Green grams</b>	0.4%	0.0%	0.0%	0.0%	0.0%	0.9%	1.8%	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%	1.1%
<b>Spinach</b>	0.0%	0.3%	0.4%	4.4%	6.6%	0.0%	0.2%	2.1%	0.4%	0.4%	0.1%	0.0%	0.5%	1.1%
<b>Pawpaws</b>	0.5%	0.2%	0.6%	0.0%	0.4%	3.1%	3.8%	0.1%	0.0%	0.7%	0.7%	0.0%	0.0%	0.9%
<b>Macadamia</b>	0.0%	0.0%	5.9%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	1.3%	0.5%	0.0%	0.0%	0.8%
<b>Wheat</b>	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%	11.2%	0.0%	0.0%	0.5%	0.0%	0.8%
<b>Peas</b>	0.0%	0.7%	0.0%	0.0%	0.5%	0.2%	1.7%	3.3%	0.9%	0.3%	0.6%	0.0%	0.5%	0.8%
<b>Millet</b>	0.4%	1.2%	0.0%	0.2%	0.0%	1.1%	0.2%	0.1%	0.5%	0.0%	3.3%	0.5%	1.1%	0.8%
<b>Cassava</b>	3.2%	0.3%	0.7%	0.0%	0.0%	1.3%	1.4%	0.1%	0.0%	1.3%	0.5%	0.5%	0.0%	0.7%
<b>Oranges</b>	0.2%	0.3%	0.0%	0.0%	0.0%	0.4%	3.2%	0.6%	0.2%	0.1%	0.0%	0.0%	0.3%	0.5%
<b>Rice</b>	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
<b>% of production</b>	96%	94%	95%	96%	91%	89%	95%	92%	96%	97%	90%	97%	97%	94%

Source: Authors' calculation using baseline data. Note: Figures represent percent of farmers cultivating at least one unit of the crop.

- Most farmers have only a primary education (54 percent), although a significant number have completed secondary schooling (37 percent).
- The self-identified head of household is female in 20 percent of cases.
- Agriculture is the primary source of employment for the majority of farmers; they have been farming for nearly 20 years on average, and they dedicate significant hours to farming.
- Farmers work an average of 2.24 acres of land, producing roughly six crops, worth around 50,000 Kenyan shillings in total.
- Most farmers believe there has been a change in the amount and timing of rainfall in the last few years, and a number believe the incidence of pests and diseases has increased. At baseline (prior to plant clinic operation), few believe plant health information has improved in the last five years.
- Regarding agricultural inputs and practices, 70 percent of farmers with annual crops and 35 percent of farmers with perennial crops reported using inorganic fertilisers, and approximately half of the farmers reported using organic fertilisers. Only 20 percent report using pesticides on annuals of perennials.

Table 3 describes crop production by county, listing all crops that were reported as produced by more than 3 percent of farmers in the county. The data show that there is significant regional variation in agricultural production. In general, beans and improved maize were the most common crops across all counties. Crops that were also important included coffee, bananas, and tea in Embu; peas, mangoes, and cowpeas in Machakos; coffee, bananas, and napier grass in Nyeri; and bananas, coffee, and cowpeas in Tharaka-Nithi. West Pokot showed the least crop diversification, with the six most important crops accounting for 86 percent of agricultural production. Overall, given the concentration of agricultural production around a few main crops, it may make sense to tailor portions of plant doctor training and educational materials to addressing key crops. Of course, the differences across the counties suggest a need to tailor some of the training to certain counties.

Gender is a critical concern in agricultural development and, as noted, 20 percent of farm households report a female head. Female-headed households and male-headed households are similar in many ways, but there are a few fundamental differences between these households. To highlight these differences, Table 4 presents the mean values for *selected* variables for female- and male-headed households as well as the p-value associated with statistical test of differences by gender. Note that many of the variables analysed were not significantly different, and those that are presented represent sets of variables where there are some differences (a p-value of less than 0.05 is typically considered statistically significant).

The table shows that female-headed households have less people, and that these heads are older and tend to have less education (having less education can affect farm production) than male heads. Female-headed households generally have fewer agricultural assets and use less agricultural inputs than households headed by males. Overall, the data point to a few areas where households headed by women are in a weaker position than those headed by men.

**Table 4. Gender Differences for Selected Variables**

Variables	Female	Male	Test: Female=Male	
	Mean	Mean	Diff	p-value
Household size	3.43	4.23	-0.80	0.00
Household head age	49.99	45.79	4.20	0.00
Head education: primary	0.71	0.50	0.21	0.00
Head education: secondary	0.25	0.40	-0.15	0.00
<i>Household head owns...</i>				
Plough	0.06	0.08	-0.02	0.05
Knapsack sprayer	0.22	0.28	-0.06	0.02
Watering can	0.12	0.15	-0.03	0.05
Sickle	0.11	0.14	-0.03	0.01
Trough	0.17	0.24	-0.07	0.00
Shovel/spade	0.51	0.55	-0.04	0.05
Hand saw	0.16	0.21	-0.05	0.01
<i>Annuals: inputs and practices</i>				
Organic fertiliser used	0.40	0.40	0.00	0.05
Inorganic fertiliser used	0.68	0.70	-0.02	0.06
Pesticide use	0.15	0.22	-0.07	0.00
Cost of seed planted	3,975	8,673	-4,698	0.03
Cost inorganic fertiliser	4,263	5,449	-1,186.	0.06
Cost pesticide	9,687	10,074	-387	0.92
Improved planting material	0.64	0.67	-0.03	0.01
Plant early	0.83	0.86	-0.03	0.02
Intercrop	0.58	0.49	0.09	0.01
<i>Perennials: inputs and practices</i>				
Organic fertiliser used	0.48	0.50	-0.02	0.74
Inorganic fertiliser used	0.34	0.36	-0.02	0.46
Pesticide use	0.15	0.21	-0.06	0.03
Cost inorganic fertiliser	2,037	2,180	-143	0.92
Cost pesticide	6,389	13,149	-6,760	0.16
Use resistant variety	0.41	0.30	0.11	0.06
Improved planting material	0.34	0.42	-0.08	0.09
Certified planting material	0.32	0.42	-0.10	0.02
Intercrop	0.31	0.20	0.11	0.01

Notes: Only selected variables included. Observations: Overall – females 545 and males 2483, Annuals – females 524 and males 2175. Perennials – females 156 and males 580.

When farmers in the plant clinic areas were asked what challenges they face in improving agricultural production, more than half cited insects as the primary issue. Issues with fungus, bacteria, and viruses were mentioned about 10 percent of the time, weather just over 10 percent of the time, and nutrient deficiency of the soil approximately 5 percent of the time. Focus group discussions confirmed a great concern about insects and plant diseases.

**Table 5. Useful Information Received by Source and Category**

Information source	Total	Seed varieties	Pest control	Fertiliser use	Agro practices	Irrigation	Composting	Marketing	Postharvesting	Value addition	Credit access	Agro-forestry	Other
Electronic media	48.2%	19.0%	40.7%	47.5%	51.8%	52.4%	53.0%	53.0%	53.5%	53.9%	53.4%	53.5%	53.6%
Agrodealer	16.6%	17.4%	18.9%	15.9%	15.8%	15.6%	16.2%	16.4%	16.4%	16.6%	15.8%	16.3%	16.9%
Other farmer	13.5%	21.6%	13.8%	12.6%	12.1%	12.2%	12.7%	12.8%	12.7%	12.8%	12.5%	12.8%	12.9%
Gov. agricultural extension service	12.9%	29.0%	15.1%	14.8%	12.1%	12.4%	10.3%	9.8%	9.9%	9.5%	9.4%	9.8%	9.2%
Agricultural coop or farmers' assoc.	1.5%	2.6%	2.1%	1.6%	1.4%	1.3%	1.5%	1.6%	1.1%	1.1%	1.6%	1.1%	1.2%
Field days, shows, fairs or field school	1.4%	3.4%	2.3%	1.4%	1.1%	0.9%	0.9%	0.9%	0.9%	1.0%	1.3%	0.9%	1.0%
Paper media	1.3%	0.0%	0.6%	1.2%	1.4%	1.4%	1.5%	1.6%	1.5%	1.5%	1.8%	1.5%	1.5%
Champion/contact farmer	1.1%	1.9%	1.5%	1.0%	0.9%	0.9%	1.1%	0.9%	1.1%	1.0%	0.9%	1.1%	1.0%
Village agricultural extension meeting	1.1%	1.8%	1.3%	1.4%	0.9%	0.7%	0.9%	0.9%	0.9%	0.8%	1.1%	1.1%	0.8%
NGO	0.9%	1.1%	1.5%	1.0%	0.7%	0.9%	0.7%	0.7%	0.7%	0.8%	0.7%	0.8%	0.8%
Private agricultural extension service	0.8%	1.0%	1.3%	0.6%	0.9%	0.7%	0.6%	0.7%	0.6%	0.6%	0.9%	0.6%	0.8%
Agricultural extension course	0.6%	0.2%	0.4%	0.6%	1.1%	0.5%	0.6%	0.5%	0.6%	0.6%	0.5%	0.6%	0.6%
Agricultural training centres	0.1%	0.8%	0.3%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Commodity-based extension services	0.0%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Authors' calculation using baseline data

In general, farmers do not seek advice on these challenges in a systematic way, and few farmers report receiving information on plant health. Table 5 provides an overview of the percentage of farmers who received useful information on a particular issue from a certain source. Most useful information came from electronic media, agrodealers, other farmers, and government agricultural services. There were other sources, but they tended to be less consequential. Generally, farmers were most likely to receive useful information through electronic media for all topics except seed varieties. For seed varieties, farmers were most likely to receive useful information through agriculture extension agents. In all categories except seed varieties, farmers reported being more likely to receive useful information from agrodealers than government extension workers. This is likely because farmers tend to be in greater contact with agrodealers.

Finally, key informants agreed with farmers' and extension agents' conclusion that there was a general lack of knowledge among stakeholders. Key informants emphasised that the level of understanding about inputs or production was low among both farmers (who often consult their neighbours on issues) and agrodealers (often the next line of defence). Each of the agrodealers we interviewed said that they used materials from companies, or that the farmers who came to them already "know what they need."

## **Baseline Insights into the Research Questions**

On the whole, the preliminary evidence suggests that PW-K has had a number of positive effects on the Kenyan plant health system. The programme appears to have been an impetus for institutional change, has increased awareness of plant health issues, and has altered the manner in which the government is addressing crop protection. Of course, there are areas where the programme could be improved, and these are addressed after the summary of the findings.

### **1. Plant Health System Change**

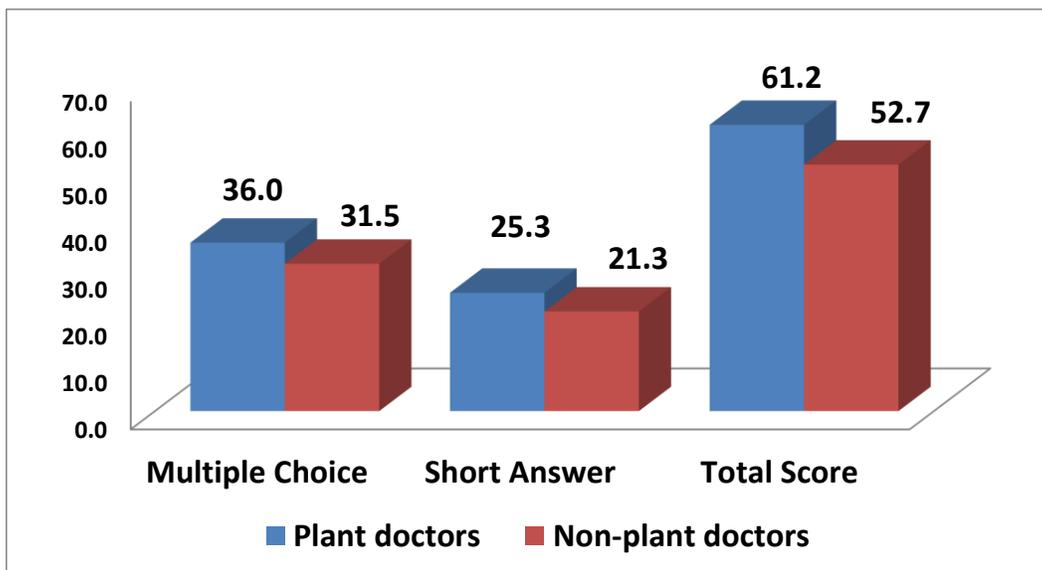
PW-K is gradually improving institutional coordination in the plant health system, generating more knowledge, and subsequently improving the likelihood of identifying outbreaks and responding in a timely manner. Stakeholder perceptions indicate that PW-K has altered the manner in which farmers interact with MoA entities at the local level. The interaction with farmers through plant clinics is widely viewed as being helpful in addressing farmers' needs with respect to plant health. This is, to a large extent, due to the training of plant doctors and improved access to information. The information generated from the plant clinics, through the POMS, combined with improved institutional coordination has the potential to continue to shift the plant health system in a positive direction. The direct contact with farmers and the general shifts in the plant health system are consistent with a strengthening of the institutions that manage plant health, as well as a reduction in damage from pests and diseases in Kenya.

However, at the national, county, and local level, PW-K could benefit from encouraging stakeholders to involve colleagues who are not part of the programme. Their involvement should include improving coordination and collaboration across institutions, as well as sharing the information generated from the plant clinics. Both of these improvements would facilitate outbreak identification and response. Furthermore, given the relatively limited coverage of the programme throughout Kenya, continuing to build sufficient links between institutions and encouraging ongoing learning about plant health would contribute to the institutionalisation of

the programme model, ensuring that stakeholders prioritise its continuation irrespective of outside funding.

A critical part of the plant health system change is the training of agricultural extension agents to be plant doctors. Investing in the skills of extension agents should expand knowledge availability. Part of the evaluation was then to test whether Plantwise trainings have a significant impact on plant health knowledge. This was accomplished through a plant doctor assessment which consisted of a multiple-choice section with 50 questions and a short-answer section with five questions. The multiple-choice questions relate to knowledge that is necessary for diagnosis and providing relevant recommendations. The short-answer questions are more comprehensive and are intended to simulate the conditions faced by plant doctors. Each section is worth 50 points, and the tests were marked by professors from the University of Nairobi. The assessment was administered to all current plant doctors (CPDs) as well as other agricultural extension agents, some of whom will be plant doctors in the future (non-PDs). Figure 2 provides a summary of results.

**Figure 2: Plant Doctor Assessment**



CPDs scored 4.5 points higher on multiple choice and 4.1 higher on short answer questions compared to non-PDs, with an 8.6 point difference overall. All differences are statistically significant. To ensure that these significant differences were from being trained as a plant doctor, rather than from the type of person that is a plant doctor, we repeated the analysis controlling for confounding factors, and CPDs still scored about 7.9 points higher than non-PDs.

Further analysis shows that of the 50 multiple-choice questions, CPDs scored significantly higher on 20 of them, or 40 percent. Of the short answers, CPDs scored significantly higher on four of the five written questions, or 80 percent. The evidence provided by the assessment of individual questions indicates that the significant difference in total values between CPDs and non-PDs is not a result of specific components of PW-K training per se, but is likely a product of the more extensive general plant health knowledge gained through the training.

A similar analysis was done by gender. Male CPDs scored 5.1 points higher on the multiple choice, 4.2 points on the short answer, and 9.3 points overall compared to male non-PDs. Female CPDs scored 3.5 points higher on multiple choice, 3.8 points higher on short answer, and 7.3 points higher overall than female non-PDs. All are statistically significant differences. For both male and female CPDs, there is promising evidence that PW-K has had a significant effect on improving plant health knowledge relative to non-PDs of both genders.

To check whether these estimated effects are consistent over time, and to further validate the results, we will administer the plant health assessment again at two additional points in time.

## **2. Evaluation of the Implementation of PW-K**

The process through which PW-K is implemented is innovative and comprehensive. It improves knowledge at multiple levels through improved training for extension officers, accessible diagnosis for farmers, and data collection to help understand where diagnosis could be improved in the short term, and where the system should address problems in the long term.

A central component of the PW-K process is the POMS. The POMS data provide a wealth of information. The analysis of the data provide an opportunity (i) to contribute to the identification of plant disease and pest outbreaks and to provide input into the Knowledge Bank, (ii) to monitor the use of plant clinics, and (iii) to analyse the validation process. As part of the assessment, the POMS data was first used to monitor the use of plant clinics.

To analyse the POMS, we used the prescription form information submitted by plant doctors in 2013 and the first semester of 2014 (4,414 prescriptions). During 2013 and 2014, 135 plant doctors from 78 clinics submitted at least one prescription form to POMS. On average, each plant doctor submitted 33 prescription forms total, with a minimum of 1 form and a maximum of 216 forms. While 25 percent of the plant doctors submitted fewer than six forms throughout the year, the top 10 percent of plant doctors provided more than 86 forms. These differences can be partly explained by differences in farmer attendance at different clinics.

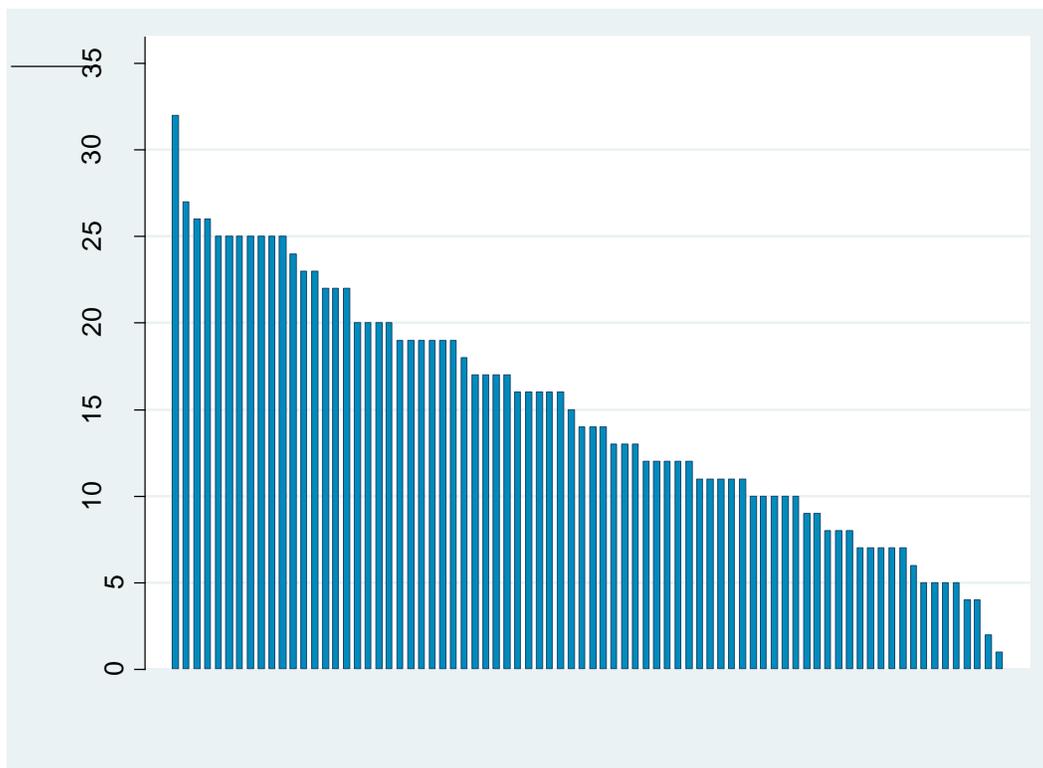
These large differences in farmer attendance may be in part due to frequency of operation of the different clinics. Each plant clinic, and therefore each plant doctor, was set to operate once every two weeks. Therefore, we examined average number of prescriptions submitted by plant doctors, as well as farmer attendance at each clinic, over biweekly periods. Biweekly periods rather than specific dates of plant clinics were used since the data did not show a clear link to individual dates that appeared to correspond with a plant clinic.

There are 26 biweekly periods in a year and 42 over the period analysed. On average, each plant doctor submitted prescription forms for only 10 of the 42 biweekly periods between January 2013 and July 2014, which equates to about 24 percent of the time. These results indicate that there were many weeks during the 42 weeks in which plant doctors saw no farmers. On average, each plant clinic submitted prescription forms for 14 of the 42 biweekly periods. The clinic that submitted prescriptions most regularly submitted forms for 32 biweekly periods.

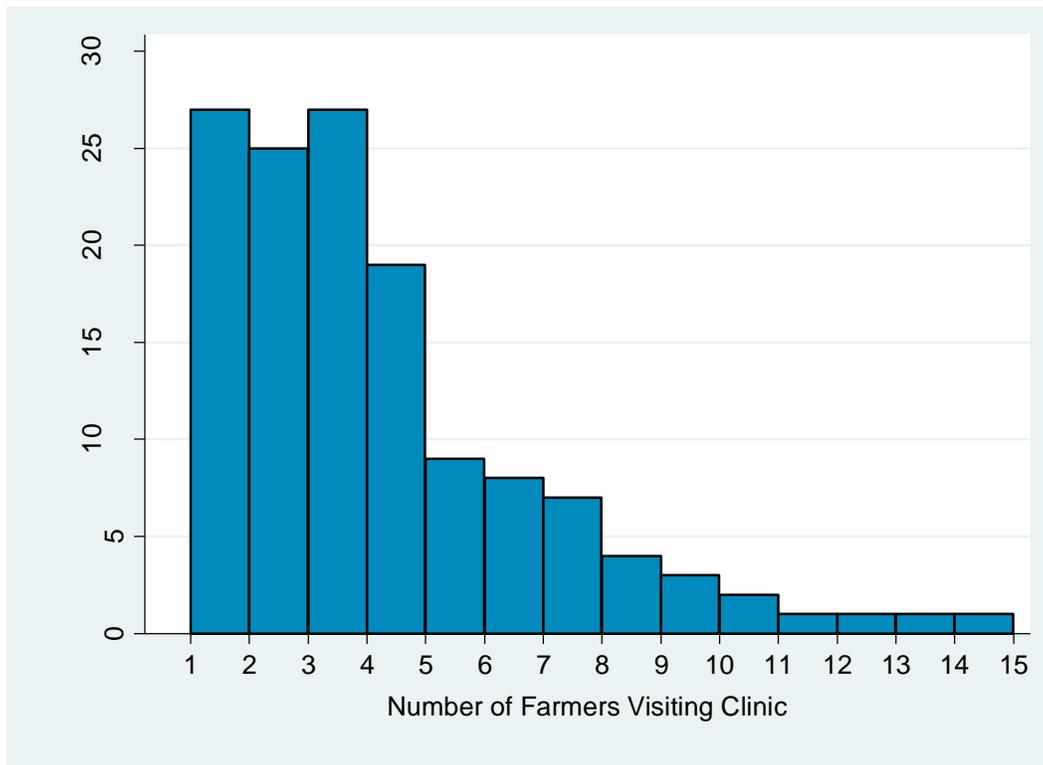
To determine how time of clinic initiation influenced results, the first biweekly period in which each clinic submitted a prescription form was identified. This is based on the first date noted in the POMS data that a prescription was submitted for that clinic and assumes that this is an

accurately dated submission. Figure 3 shows the number of biweekly periods in which each clinic submitted no prescriptions after that initial submission. Though many clinics did not submit their first prescription form until very late in the time period, there are still many biweekly periods after initiation in which clinics saw no farmers. The mean number of biweekly periods with no prescriptions submitted was about 14. Twenty-five percent of clinics had more than 20 biweekly periods with no prescription forms submitted, even after accounting for different starting dates for the clinics. These figures still indicate that clinics saw farmers much less often than anticipated.

**Figure 3: Biweekly Periods with No Prescriptions by Plant Clinic (After Initial Clinics)**



**Figure 4: Frequency of Farmer Assistance from Plant Doctors**



As part of the PW-K management process, a Kenya-based data validation team checks the information that plant doctors gather on the prescription forms. The validation team examines the POMS data to determine if the diagnosis and recommendations provided by the plant doctor is consistent with the information provided about the plant health issue. A valid diagnosis implies that the diagnosis is consistent with the symptoms and a valid recommendation implies the plant doctor is recommending a reasonable course of action given the diagnosis. The POMS data includes the original data submitted by the plant doctor as well as the output of the validation process. Beyond the monitoring of the clinic activities, the evaluation also includes an analysis of the determinants of the validation process using data from the prescription forms as well as administrative data provided by the MoA.

The results of this analysis show that there are no major differences in likelihood of a valid diagnosis or recommendation by development stage. Only plants in the post-harvest stage have a much lower probability of receiving a valid diagnosis compared to plants in the intermediate stage. Interestingly, around 70 percent of the plant clinic visits are made when the plants are in an advanced development stage, which may be too late for recommendations to be effective for the current agricultural season.

Regarding the affecting organism, the results show that plants affected by insects or mites are 12 percentage points more likely to receive a valid diagnosis than those with fungi. Plants affected by bacteria, viruses, and fungi have similar rates of diagnosis validity. In turn, prescriptions for plants affected by nematodes, phytoplasma, weeds, or not reporting the affecting organism are more than 13 percentage points less likely to have a valid diagnosis compared to those with

fungi. Lastly, plants reported as being affected by a virus are 11 percentage points less likely to have an effective recommendation compared to those with fungi.

With respect to the part affected, 34 percent of prescription forms are for problems with leaves, 10 percent with the fruit, and 35 percent with multiple parts affected. Consultations on plants whose fruits are affected are 8 percentage points more likely to have a valid diagnosis compared to those affected on the leaves. The remaining plant parts affected have a similar probability of getting a valid diagnosis.

In terms of symptoms, the data show there is large variation in the types of occurring symptoms, with no single symptom representing more than 5 percent of total prescriptions. In fact, the largest category is for those with multiple symptoms. The results show that plants that are wilted, or are losing leaves or dropping fruit, are more likely to have a valid diagnosis relative to those with multiple symptoms. Yellowed plants or with leaf spots are 16 percentage points less likely to get a valid diagnosis. Plants that are wilted and also have other symptoms are less likely to receive an effective recommendation.

The analyses performed provide good examples of the types of analyses that could be implemented on a regular basis so that data collected at the plant clinics can be used to inform implementation decisions such as additional training in topics with lower validation rates.

Though the process through which PW-K is implemented is promising and well received overall, baseline data indicate some significant areas for improvements in programme implementation. First, all stakeholders noted the need for greater coordination and indicated an interest in more targeted training and additional training. Second, on-the-ground improvements—such as additional assistance from experts, coordination among extension agents, and the provision of additional materials—could help facilitate diagnosis. Finally, the POMS data are under-analysed and under-utilised in decision making, and the Knowledge Bank is widely discussed but rarely used. As a result, while the PW-K model appears to be sound, significant improvements in implementation should be undertaken.

### **3. Farm-level Impact**

At the farm level, PW-K aims to impact farmers' ability to manage pests and diseases, their ability to be efficient and productive as a result of this improved management, and their overall income and food security. Adequately identifying the extent and magnitude of farm-level impacts is particularly challenging without quantitative information, so for the baseline report we focus on farmers' perception of impacts.

All of the farmer focus groups reported that pests and diseases are a severe threat to their livelihoods. The qualitative data collected suggest that PW-K may help mitigate the severity of livelihood effects by increasing farmers' ability to respond to outbreaks. Farmers from all four clinic areas studied reported that the plant clinics had been helpful in responding to pests and diseases. Focus groups with trained plant doctors corroborated the findings of farmer focus groups. In each treatment area, plant doctors believed their effectiveness as extension agents had been enhanced by the programme.

Based on focus group and interview data, stakeholders believe that PW-K's focus on improved pest and disease management and increased efficiency and productivity have helped increase income from agriculture and food security. For example, a farmer in Machakos commented: "I have been able to get more yields from planting tomatoes and the profit margins are higher." Agriculture extension agents and plant doctors were similarly convinced of the benefits plant clinics were bringing to farmers. According to their reports in focus groups and interviews, PW-K has enabled farmers to better manage plant pests and diseases, produce crops more efficiently, and increase their income.

Baseline data indicate that PW-K helps farmers who attend clinics in terms of being able to diagnose pests and diseases and consequently manage their crops. Stakeholders also anecdotally indicated that the programme had contributed to improved efficiency and productivity. However, it is impossible to assess actual impact on productivity, income, or food security among smallholder farmers at this point.

#### **4. Cost Analysis**

The costs associated with PW-K correspond to the three primary sets of PW-K activities: (i) national coordination, (ii) plant clinic set-up and operation, and (iii) POMS set-up and operation. For each of these sets of activities, the additional costs of PW-K beyond the normal operating costs of the agricultural extension system have been identified including the costs of investing in each of these activities—both to initiate the activities and maintain them—as well as the opportunity costs of the time of government employees. At present, most of the investments into PW-K have been funded by CABI through direct payments or the time of their staff. The opportunity costs of MoA staff time have been covered by the Kenya government.

A detailed analysis of costs is presented in the report. As would be likely with a programme that is in an expansionary phase, the overall costs are expanding and the expectation is that these costs will continue to rise. These costs are not exorbitant, however, especially when compared to agricultural projects supported by development banks such as the World Bank or African Development Bank. The reason is that the programme primarily focuses on institutional change and therefore does not require large investments. Investments that do take place focus on improving human capital through training and facilitating coordination. This facilitates a more efficient use of human resources and the costs are likely to be justifiable.

The costs of the plant clinics exceed 50 percent of total costs in all years and it is likely that these costs will rise in absolute and relative terms if the programme continues to expand. While the costs of national coordination and managing the data will also rise in absolute terms with expansion, the primary increase will likely be from the plant clinics. The reason for this is that there are greater economies of scale in national coordination and data management than with the plant clinics.

A large portion of the costs are the costs of government staff, and these assume that the staff, particularly agricultural extension staff, are fully employed. The key information interviews and focus groups do *not* suggest this is the case, and in fact suggest that participation in the clinic is an improved use of existing human capital. Further, these costs are already included in the financial outlays of the government at present so do not represent an additional financial cost. The additional financial costs will come as CABI hands over the programme to the government

and the government takes on the costs that CABI has thus far borne. While not trivial, these costs are not exorbitant.

Of course, in order to determine whether the expenditures on PW-K are indeed justifiable, one must consider the potential benefits— reduced losses as a result of pests and diseases, both now and in the future. Calculating these benefits requires quantitative estimates of improvements in yields, and the value of these improvements to farmers. This is best estimated using follow-up data. At this stage, there is no evidence to suggest that costs will be unreasonable.

## **Suggestions for the Improvement of Plantwise-Kenya**

The results suggest that PW-K has the potential to make significant positive impacts on reducing losses from crop pests and diseases, but also suggest the need for continued action. In this section, we offer a number of key take-home messages for adjusting PW-K to improve its operation.

### **1. Systems must be developed to provide timely information from the plant clinics to key actors in the plant health system.**

The current system—with paper forms for plant health clinic data, data entry requirements, infrequent validation, and inadequate systems for data cleaning—is too slow to realise the full potential of the information collected. The continued efforts to improve the data collection system have followed a logical path and have led to improvements over time. These efforts must be continued and expanded upon. A key way of doing this is to embrace E-plant clinics and expand their use. Improvements to the POMS system should also continue. Finally, efforts must be made and a system put in place to ensure that the information collected through the POMS is transmitted to key actors in the plant health system.

### **2. The National Forum needs to create protocols for responding to plant health outbreaks and chronic issues when they are identified in the field.**

Providing information on pests and diseases to key actors is only one critical link in improving the management of plant health in Kenya. PW-K needs to promote action. Protocols need to be put in place to ensure that the provided information is used to respond to potential outbreaks and chronic issues. These protocols should include the types of action that should take place when a significant problem is highlighted through the gathered information. This would necessarily entail a plan of action for utilising the differential skills of the various entities throughout the system, not just at the higher level but throughout the involved organisations.

### **3. Farmers underutilise the plant clinics, and it should be possible to help farmers make better use of them.**

At present, plant clinics are insufficiently used. This may be an issue with the clinics not being regularly operated or it may be because farmers are not attending—the source of the issue needs to be investigated. One clear issue is that the marketing approach used to notify local farmers about plant clinics appears *ad hoc* and not particularly targeted. A more systematic approach to marketing would be helpful. Given the high level of mobile phone use in Kenya, any marketing strategy should incorporate greater use of mobile phone technology to expand the reach of the

programme. Of course, this should just be one element of a broader strategy to ensure greater awareness and use of plant clinics.

#### **4. There is the potential to improve the management of the data collection system.**

Collecting and using actionable data is a key aspect of PW-K, yet the efficiency and use of the data collection system could be improved. First, the use of mobile technology for plant doctors, via E-plant clinics, is likely to improve the quality of plant doctor diagnoses, reduce errors in data collection, and ensure that PW-K receives data in a timely manner. If well managed, it could also facilitate speedier verification. Second, the data verification system could be altered to provide more timely feedback to end users. Finally, the data management system could be used to conduct a broader range of analyses than is currently undertaken in order to answer key questions. For example, a representative from the seed industry noted that the industry relies on access to accurate data and that more datasets like this would greatly assist their efforts.

#### **5. The selection of plant doctors should be carefully considered.**

At present, the plant doctor selection process seems somewhat arbitrary, in that it appears to be conducted in a decentralised manner, with selection linked to responsibilities in the field. This is not necessarily a bad approach, but there seem to be a number of cases where those who are near retirement have been selected. Since plant doctor knowledge is linked to both training and practice, choosing people near retirement may not be the most cost-effective approach because their skill development is lost fairly quickly after it is gained. It might be worthwhile to only consider people who are a certain number of years from retirement (e.g., more than five years) for training. Furthermore, there is some evidence that Field Extension Officers (FEOs) are better at diagnosis (7 percentage points more likely to provide a valid diagnosis) and at providing recommendations (10 percentage point more likely to provide valid recommendations) than their Agriculture Extension Officer (AEO) counterparts. This suggests that it might be worth exploring the reasons for these differences in order to address the shortcomings of AEOs, or alternatively worth selecting more FEOs.

#### **6. There is a need for continuous plant doctor training, based on POMS analysis, and improved information provision.**

Plant doctors continually face unfamiliar problems and need to be regularly trained in order to update their ability to accurately diagnose plant health problems. They also need regular access to updated information. Mobile devices that are currently being piloted in the field through E-plant clinics appear to improve information access and seem to be a worthy investment. Furthermore, as seen in this baseline report, the POMS data can easily be used to identify weaknesses among plant doctors and determine what actions might be taken to overcome shortcomings.

#### **7. To ensure government employees have the right incentives, PW-K activities should be explicitly incorporated into the performance contracts of government employees.**

While government employees appear to be doing the work that they are required to do under PW-K, a number of employees noted that other activities can take precedence. Integrating PW-K into performance contracts within public employee work plans would help to ensure that time is dedicated to the programme.



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