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Changes in plant health system performance and responsiveness in Ethiopia: Stakeholder perceptions

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Cover photo

Plant clinic in Tigray region. *Photo*: Girmay Shinun

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Acronyms

AISCO	Agricultural Inputs Supply Corporation
ATA	Agriculture Transformation Agency
BoA	Board of Agriculture
BoANR	Bureau of Agriculture and Natural Resources
CGIAR	Consultative Group on International Agricultural Research
DA	Development Agent
DLCOEA	Desert Locust Control Organisation for Eastern AFrica
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organisation
FFS	Farmer Field Schools
FTC	Farmers Training Centre
GIZ	Deutsche Gesellschaft fűr Internationale Zusammenarbeit
ICIPE	International Centre of Insect Physiology and Ecology
ICT	Information and Communication Technology
IPM	Integrated Pest Management
KPI	Key Performance Indicator
M&E	Monitoring and Evaluation
MoANR	Ministry of Agriculture and Natural Resources
NGO	Non-Governmental Organisation
PHC	Plant Health Clinics
PHRD	Plant Health Regulatory Directorate
PHS	Plant Health System
PMSS	Pest Management Support Service
POMS	Plantwise Online Management System
SNV	Netherlands Development Organisation
WHO	World Health Organization
ToC	Theory of Change

Executive summary

This report presents the findings of a qualitative study on the effect of Plantwise on the plant health system (PHS) in Ethiopia. In August 2017, stakeholders and farmers in the regions of Oromia and Tigray were interviewed on the major changes that occurred in the PHS in recent years. These stakeholders had been involved in, or benefited from, Plantwise activities. The qualitative data was used to explore changes observed in the different functions of the plant health system (PHS) since the start of the Plantwise programme in Ethiopia in 2013, and the underlying drivers of change. The PHS functions are defined as: 1. Farmer advisory services; 2. Plant health information management; 3. Diagnostic services; 4. Research and technology development; 5. Input supply; and 6. Policy, regulation and control. The effects of the changes on the PHS performance and responsiveness were assessed through the following indicators: timeliness, availability, affordability, acceptability, coherence and reach.

Although the Federal Government of Ethiopia gives high priority to agricultural development, plant health has been neglected since the mid-1990s. In recent years, increasing pressure of crop pests and diseases has resulted in a growing awareness of the need to reinvigorate the PHS in Ethiopia. Plantwise was introduced in 2013, at an opportune time when the Federal Government was looking to improve the capacity of the Ministry of Agriculture and Natural Resources (MoANR) in plant health.

All stakeholders reported improvements in the performance and responsiveness of the PHS, in particular farmer advisory services and diagnostic services, as a result of the Plantwise intervention. In Ethiopia, Plantwise has particularly focused on strengthening farmer advisory services in plant health and crop protection. This has included capacity building of 270 extension officers (now plant doctors) through training on plant health; and the launch of community-based plant clinics (now 40 Plantwise initiated clinics[1]) in the Amhara, Oromia and Tigray regions. The community-based plant clinics have been established in so-called hot-spot areas: kebeles with intensive and irrigated farming that face many plant health problems. The trainings were also attended by woreda (district), zonal and regional crop protection experts, and have resulted in more effective diagnostic and advisory services on plant health (improved acceptability and coherence). The community-based plant clinics further improved the reach and availability of plant health advice in local communities. The speed (timeliness) of diagnosis and advice has also improved due to a combination of improved knowledge as well as faster communication tools (e.g. mobile phones, internet). Farmers confirmed these improvements at kebele level, and reported that productivity had increased as a result. However, they reported that changes created through other interventions (improved agronomic practices, collective marketing, etc.) also contributed to productivity increases.

The data management system of Plantwise (POMS) is perceived as a powerful tool for the management of plant health information, but it has not yet been fully used in Ethiopia as the entry of plant clinic records is constrained by lack of capacity (of staff and ICT equipment)

[1] In addition, the regional government of Tigray have launched 50 plant clinics as part of their out-scaling efforts

and language problems. The effect of Plantwise on plant health information management is thus negligible.

Plantwise has strengthened linkages with researchers in plant health and crop protection, and involved them in trainings and production of extension materials; but it has not significantly influenced the plant health research agenda. It has, however, influenced the use of agricultural inputs by farmers, promoting improved agronomic and cultural alternatives for pest control, and safe pesticide use only as a last resort, as well as working with agro-dealers to ensure that only registered and effective agro-chemical inputs are supplied.

Plantwise has also worked with policy makers, increasing collaboration and knowledge exchange. Although the effect of Plantwise on the PHS beyond the current target areas is limited, the Federal Government and the Regional Governments in Oromia and Tigray are committed to replicate the Plantwise model, embedding it into their work plans and budgets. The regional government of Amhara, however, has not yet allocated funding to the expansion of the Plantwise model. At national level, changes in policies and regulations are mainly driven by the government in response to increasing demands from farmers to address the mounting pest problems. Plantwise has engaged in strengthening linkages with different stakeholders groups (e.g. research, NGOs) but this has no immediate effect on the performance and responsiveness of the PHS. Most noticeable effects are thus observed at local level, but staff turnover among fieldworkers and their superiors is reported as a constraining factor.

1. Introduction

1.1 Background to the study: the Plantwise programme

Plantwise is a global programme led by CABI since 2011, which works to help farmers reduce crop losses related to plant health problems. The objective of Plantwise is to enable farmers around the world to lose less, produce more and improve the quality of what they grow. Plantwise focuses on strengthening systems for plant health advice to smallholder farmers through three core interventions:

- **Plant clinic networks.** Working with existing extension providers to implement networks of plant clinics to support farmers in solving both biotic problems (pests, diseases and weeds) and abiotic problems (e.g. nutrient deficiencies, drought) where there is the greatest need.
- **Systems for management and use of plant clinic data (POMS)** and **provision of plant health information (Knowledge Bank).** Supporting the establishment of appropriate systems and procedures for managing plant clinic data and providing plant health information which enable the proactive use of data and information for operational and strategic purposes at local and national levels.
- **A systems approach.** Working with key stakeholders to improve the capacity and responsiveness of national plant health systems (PHS) by strengthening linkages between agricultural service providers, plant health regulatory bodies, diagnostic services, research and training institutes, input suppliers and private extension.

The Theory of Change (Fig. 1) reflects the systems approach upon which Plantwise is based. Plantwise as a change agent aims to strengthen the linkages between the different system components within the countries, leading to the following outcomes: (1) larger numbers of farmers having access to reliable plant health information; (2) rapid identification of new and emerging pests; and (3) increased accountability of organisations to farmers. All this is expected to strengthen national response systems to plant health threats, thus increasing agricultural productivity and ultimately achieving developmental impact through improved livelihoods and greater food security.

The aim of this study is to assess to what extent the Plantwise intervention has brought about change in the PHS's performance and responsiveness in Ethiopia.

1.2 Agricultural development in Ethiopia

The Ethiopian Government gives high priority to agricultural development in its quest to become a middle-income country by 2025 on the basis of its agriculture-led industrialization development policy. The gross agricultural output has been increasing annually by 8% in recent years. Between 13% and 17% of government expenditure (about 5% of the gross domestic product) is being invested in agriculture. The aim is to invest USD 16.6 billion over ten years, with funds coming from the domestic government budget (60%) and from development partners (40%). Increasing the productivity of smallholder agriculture is the government's top priority (Chipeta et al., 2015). The extension system, which falls under the remit of the Ministry of Agriculture and Natural Resources (MoANR), is seen as a critical tool to achieve this vision of agricultural growth and transformation. Ethiopia has one of the most

intensive agricultural extension systems in the world, with approximately 21 extension officers per 10,000 farmers.

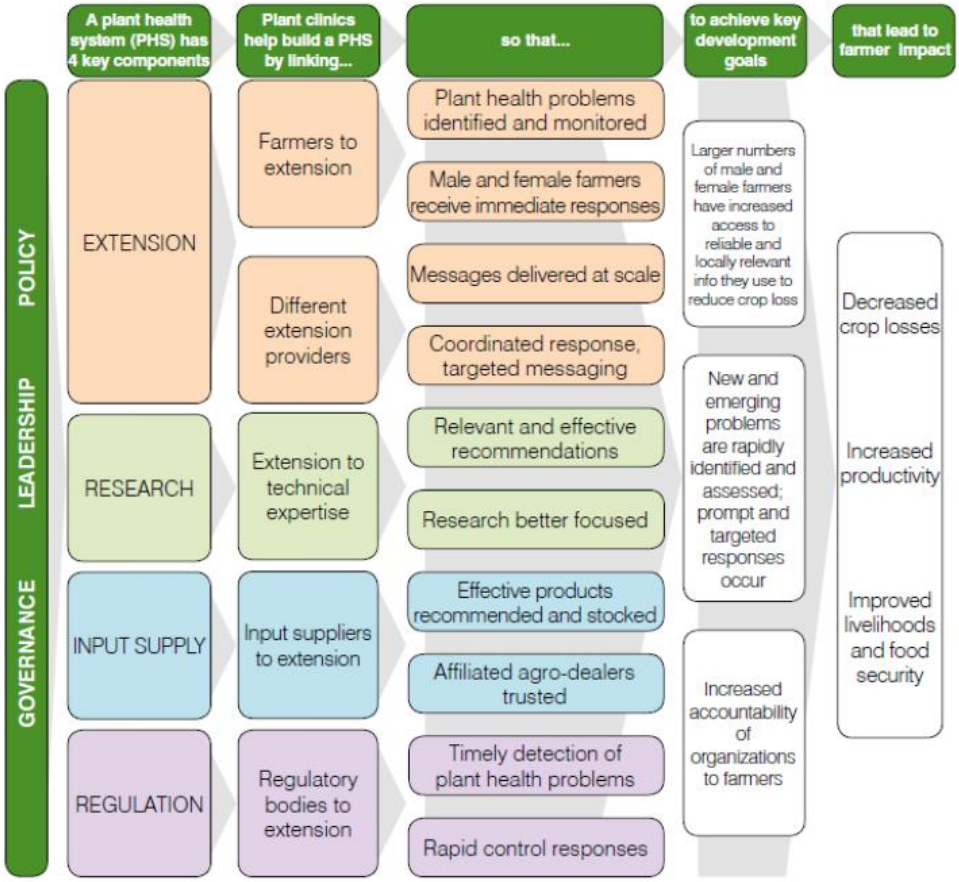

Figure 1. The Plantwise Theory of Change (ToC). Source: CABI Plantwise strategy 2015-2020

The regional Bureaux of Agriculture and Natural Resources (BoANRs) are responsible for the operation of the extension services. It is estimated that 60,000 extension officers (called Development Agents – DAs) are operating on the ground. There are three extension officers (livestock, natural resources and agronomy) per kebele[2]. At the core of the extension system are the Farmers Training Centres (FTCs), which provide advisory services to farmers including training, demonstrations of improved farming techniques, and market information. There were approximately 11,000 FTCs in operation throughout the country in 2014, but the aim is to increase this to 18,000 FTCs (ATA, 2014). However, despite these huge investments, a recent study by Leta et al. (2017) shows that the extension services are not satisfactorily addressing the needs and demands of farmers. Some of the challenges are: 1) extension services predominantly oriented towards top-down approaches in technology transfer; 2) unaffordable and inaccessible agricultural inputs; 3) low capacity of extension officers to provide efficient and effective services; 4) high staff turnover; and 5) weak linkages between research, extension and farmers.

[2] The kebele is the lowest level administrative unit in Ethiopia, comprising a local community of 800-1000 households on average.

1.3 Institutional background to the plant health system of Ethiopia

The MoANR and the regional BoANRs have a mandate to support and promote plant health. Ethiopia started its Pest Management Support Service (PMSS) in the 1940s with a focus on desert locust. The service was gradually expanded to include other pests that caused economic damage to different crops. The support included pest identification, technical training and advice on how to manage pests, and provision of inputs to apply pesticides. By 1992, the PMSS was deemed to have become competent in responding to the needs of the country. National plant protection laboratories and regional 'plant health clinics' (labs) were established, as well as quarantine posts at international points of entry and export of agricultural produce (MoANR, 2015). However, none of these laboratories or clinics were directly supporting farmers with plant health advice (see Box 1). Particularly after 2010, crop protection had become a low priority in MoANR, in particular the support services for the management of regular pests, resulting in loosely regulated pesticides use by farmers and the free movement and utilization of plant materials with unknown effects (see organogram in Annex 3).

1.4 Plantwise in Ethiopia

Plantwise was first introduced in Ethiopia in 2013, at a time when pest problems were mounting and policy makers were looking for ways to address this issue. When CABI introduced the Plantwise approach to the MoANR, the Ministry showed great interest and commitment to collaborate with Plantwise to address the gaps in its crop protection diagnostic and extension/advisory services. At that time, plant health did not feature strongly in the mandate of the extension services. There was no system for monitoring and reporting on pest outbreaks, except for desert locusts and more recently the African army worm, both migratory pests (interview 1[3]). Two ministry staff went to Kenya for training in 2011 and, in consultation with CABI, decided to start a pilot in Oromia in 2013 (interviews 1, 2). The positive experiences in Oromia encouraged the national and regional governments to introduce community-based plant clinics in the Amhara and Tigray regions in 2014. In 2015, a total of 30 community-based plant clinics were established, increasing to 40 in 2016. Plant doctors are recruited from qualified local extension officers (Plantwise, 2015; 2016).

Box 1. Two types of plant clinics

In Ethiopia, two types of plant clinics are distinguished.

'Plant health clinics' (PHCs) are run by the Regional BoANRs and include laboratories for pest identification, surveillance and monitoring, among others. They are thinly spread and there are a total of 16 PHCs throughout Ethiopia. Though included in their mandate, they hardly provide direct support to the farming communities.

'Community-based plant clinics' are the Plantwise-type of plant clinics that are managed by a plant doctor and located within a community (kebele). Farmers can bring their affected plant samples to receive a diagnosis and prescription form for treatment. The plant doctors can access additional support and services from the regional PHCs.

The financial contribution of Plantwise is relatively small in comparison to the Government's overall expenditure on agricultural advisory services. The contribution has mainly been used for training, supervision, plant clinic facilities, stakeholder fora, and extension materials.

[3] Details of all interviews are given in Annex 2.

2. Methodology

2.1 Defining the plant health system

The following PHS definition is used in this study: “A plant health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain plant health” (Danielsen and Matsiko, 2016; after WHO, 2007). A PHS performs the following functions (Table 1):

Table 1. Plant health system functions (Williams et al., 2015)

#	Function
1	**Farmer advisory services** Agricultural extension, advisory services incl. print and multimedia (radio, TV, helplines, ICTs); Training and extension approaches (plant clinics, on-farm demos, FFS, field days, etc.);
2	**Plant health information management** Approaches and structures of providing plant health information to relevant actors at local and central levels; Resources, departments; pests lists, published information; Information management systems, including plant clinic data management and use, etc.
3	**Diagnostic services** Diagnostic facilities and expertise for diagnosing plant health problems incl. pests, diseases, soil health problems and nutrient deficiencies; Referral systems
4	**Research and technology development** Universities, research institutes and research stations that take part in technology development. Farmer participatory technology development and validation of indigenous practice. Private sector research e.g. breeding companies.
5	**Input supply** Supply of agricultural inputs (seed, pesticides, fertiliser, biocontrol products etc.); Public, NGO and private suppliers; Importers, breeders, distributers, local agro dealers and community schemes; Subsidy schemes for farmers on agriculture inputs.
6	**Policy, regulation and control** Crop protection; Quarantine and border control; Surveillance; Certification (e.g. seed, pesticides); Registration; Quality control of inputs, import and export; Policies supporting PHS functions.

The key actors within each function were previously identified during a stakeholder meeting held in 2016 (Williams and Efa, 2016). These are listed in Annex 4.

Well-functioning PHS functions are supporting the system’s **performance** and **responsiveness**. Health system performance and responsiveness are described in different ways in the literature. While there are similarities and overlaps, there are no commonly agreed assessment frameworks and criteria. Choices depend on purpose, perspective and what is feasible in a particular setting. Broadly speaking, performance measurements seek to monitor, evaluate and communicate the extent to which various aspects of the health system meet their key objectives (Smith et al., 2008), while responsiveness is how well the health

system meets the legitimate expectations of the population (Derby et al., 2000). Challenges in particular parts can have ramifications in other parts of the system (Mutale et al., 2013).

The following indicators were used in this study to assess the performance and responsiveness of the PHS. These are from now on called key performance indicators (KPIs):

- **Timeliness** – is the service or good delivered in time (i.e. when required by user) without unnecessary delays?
- **Availability and accessibility** – is the service or good available and accessible to the users? Are certain groups excluded (because of gender, ethnicity, literacy level, status, distance, etc.)?
- **Affordability** – is the service or good affordable to the users? Do users perceive it is good value for money?
- **Acceptability** –is the service or good acceptable to the user? Is it relevant, effective and appropriate?
- **Coherence** – to what extent is the service or good aligned with goods and services in other PHS functions or other policies and practices?
- **Reach** – how many users does the good or service provide coverage for, and how many users access the good or service?

The respondents' narratives of change were used to assess the indicators qualitatively.

2.2 Research methods & tools

System change cannot be understood by looking only at the outputs (performance and responsiveness); an understanding of the underlying structures, processes and functions of the system is also required. In this study, system change was assessed based on stakeholders' narratives; where applicable, supportive evidence was also collected. The study explored the views of PHS stakeholders on the major changes in each of the six PHS functions in recent years, how these changes came about and how that influenced the performance and responsiveness of the system. The methodology is embedded in qualitative and primarily inductive research, rather than testing theories through deductive methods.

2.2.1 Tracing the narrative of PHS change

The ways in which the Plantwise programme has influenced and effected change in the plant health system of Ethiopia was explored, first, through key informant interviews with CABI and MoANR staff working on Plantwise, including the CABI country coordinator, the national coordinator and the national data managers. The areas explored were based on an M&E framework for human health systems described by Witter et al. (2013). Adapting this framework to this study resulted in the following domains that were considered when tracing PHS change from the perspective of Plantwise:

1. **Context:** What is the context and how does it influence the implementation of Plantwise?
2. **Policy formulation:** How was Plantwise introduced and rolled out?
3. **Design features:** How was Plantwise intended to affect the PHS in Ethiopia?
4. **Implementation:** How does the Plantwise ToC compare with practice (*de jure* design vs *de facto* practice)?
5. **Plant Health System effects:** What are the effects of Plantwise on the PHS functions?

Next, a range of PHS stakeholders were asked to describe the major changes that had occurred in recent years. To trace changes in the PHS and the drivers and pressures that triggered the change, we loosely followed the methodology of "outcome evidencing" which has been developed to evaluate programme interventions in complex systems (Paz-Ybarnegaray and Douthwaite, 2016). We have adapted the method for the purpose of this study, as depicted in Annex 1.

The changes may have been triggered by various drivers and pressures including: 1) contextual changes; 2) changes in the social system (the constellation of stakeholders, their actions or interactions between them); and 3) changes in the system building blocks, including workforce, finance and governance/ leadership (adapted from WHO, 2007).

2.2.2 Qualitative data collection

This study collected qualitative data from a total of 40 respondents through key informant interviews and group interviews (of 2-4 respondents with similar roles). Depending on their role and mandate, respondents were interviewed on the most important changes (and the drivers and effects of these changes) in specific functions within the plant health system. The main respondents were crop protection experts (at national, regional, woreda[4] and kebele levels), plant doctors, farmers, academics (lecturers and researchers), and NGOs (Table 2). A complete list of respondents is provided in Annex 2.

Table 2. Overview of respondents in Ethiopia

Stakeholder group	Number of respondents			
	National	Tigray	Oromia	Total
MoANR	5			5
CABI Country Coordinator	1			1
Regional BoANR		3	1	4
Crop protection experts		5	3	8
Plant doctors		6	3	9
Farmers		5	2	7
NGO	1			1
Academics	4			4
Agro-dealer		1		1
Total respondents	**11**	**20**	**9**	**40**

A total of nine plant doctors (five female and four male) were interviewed on their experiences with the plant clinics and the changes they have seen in pest management and crop protection in their kebeles (

[4] A woreda is an administrative unit equivalent to district.

Table *3*). Most plant doctors that were interviewed had received the Plantwise training two years previously.

Table 3. Overview of plant doctors interviewed

Gender	Years in position		Region
	Extension officer	Plant doctor	
F	2	0.5	Tigray
M	10	2	Tigray
F	n/a	1	Tigray
M	n/a	2	Tigray
M	n/a	2	Tigray
F	3	2	Tigray
F	2	2	Oromia
M	7	4	Oromia
F	7	2	Oromia

n/a – not available

The interviews were carried out face-to-face in a public setting. Translation was required in most cases as the respondents were not conversant in English. The interviews were semi-structured, using a limited set of key questions plus additional follow-up questions. Specific issues, that were relevant for some respondents, were explored in more detail in some of the interviews. It should be noted that Plantwise staff were present at the majority of the interviews, which may have influenced the answers of the respondents to some extent. Some of the planned interviews in Oromia were cancelled or conducted by phone due to local unrest during the fieldwork period.

Stakeholders' responses were also interpreted with reference to the six key performance indicators (KPIs): timeliness; availability; affordability; acceptability (quality/effectiveness); coherence (compatibility with farmers' practices); and reach. Stakeholders were not asked to rate these directly, but the observed changes in the PHS were discussed during the interviews in terms of the indicators. Farmers' views with regard to the KPIs were elicited through three group interviews, with farmers who had visited the plant clinics in their respective kebeles.

3. Findings

The findings are presented according to the six plant health system functions defined Table 1. This chapter describes the **changes** in the PHS, and the **drivers behind these changes**, according to the views of Plantwise staff and other PHS stakeholders. They were asked to consider the period between 2013 (when CABI Plantwise activities started in Ethiopia) and 2017 (when this assessment took place).

Many respondents mentioned that the main driver of recent PHS changes is the increasing problem of pests, in particular in intensive farming areas where diversification of crops and expansion of irrigated land is associated with the emergence of new pests (e.g. interviews 7, 8). Table 4 summarizes the main trends and their drivers in PHS performance and responsiveness, as reported by the stakeholders, in terms of the six KPIs defined in Section 2.1. These relate primarily to farmer advisory services, plant health information management, and input supply.

Table 4. Main drivers of changes in PHS performance and responsiveness in Ethiopia

Indicator	Trend (2013-2017)	Contributing factors or drivers
Timeliness	Improved timeliness in detection of pests and advice on plant health	• Modern communication technology • Improved knowledge of workforce through Plantwise trainings • Plantwise information materials on plant health • Pest monitoring system MoANR
Availability / accessibility	Improved in hot-spot areas Tigray and Oromia	• Community-based plant clinics (change in service delivery) • Local collaborations between plant doctors and input suppliers (to control regular pests) • Increased number of input suppliers due to emergence of small-scale agri-businesses
Acceptability	Improved effectiveness of recommendations and acceptance among farmers	• Improved knowledge, interest and confidence of workforce through Plantwise trainings • Plantwise information materials on plant health
Affordability	Increased use of cultural practices for pest management	• Improved knowledge of workforce through Plantwise trainings • Plantwise information materials on plant health
Coherence	Improved in Tigray and Oromia regions	• Improved knowledge of workforce through Plantwise trainings and embedding into existing structure and system • Plantwise information materials on plant health • Restructuring PHRD by MoANR
Reach	Improved in hot-spot areas Tigray and Oromia	• Community-based plant clinics (change in service delivery) • Non-Plantwise community-based plant clinics (which were out-scaled by regions) • Improved knowledge of workforce through Plantwise trainings, who also train others • Farmer-to-farmer exchange

Although the stakeholders acknowledged the positive effects of Plantwise at local level, many also commented that the approach should be out-scaled to have a substantial and noticeable effect at regional and national level (e.g. interviews 3, 22, 23, 24).

3.1 Farmer advisory services

The main focus of Plantwise in Ethiopia has been to strengthen farmer advisory services through the establishment of community-based plant clinics, training of extension workers as plant doctors, and provision of reference materials for pest identification and crop protection. According to the PHS stakeholders, the main changes observed in the farmer advisory services relate to improvements in the knowledge of the workforce and in service delivery, resulting in more effective pest management.

> Interview 21: "*In regard of the pilot of Plantwise, a lot of changes have come. Capacity of knowledge has increased in crop protection and in pest identification, and also in how they serve farmers. It has completely changed. Plant clinic communities are very different compared with non-plant clinic areas. […] They are assisting the farmers better compared to before.*"

The elaborate Ethiopian extension system has provided a unique opportunity for the Plantwise approach, as it could be superimposed on the existing extension structure. This includes Farmer Training Centres (FTCs) where extension officers carry out training and demonstrations for farmers (interview 1). However they did not previously address plant health issues because: 1) they lacked the competency and knowledge; and 2) the focus was on distribution of improved seeds and fertilizers, promoting agronomic practices, and watershed management (interview 1).

Most stakeholders provided examples of more effective pest management as a result of efforts of Plantwise as well as MoANR, including more effective treatment, and improved **timeliness** of identification (or monitoring) and response (e.g. interviews 4, 7).

The improved effectiveness in pest management has reportedly resulted in a reduction of crop losses. Survey data from Tigray suggest that crop losses due to pests have gradually reduced from 17% in 2014 to 5% in 2017 (interview 7, Report by Regional Government in Amharic). Respondents provided anecdotal evidence of production increases due to improved pest management, for example of *Tuta absoluta* in tomato which can destroy 75% of the crop (interview 12).

3.1.1 Community-based plant clinics

The community-based plant clinics were established within hot-spot areas (year-round intensive and irrigated farming with high pressure of pests), where maximum impact could be achieved.

> Interview 7: "*We have 34 woredas in Tigray. The woredas with high potential of irrigation are selected first [for Plantwise]. Of those, 10 woredas with high incidence of pests have been selected. When we notified the woredas, we let them choose the kebeles where to put the plant clinics based on irrigated land and pest incidence.*"

According to internal reports (by the time of this survey) 2,882 clinic sessions have been conducted since the start of Plantwise in Ethiopia, with an average of 3.5 queries per session

(Table 5). This is a minimum estimate as the clinic sessions are recorded on paper; and some plant doctors fail to hand over all records when they are transferred to other locations. Furthermore, activities of recently established community-based plant clinics have not been included. In addition to the Plantwise-introduced clinics, 50 community-based plant clinics have been established by the regional government of Tigray, and ten by Self Help Africa in southern regions.

Table 5. Clinic sessions conducted and farmer attendance since 2013 (40 plant clinics) – as of August 2017.

Region	Clinic sessions run	Farmers visited clinics	Av. queries per session
Oromia	1,850	3,957	2.1
Tigray	572	3,336	5.9
Amhara	460	2,900	6.3
Total	2,882*	10,193*	3.5

*These figures refer to the clinics directly set up by Plantwise and does not include those scaled up by Regions and Self Help Africa

The introduction of community-based plant clinics has improved service delivery for plant health. Before, the extension officers had to go to farmers' fields to give advice on plant health. Now plant clinics are scheduled on a regular basis (once a week or once every two weeks) and farmers bring their samples of infected crops; though the plant doctors may also provide advice outside of the clinic hours, when the FTC is open or when they visit farmers' fields (interview 1). The advice itself has also changed. Plant doctors provide advice on cultural practices for pest management, while the use of agro-chemicals is recommended only as a last resort (e.g. interview 18). As a result, farmers now apply good agronomic practices and closely monitor pests (interview 10). One plant doctor reported that 90% of the farmers buying agro-chemical inputs in the woreda followed the prescriptions of the plant doctor and used on average 10% less chemicals (interview 13).

> Interview 18: "*To give an example: we have got a training on Green and Yellow control practices. We did not know these methods before. Farmers were running to chemicals as best option. Now we can advise them on a variety of management practices, also non-chemical. Even ourselves did not know any other solutions but chemicals. […] Even when only 5% of the field was affected [farmers] ran to chemicals. Now they are aware of the cultural practices and know chemicals are last option.*"

Both plant doctors and farmers reported that the **timeliness** of diagnosis and recommendations for treatment has improved. This is due both to the improved knowledge and materials on pests and diseases, and to new technology (in particular smartphones) that allows for quicker communication between plant doctors and crop protection experts through social media (e.g. interview 16). The plant doctors are now able to give accurate and effective advice; and farmers now seek their advice and implement it (e.g. interviews 16, 17, 20). The improvement in advice was also mentioned by farmers in the interviews regarding the KPIs, indicating the **acceptability** among farmers of the advice given.

> Interview 16: "*Now every farmer comes to the clinic and gets advice. Before, there were more pests in the fields of the farmers, but now the control of the pest is good with the advice of the plant clinic, so productivity is increased.*"

> Interview 20: "*Previously farmers would not ask advice but go to town to look for chemicals without having samples and just describe the problem to the agro-dealer who would give them whatever chemical. Now farmers come to me (PD) and I give recommendations for treatment.*"

However, this is not the case for all farmers, as a plant doctor in Oromia reports (interview 20).

> Interview 20: "*Farmers are used to a particular known chemical, and they don't accept if I recommend another product. They still take the product they know and this may fail.*"

Another change has been that some farmers manage pests through cultural practices first, before spraying chemicals, as this story on a recent TV program shows:

> Interview 6: "*But the new pest (Fall Armyworm) that is introduced this year, I was hearing on TV about how farmers are trying to tackle the pest. They were trying to use the options that they can do easily. They were trying to limit the pest population. That means that farmers have developed some knowledge on how to control pests. Sometimes they may wait until it eats half their field and start controlling late. But what I heard on the TV, they were monitoring every day and tried to control the pest in early stages. They were taking cultural measures before spraying – that is new.*"

Some plant doctors reported that farmers from neighbouring kebeles also visit the plant clinics and crop experts share their knowledge and information sources with their colleagues (interviews 16, 21), further increasing the **availability** of plant health advice to farmers. However, these spill-over effects are limited, with positive changes mainly remaining within the kebele where the plant doctor is based.

Given that plant health was previously ignored by many extension officers due to lack of knowledge and accountability, the **reach** has now improved considerably in selected hot-spot areas in Tigray and Oromia. One plant doctor reported that previously he gave advice on plant protection to five to six farmers per month, but how he advises about seven farmers per week in the plant clinic (interview 10). Plant doctors also give advice to farmers outside of the plant clinics, but do not always record this (interview 20). The farmers also reported that 25-40% of households in their kebeles use the plant clinics. Because the recommendations of the plant doctors are effective, farmers increasingly share this information between themselves (interviews 10, 13, 18), further increasing reach: one farmer estimated that advice would be shared with 5-10 other farmers. Plant doctors also reported they have reached an additional 500 farmers on average through community meetings to raise awareness on plant health.

Box 2. Staff turnover among plant doctors

In Tigray, out of the 30 extension officers that were trained as plant doctors, 11 have been transferred to other positions (37%) since the first training in 2013. Four of the 11 have been replaced with new plant doctors (interview 7).

In Oromia, an estimated 30% of the trained plant doctors have been transferred (interview 21).

One of the identified barriers to achieving sustained impact within the advisory services is the high turnover of staff within MoANR and the regional BoANRs, as well as among plant doctors (Box 2). Many respondents noted the constraints that plant doctors face in their role, in particular the workload and the turnover of staff, as extension officers are regularly transferred to different locations or positions (e.g. interviews 4, 8, 10, 12, 13). Some plant doctors mentioned that they did not want to move to another kebele where there is no plant clinic, and requested permission to remain in their current kebeles (e.g. interview 13). The high turnover means not only that new extension officers need to be trained as plant doctors, but also that commitment amongst their superiors needs to be nurtured again if new staff or officials come into these positions (interviews 1, 7, 21).

The farmers who were interviewed regarding the performance and responsiveness of the PHS were all involved in intensive farming of cereals and horticultural crops on irrigated land. They reported the following pests and diseases on their crops:

- root rot on pepper;
- blight, bore worm and *Tuta absoluta* on tomato;
- thrips and shoot flies on onion;
- stalk borer and aphids on sorghum and maize;
- shoot fly on teff;
- rust on wheat;
- mildew on potato;
- fall armyworm.

They all commented that they struggled to protect their crops and manage pests before the plant clinics were established. Treatments were based on trial and error, whereas now the plant doctor's recommendation solves the problem in most cases (interviews 11, 14, 19). The farmers from Genfel, Tigray, also reported that they changed their agronomic practices on the advice of the plant doctor: reducing the amount of irrigation water has reduced the incidence of pests. The same farmers complained, however, that the prescription sheets are bulky to read. Another complaint was that visiting the plant clinic, getting the prescription and then buying the agro-chemicals takes a long time (up to 1.5 hours)

Overall, farmers reported a considerable improvement in the PHS performance and responsiveness, and a decrease in the usage of agro-chemicals as they improved their agronomic practices for better pest management, based on advice they received at the plant clinics. However, the associated cost reductions were considered negligible compared to the yield increases (interview 11, 14). The farmers appreciated the improved productivity and increased revenues, although some made it clear that the increases were not only due to the improved plant health, but also to other changes in farming practices and marketing. The following examples were given:

- Previously, farmers harvested 1 ton of onion from 0.25 ha, and made a net profit of USD 109. Now they harvest 2 tons, with a net profit of USD 508. However, this increase is not only due to the plant health advice of the plant doctors; the farmers are also better organized and have engaged in collective marketing (interview 11).

- Wheat production has substantially increased due to row planting, improved varieties, and application of the right herbicides and agro-chemical inputs as recommended by the community-based plant clinic. Previously the farmers harvested 1.2 tons of wheat per ha; this has now increased to 3.2 tons per ha (interview 19).

- Farmers harvested 70 boxes of tomato per 0.25 ha before, now 200 boxes up to 267 last season. This increase is due to the support on appropriate agronomic practices (e.g. improving soil fertility, timely ploughing), and the right recommendations on pest control and agro-chemical inputs due to the community-based plant clinics (interview 14).

3.1.2 Plant doctor training

The extension officers responsible for crop production are supposed to provide advice on plant health, but often lack the knowledge and the incentives as they do not have to report on this as a specific activity under the current extension system (interview 1). Plantwise addresses this knowledge gap by building the capacity of the existing workforce. So far, 270 extension officers, as well as crop protection experts at woreda, zonal and regional levels, have participated in the Plantwise plant doctor trainings (e.g. interviews 8, 9, 12). All plant doctors confirmed that their knowledge and capacity in pest diagnosis and plant health recommendations had been improved due to the training, manuals and reference materials provided by Plantwise (e.g. interviews 12, 16, 21).

> Interview 12: *"Before we were not sure what to do. Now I can recommend with knowledge."*

> Interview 21: "*There is quite a change. Before training I was not quite sure myself, but after the training I upgraded my knowledge. Also the other plant doctors and experts are quite different from previous. It is a complete change. In regard of competency we may not be 100% competent, there are still some gaps. But it is better, not yet best. 75-80% are better from previous.*"

The plant doctors also reported that they now have more confidence in what advice to give, resulting in increased trust and loyalty of the farmers (interviews 10, 13, 16, 18, 20). The farmers similarly reported increased **coherence** in the advice offered by trained plant doctors. Plantwise training has increased the interest of plant doctors in crop protection: previously, their main focus was on agronomy and production (e.g. interview 20). It is also seen as more in-depth and practical than other trainings available to extension officers. The Plantwise training approach was widely appreciated and is being replicated within the Crop Protection Directorate in Tigray (interviews 8, 12).

> Interview 8: "*Those who received the CABI training, they adopt the [teaching] material but also the learning process. They take on the teaching methodology. Previously it was just a lecture; it was not participatory. Now we make two-way communication, the trainer gains knowledge from the participants and the other way around. There is more practical, more exercises, more pictures.*"

Some respondents made specific recommendations for further improvement of the Plantwise approach, such as incorporating demonstrations on pesticide application (interview 9) or supplying agro-chemical inputs near the plant clinics (interview 14). Some farmers noticed that certain pests become resistant to agro-chemicals, so they requested improved disease-resistant varieties of tomato and onion (interview 19).

3.2 Plant health information management

At present, Ethiopia does not have a national digital system to process and monitor plant health information, and there is a shortage of professionals who can provide pest identification services. As a result, the status of regular pests around the country is not fully known, and the emergence of new pests may go unnoticed until they cause significant economic damage to crops (MoANR, 2015). Information flow may depend on a chain of particular individuals within various administrative bodies who pass on information.

The Government is responsible for monitoring and surveying migratory pests, in particular desert locust and African army worm, in order to forecast outbreaks and give early warnings (interviews 1, 4). The MoANR conducts seasonal surveillance for migratory pests in hotspot areas where pest incidences are high. This data allows MoANR to provide forecasts and send out early warning messages to farmers through SMS. SMS messages are also used by farmers who monitor their crops for regular pests such as wheat rust (interview 4). The BoANRs conduct seasonal surveys on crop production and regular pest problems (interviews 3, 4, 8). When a new pest emerges, extension officers report this to the nearest agricultural office, who in turn report to the BoANR (interview 3). However, these monitoring activities are patchy for regular pests. MoANR is currently contracting consultants to develop ICT systems to create a national database (with regional access) to store data and exchange information more effectively (interviews 3, 4).

Box 3. Data entry challenges: an example

The regional coordinator in Tigray entered data from 306 prescription forms in 2016 (from 10 plant clinics) to carry out an analysis on the major crops, pests and recommendations made. Translating and entering the data took 10-15 minutes per form, thus 68 hours. This was done outside the normal working hours as data entry is not part of his day-to-day tasks. He is the only person in Tigray who can enter the data, as the woreda crop protection experts have neither the computers nor the ICT skills required (pers. comm. Michael, 16/08/2017).

On-the-ground monitoring by MoANR has resulted in a reduced incidence of African army worm and wheat rust in Ethiopia, and consequently a reduction in pesticide use, according to a senior staff member of MoANR (interview 4).

Community-based plant clinics also help with the regular monitoring of both regular and migratory pests at grassroots level. Plant doctors note the pests in their locality and take this into account in their planning of extension activities for the next season.

> Interview 8: "*The data obtained at plant clinics can be used [by plant doctors] for planning at grassroots level. They can see the number of pests identified this year for each crop, so next year they can plan for inputs, extension activities. They know the major pests in the kebele and what inputs are needed.*"

The Plantwise data management system (POMS) could be used to aggregate, validate and analyse this data. However, in practice clinic data mostly remains on paper and is not entered into POMS due to data entry challenges, including lack of staff, limited English language and ICT skills of plant doctors, and lack of ICT equipment at local level (Plantwise, 2016; interviews 1 and 7: see also Box 3). In 2017, only 147 queries from nine different community-based plant clinics were recorded in POMS. Five tablets have been purchased

and given to plant doctors in 2017 so that they can enter data directly during the clinics, but more tablets will be required to significantly speed up data entry. Plantwise is also planning to accommodate local languages such as Amharic in the POMS database in the near future (interview 1).

3.3 Diagnostic services

Regional plant health clinics (labs) are supposed to provide diagnostic and technical support in pest management to extension officers and farmers, but these are under-resourced and the laboratories poorly equipped (MoANR, 2015). It is only in recent years that some regional governments have started investing in upgrading the regional plant health clinics. At present, there are 16 regional plant health clinics in Ethiopia. Staff of these clinics were supposed to conduct surveys, identify pests, prepare pest lists for major crops, train farmers and other extension staff, and give feedback to the national Directorate about regional problems (interview 4).

Respondents reported that the **quality** and **accuracy** of diagnostic services by plant doctors and local crop protection experts has improved due to the training and reference materials provided by Plantwise (e.g. interviews 12, 16, 17, 21). The manuals, reference materials, and pictorial guides (photosheets, field diagnostic guides) that can be used for diagnosis are much appreciated by the plant doctors. They are also provided with a camera, knives, hand lenses, and other equipment to help them with diagnosis of pests and diseases. Before Plantwise, they only had one generic crop manual which was insufficient to guide them in pest management and crop protection. Under Plantwise, more diagnosis is now done at grassroots level by plant doctors (interviews 4, 17).

> Interview 17: "*Before we would ask zonal level or regional level for support for diagnosis and they would explain about the pest by giving information by letters. But it was not enough; it was very difficult to diagnose pests. Now we can diagnose the pest and give advice to farmers like IPM.*"

When plant doctors come across a new pest or disease in their kebele, they report it to the BoANR at woreda level, either bringing a sample or describing the symptoms in a letter or e-mail (sometimes with pictures). They typically get a response within three days with the identification and recommendation. If the woreda crop protection expert does not know the pest, it will be passed on to zonal level within BoANR. The plant doctors were content with the effectiveness of this chain. But some plant doctors also reported that they were now less dependent on the knowledge of the crop protection experts at woreda and zone level. One explained that with the coloured identification manuals she can identify pests herself and only sends requests for identification to the crop protection expert at the woreda office once every six months. Before, she would send ten requests in the same time period (interview 16). The improved grassroots capacity in diagnosis of pest problems also allows the crop protection experts and extension officers to focus on prevention rather than cure (interview 12).

Diagnosis of pests is now quicker than it was previously due to developments in ICT technology. Extension officers and crop protection experts increasingly use internet resources for information (including the Plantwise Knowledge Bank) and exchange information through mobile technology (using social media, SMS, WhatsApp etc.).

Interview 16: "*We get a response now in three days through internet and social media. Before it would take one month because more days were needed to identify the pest, and communication was slower.*"

The regional plant health clinics in Tigray and Oromia also observed an improved awareness of pests and more effective diagnosis. This is the combined effect of Plantwise, of renewed investments of MoANR, and the increasing awareness of farmers on pest management (interviews 7, 21).

Interview 7: "*[…] before we were idle. Now we give effective identification and recommendation due to the new equipment received. Farmers are more aware of the effect of plant pests. Before they did not recognize pests; they harvested what they got. But now they understand how plant pests reduce productivity. So the [regional plant health clinic] laboratory becomes more responsible to identify [pests] and recommend appropriately.*"

Although linkages between the farmer advisory services and other PHS functions are still weak, there is a willingness to strengthen these relationships. An example is the opportunity to link the community-based plant clinics with the regional and national crop protection laboratories that are hosted by the regional plant health clinics.

Interview 4: *"For future, we want to build strong relationships with plant clinics. We want to advance the laboratories at national level with upgraded equipment and staff training. We aim to make the link for the clinics to support each other. [Regional] plant health clinics can guide and assist [community-based] plant clinics."*

3.4 Research and technology development

There has been little change in the research and technology development sector in Ethiopia in recent years. Crop protection experts at research institutes reported no change. Lack of financial resources, lack of trained manpower in crop protection, limited research facilities, and the need to import supplies for diagnostic research were mentioned as constraints to research on crop protection or when some pest outbreaks occur (interviews 6, 21, 24). Some respondents were of the opinion that research in this area had even weakened over the years, as research capacities deteriorated (interviews 7, 21).

When new technologies for pest management are being developed by researchers, dissemination is also an issue.

Interview 23: "*We have some biocontrol technologies but they are on the shelves. They are not taken to farmers. […] The system doesn't allow us to train farmers. Only DAs and agricultural experts train farmers.*"

The linkages between extension and research are not very strong. Researchers were of the opinion that their linkages with MoANR and extension could be improved (interviews 6, 23, 24; MoANR, 2015): at present, they only meet at national conferences or at workshops on crop protection (interview 6). Plantwise, however, has created links and established working relations with national and regional researchers in crop protection and plant health. Researchers are invited to training-of-trainers events and workshops to develop plant health information materials and crop manuals. In addition, Plantwise has integrated plant health practices and technologies, developed by regional and national research centres, into

extension materials for Ethiopia. Researchers have also agreed and are ready to give diagnostic support to plant doctors. However, the relationship is loose, and so far there has been no perceived influence on the research agenda (interview 1).

3.5 Input supply

In rain-fed agriculture in Ethiopia, input use is low as farmers predominantly use cultural practices to manage pests (interview 16). In irrigated and commercial agriculture, however, the use of pesticides to manage and control pests is more common (MoANR, 2015). Most agro-chemicals used in Ethiopia are imported, and there has been a rapid increase in imports in recent years, in particular of insecticides and herbicides. The private sector is responsible for two-thirds of the distribution of herbicides, insecticides and fungicides to smallholder farmers (Tamru et al., 2016). Respondents reported that more input suppliers were emerging in recent years as the demand for agro-chemical inputs increases due to an expansion of intensive irrigated agriculture, and as small businesses increase in number (interviews 7, 12, 21).

> Interview 21: "*Four to five years ago there were little inputs for crop protection. Nowadays a lot of inputs are available because of the increasing pest problems. If you take Tuta absoluta, it is a newly emerged pest. After recommendation by research, the new inputs have become available. […] Not only the government supplies the input, but also agro-dealers and private sector actors according to their capacities. One company may supply herbicides, other fungicides and pesticides. This happened over the last three to four years. Gradually it is improving.*"

The MoANR issues a list of registered pesticides on an annual basis. Adulteration of agro-chemicals, however, results in poor quality and ineffective pest management (Tamru et al., 2016; interviews 6, 7). The regulatory authorities lack capacity and resources to ensure proper design and implementation of regulatory policies for agro-chemicals (Tamru et al., 2016). In order to address irregularities in input supply and to control illegal practices, a regulation on agro-dealers was initiated by the regional government in Tigray in 2015, but implementation has been slow (interview 7).

> Interview 7: "*The Government tries to regulate the illegal traders, but the implementation of this regulation is not yet very active. Plant protection experts monitor the activities of illegal traders, but there is no full control yet.*"

Plantwise intervenes indirectly in input supply at local level. Plant doctors are encouraged to teach farmers about the dangers of misuse of chemical pesticides and to recommend non-chemical pest management options. They are also encouraged to work with local input suppliers (agro-dealers, unions, farmer cooperatives). to ensure an appropriate supply of agro-chemical inputs They advise the agro-dealers on what agro-chemicals to stock, provide forecasts of demand based on the local prevalence of specific pests and diseases (interviews 1, 7), and refer farmers to these agro-dealers to buy the inputs. The input suppliers sell the certified inputs according to the prescriptions of the plant doctors. The agro-dealers are willing to collaborate as the plant doctors' referrals and the regulation of illegal traders is to their advantage (interviews 10, 20). In this way, plant doctors confirmed that the **availability** and **accessibility** of agro-chemical inputs has improved at local level (interviews 10, 13); and this was confirmed by the farmers' own observations. However, these

collaborations are scattered, and the accessibility of inputs remains an issue for many farmers in Ethiopia (interview 6).

> Interview 6: "*The accessibility and affordability of plant protection products [chemical inputs] is an issue. The Green and Yellow lists recommend the less toxic products, but farmers may not have the chance to get different alternatives. They may be available but not affordable to farmers. The packaging system could be a problem. The chemicals are in 5 litres, so farmers may have difficulty in buying because it is too large and expensive. The chemical market chain could be an issue. The MoANR is distributing the chemicals through farmer cooperatives, so they may only provide a few alternatives. There are shops in big towns, agro-chemical dealers, but they have their own problems with the legality of products.*"

Promotion and implementation of non-chemical pest management practices has been limited in the past (MoANR, 2015). However, the advisory services increasingly recommend application of cultural practices first and use of agro-chemical inputs as a last resort only to control pests (e.g. interview 4). Although little was mentioned in the stakeholder interviews regarding **affordability**, the fact that the **timeliness** of pest management has improved, and that more agronomic methods are introduced (or are considered as a first option), one could deduce that pest management has become more affordable to farmers. Market prices of pesticides, however, are increasing. Farmers mentioned that inputs supplied by agro-dealers are more expensive than those supplied by the Government; and that although prices are increasing, the extra cost is worthwhile as they are now able to use the inputs more effectively.

New NGO initiatives (SNV/Croplife, GIZ) are emerging that train farmers in pesticide spraying and provide them with spraying equipment and personal protective clothing, so they can become local service providers offering spraying services to other farmers in the local communities (interview 21).

3.6 Policy, regulation and control

The federal and regional governments in Ethiopia are increasingly concerned about the devastating impacts of newly emerging pests on the national economy and on biodiversity (MoANR, 2015).

The creation of the Plant Health Regulatory Directorate (PHRD) in 2014 increased the manpower of MoANR and strengthened its mandate for crop protection, enabling it to address pest problems more effectively (interviews 4, 21). MoANR also started to take action to reinvigorate the PMSS, including restructuring and relocating it to PHRD in order to improve pest management support across the country (MoANR, 2015). Although **coherence** was not explicitly mentioned by respondents, the establishment of the PHRD to align policies and regulations for plant health, the capacity building in plant health at multiple levels, and the increased interactions between stakeholders (extension, research, input suppliers, NGOs) all point to an effort to improve coherence within the PHS, particularly in Tigray and Oromia.

Plantwise was embedded within the changing structure of the Federal MoANR (interview 21). Although it is not directly targeting policy or regulation, the implementing staff of Plantwise are also employees of the crop protection departments of MoANR and BoANRs, so a natural

exchange of knowledge takes place. This allows the integration of Plantwise knowledge into the strategies and activities of MoANR and BoANRs.

At lower administrative levels, however, there has been little change so far in manpower or mandate. One respondent commented that in non-Plantwise areas improvements in policy and regulation are discussed at district and regional level, but not implemented at the local level. This is why it was thought that the Plantwise programme is needed to make a bridge between policy and local implementation to achieve positive change at local level:

> Interview 22: "*In recent years there has not been much change [in crop protection and pest management]. Farmers are not aware of crop pests and diseases. Most change [in policies] is at district and regional level. There is a gap between that level and farmers. Plantwise can fill this gap with its new approach of plant clinics.*"

There is still little regulation on pest control, but the Federal Government is working on new regulation regarding quarantine and pesticides (interview 21).

> Interview 21: "*The regulations are being prepared now at national level and will be declared soon. […] The regulation encompasses both pesticides and quarantine of pests. We want to stop early movement of pests. Now the country's border is porous; anything can enter from different directions. In regard of pesticides, we want to control the use and supply as it is not standardized. Now any product is supplied by anyone. There is no separation of pesticides from food items etc. This regulation is a critical one.*"

At present, there are community-based plant clinics in only three of the nine regions in Ethiopia: Tigray, Amhara and Oromia. MoANR is committed to replicating the approach in other regions.

> Interview 4: *"We want to scale up the program. […] This is the best approach to assist farmers in environmentally safe and sound solutions to crop pests. The Plantwise programme is included in annual plans of the directorate and experts are assigned to it. […] We want to scale up gradually to all major crop growing regions."*

The regional governments in Tigray and Oromia replicate the Plantwise approach in other woredas using their own funding. In Tigray, a total of 66 kebeles are serviced by plant doctors of which 50 are financially supported by the regional government (since 2015/2016). The regional government aims to expand to 100 community-based plant clinics (interview 8). Oromia has an ambitious plan to outscale to 200 community-based plant clinics in three years, as well as establishing one regional referral plant health clinic (interview 21). Other regional governments, however, are slow in integrating the approach in their own extension activities, although there is some interest (interviews 3, 8).

Support from administrative bodies is an important factor to provide effective plant health policies and services. Community-based plant clinics are most effective when the authorities at kebele and woreda levels acknowledge the importance of plant health and support the community-based plant clinics (interview 7).

> Interview 2: *"When there is commitment at high level for plant protection, the implementation is easier. […] If there is no buy-in from higher officials, the [Plantwise] approach is useless."*

Interview 7: "*Community-based plant clinics that perform best have high attention by administrative bodies. They consider this service as crucial for productivity of farmers. But in other woredas, plant doctors are given other assignments and cannot keep the schedule. The attention is the major factor for the performance of the plant clinics. Otherwise, the knowledge of the plant doctor is the same. But the schedule is different depending on the authorities*."

Plant doctors confirmed the importance of governance and leadership. Staff changes in leadership positions at woreda level affect the commitment of local authorities, and thus support for plant doctors (interview 10). When local leadership does not fully understand the importance of crop protection, other activities (e.g. distribution of fertilizers, natural resource management) get priority over the training of farmers on plant health (interview 13). Conversely, supportive administration at kebele level can help to mobilize the community and raise awareness about the plant clinic (interview 16).

3.7 Overview of performance and responsiveness of PHS functions

The effects of Plantwise on the performance and responsiveness of PHS functions are summarised in Table 6.

Table 6. Observed changes in performance and responsiveness of PHS functions due to Plantwise

Function	Timeliness	Availability	Affordability	Acceptability	Coherence	Reach
Advisory services	Strong improvement at local level	Strong improvement at local level	Strong improvement at local level	Strong improvement at local level	Strong improvement at local level	Improvement at local level
Plant health information management	No impact	Limited impact at local level.	No impact	Limited impact at local level.	No impact	No impact at local level
Diagnostic services	Improvement at local / regional level	Improvement at local / regional level	No impact	Improvement at local / regional level	Improvement at local level	Improvement at local level
Research and technology development	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Input supply	Improvement at local level	Improvement at local level	Not applicable	Improvement at local level	Not applicable	Not applicable
Policy, regulation and control	Not applicable	Not applicable	Not applicable	Not applicable	Improvement in knowledge and expertise of staff at national and regional levels	Not applicable

Conclusions

Changes in the PHS due to Plantwise were mainly observed at local level, in communities where plant doctors had been trained and community-based plant clinics introduced. The most significant changes have been to farmer advisory services, diagnostic services and input supply, all of which have been strengthened through capacity building and improved collaboration between stakeholders.

4.1 Farmer advisory services

The establishment and operation of 40 community-based plant clinics, and training of extension workers as plant doctors, has greatly enhanced the ability of the extension service to deliver plant health advice. MoANR had recognized that there was a knowledge gap among extension workers on plant health, and this is now being effectively addressed with Plantwise trainings and information materials in the regions of Amhara, Oromia and Tigray where the programme is active. The strengthened capacity of the extension workers is improving the identification and monitoring of plant health problems, and farmers now receive prompt and relevant advice when they face pest problems. At local level, this results in reduced crop losses. The increased productivity is partly related to better pest management, partly to an overall improvement of agronomic practices and collective marketing in some places. The community-based plant clinics provide an allocated space (in time and in location) for plant health advice, but given the permanent presence of the extension workers in the kebeles it could be questioned whether plant clinics have an added value or not. The main benefit seems to be that with the community-based plant clinics, plant health becomes part of the portfolio of extension workers, so it is no longer neglected. The influence of Plantwise on other extension providers (e.g. NGOs) is still in its infancy; Self Help Africa is the first NGO to collaborate with Plantwise (and MoANR) in a new programme.

4.2 Plant health information management

In Ethiopia, MoANR is responsible for pest surveillance and monitoring, both of seasonal migratory pests and of regular crop pests. For regular pests, monitoring is patchy owing to a lack of expertise in pest identification. Plant clinics can provide additional pest incidence data, and plant doctors currently use local data to plan their extension activities. The Plantwise data management system (POMS) could be used to manage this data and make it available for nationwide surveillance efforts, but at present its use is limited by language issues and difficulties in uploading data from the paper forms used at the clinics. Further roll-out of tablets for electronic data capture at the plant clinics (‘e-clinics’) would greatly improve the management of plant health information from the community-based plant clinics in Ethiopia.

4.3 Diagnostic services

Pest diagnosis has traditionally been the remit of the regional plant health clinics, but these are poorly-equipped and under-resourced. In the Plantwise areas, pest diagnosis has been greatly improved by the ability of the trained plant doctors to diagnose pests as they appear

at the clinics. If they are unable to make a diagnosis themselves, they can seek help through BoANR or using a range of internet resources, including the Plantwise Knowledge Bank. They can also exchange information with other plant doctors through SMS or social media such as WhatsApp.

4.4. Research and technology development

Plantwise has had little influence on plant health research capacity and priorities in Ethiopia, despite having fostered links with researchers for diagnostic support and to assist with training and development of information materials and manuals.

4.5 Input supply

Plant doctors advise farmers on safe use of pesticides, and recommend non-chemical management options. At local (kebele and woreda) level, some plant doctors engage with agro-dealers to make sure that registered and effective agro-chemical inputs are supplied. In this way they are building a small local network of trusted agro-dealers, where farmers can purchase the agro-chemical inputs which are recommended by the plant doctors. PHS stakeholders, including farmers, reported that Plantwise has improved farmers' access to quality agro-inputs, and the way in which they are used.

4.6 Policy, regulation and control

In Ethiopia, MoANR is responsible for plant health regulation and control, and the associated policies and structures are currently being revised. Plantwise came at an opportune time, where it contributes to a more effective plant health system by strengthening the capacity of crop protection experts and extension workers. However, increasing pest problems and pressure from farmer organizations were cited as main drivers of the changes in policy and regulation. Plantwise contributes to these ongoing changes by feeding knowledge and information into the system.

National and regional governments and NGOs have recently (since 2015/2016) started to incorporate the Plantwise approach into their own programming and budgets. This will help to promote system change, but at present still depends on the commitment and efforts of individuals in key positions.

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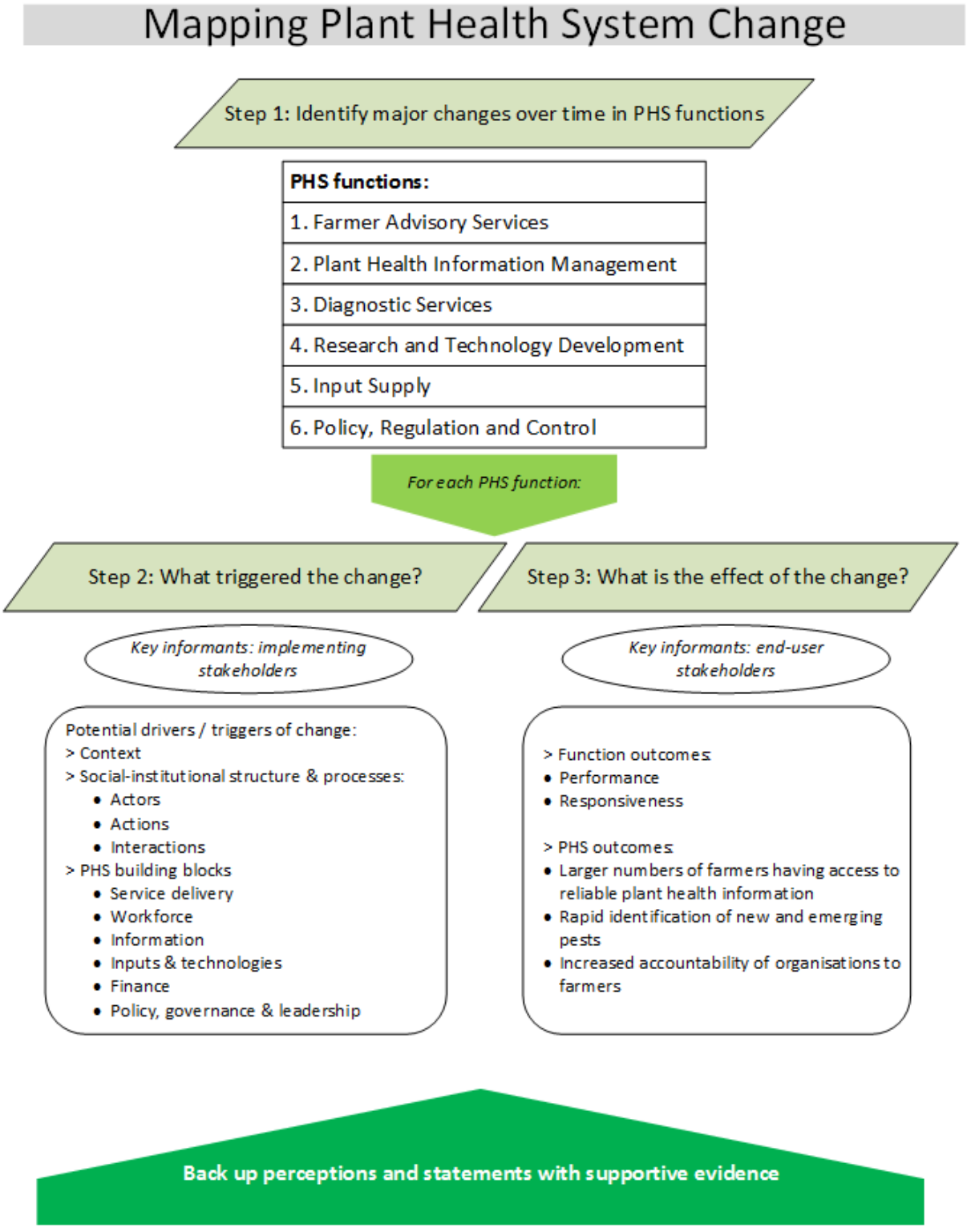
Annexes

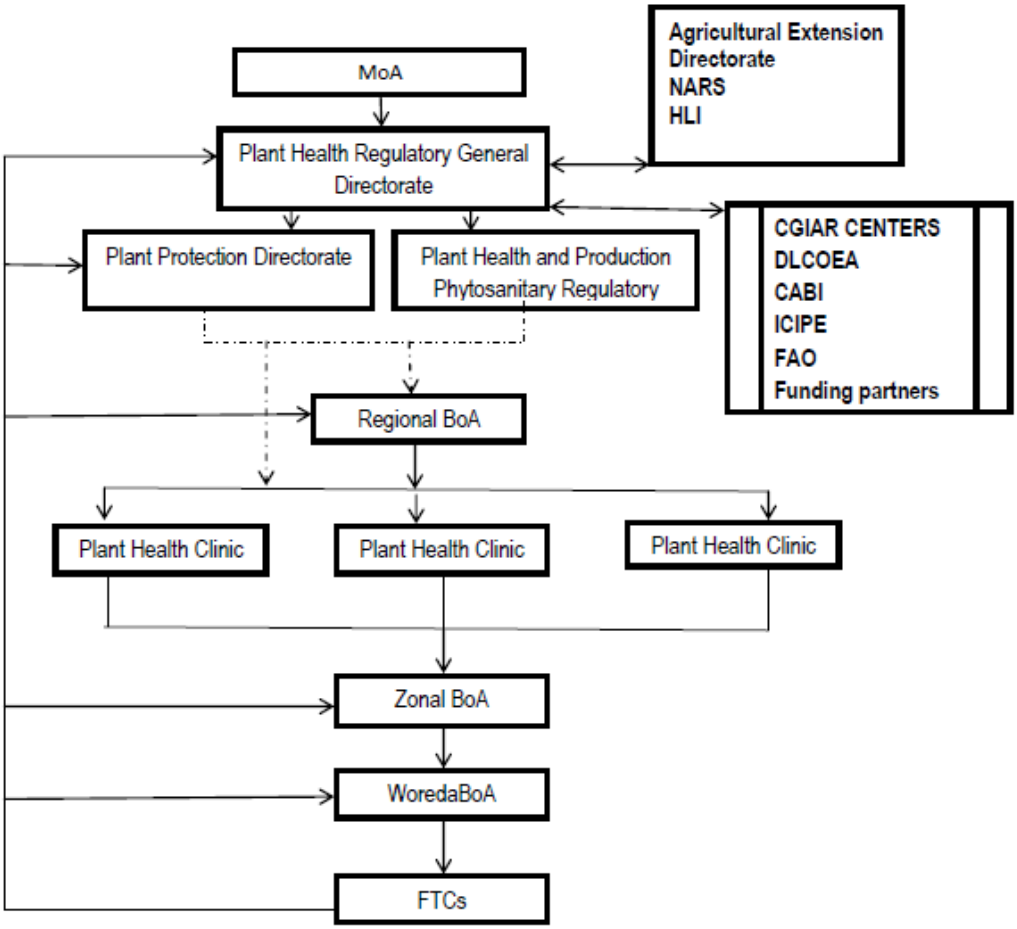
Annex 1. Methodological steps to reconstruct the PHS narrative on system change



Annex 2. Overview of respondents in Ethiopia

Interview	Stakeholder	Duty station	Date
1	CABI country coordinator	Addis Ababa	14/8/2017
	National coordinator Plantwise	Addis Ababa	14/8/2017
	National data manager Plantwise	Addis Ababa	14/8/2017
2	Former national coordinator Plantwise	Addis Ababa	14/8/2017
3	Director General Plant Health Regulatory Directorate (MoANR)	Addis Ababa	14/8/2017
4	Director Plant Protection directorate (MoANR)	Addis Ababa	14/8/2017
5	Programmes Manager, Self Help Africa	Addis Ababa	14/8/2017
6	Lecturer Ambo University	Ambo, Oromia	15/8/2017
7	Regional coordinator Plantwise (Tigray)	Meleke, Tigray	16/8/2017
8	Former head of Crop Protection and regional plant health clinic (Tigray)	Meleke, Tigray	16/8/2017
9	Regional expert in crop protection (Tigray)	Meleke, Tigray	16/8/2017
	Regional pesticide application expert (Tigray)	Meleke, Tigray	
10	Plant doctor (Kilita Awlealo woreda)	Kilita Awlealo, Tigray	16/8/2017
	Plant doctor (Kilita Awlealo woreda)	Kilita Awlealo, Tigray	
11	Two farmers (Genfel kebele)	Kilita Awlealo, Tigray	16/8/2017
12	Head of crop protection (Southern zone), Tigray	Ofela, Tigray	17/8/2017
	District crop protection expert (Ofla woreda)	Raya Azebo, Tigray	
	District crop protection expert (Raya Azebo woreda)	Raya Azebo, Tigray	
13	Plant doctor (Werebaya kebele)	Raya Azebo, Tigray	17/8/2017
	Plant doctor (Warigba kebele)	Raya Azebo, Tigray	
	Plant doctor (Sesela kebele)	Raya Azebo, Tigray	
14	Three farmers (Warlgba kebele)	Raya Azebo, Tigray	17/8/2017
15	Agro-dealer Raya Azebo	Mohoni, Tigray	17/8/2017
16	Zonal crop protection expert (South Eastern zone)	Maichew, Tigray	18/8/2017
	District crop protection expert	Sarte Samire, Tigray	
	Plant doctor Sarte Samre woreda	Sarte Samire, Tigray	
17	Zonal crop protection expert (South West Shewa)	SW Shewa, Oromia	21/8/2017
	District crop protection expert, Wolliso	SW Shewa, Oromia	
18	Plant doctor (South West Shewa)	SW Shewa, Oromia	21/8/2017
	Plant doctor (South West Shewa)	SW Shewa, Oromia	
19	Two farmers (South West Shewa), Obi Koji and Denbali Keta		21/8/2017
20	Zonal crop protection expert (West Shewa),	Ambo, Oromia	22/8/2017
	Plant doctor (Toke Kutaye woreda)	Toke Kutaye, Oromia	
21	Regional coordinator & Director of crop production and protection, Regional Bureau Oromia	Addis Ababa (Oromia)	22/8/2017
22	Researcher Sinana Agricultural Research Center, Oromia ARI	Sinana, Bale, Ormia	23/8/2017
23	Former Director of Ambo National Crop Protection Research Center (EIAR)	Ambo, Oromia	23/8/2017
24	Researcher of Ambo National Crop Protection Research Center (EIAR)	Ambo, Oromia	23/8/2017

Annex 3. Organogram of public crop protection and pest management services



Annex 4. PHS stakeholders in Ethiopia

PHS function	Stakeholder	Level	Mandate / role	Role in PHS
1. Farmer Advisory services	Extension Directorate (MoANR)	National	Implementation of pluralistic extension system	Policy formulation for extension services
	Regional Bureau of Agriculture (MoANR)	Regional	Information dissemination	Workforce (plant doctors)
	Crop Protection Agency	Regional	Monitor pests, advisory services on crop protection	Local implementing organization plant clinics
	NGOs	Regional	Technical assistance and capacity building	Collaboration to outscale plant clinics
	Extension agents	Woreda	Provide agricultural advisory services to farmers	Plant doctors
	Agro-dealer stockists (companies)	Woreda	Input supply	Input suppliers
2. Plant health information management	PHRD (MoANR)	National	Regulation and implementation of plant protection services	Policy and regulation, national host of Plantwise
	Bureau of Agriculture	Regional	Agricultural development, incl. crop protection.	Workforce (extension officers)
	Regional (local) Government Crop Protection and Extension Agency	Regional	Hosting regional plant health clinics	Local implementing organization, responsible for plant clinics
3. Diagnostic services	PHRD (MoANR)	National	Regulation and implementation of plant protection services	Monitoring of migratory pests
	Research organizations	Regional	Research and diagnostic services	Technical and diagnostic support
	Plant Health Clinics	Regional	Diagnosis of plant pests and diseases; reports to Bureau	Diagnostic support
	Extension agents	Woreda	Provide agricultural advisory services to farmers	Plant doctors
	Agro-dealer stockists (companies)	Woreda	Input supply	
4. Research & technology development	Research organizations	Regional	Research and diagnostic services	Technical and diagnostic support
5. Input supply	PHRD (MoANR)	National	Regulation and implementation of plant protection services	Lead partner Plantwise program; hosting chair of Plantwise steering committee
	AISCO	National	Input supply	
	Farmers Union Cooperative	Regional	Input supply	
	Agro-dealer stockists (companies)	Woreda	Input supply	
	Extension agents	Woreda	Provide agricultural advisory services to farmers	Plant doctors
6. Policy, regulation & control	PHRD (MoANR)	National	Regulation and implementation of plant protection services	Lead partner Plantwise program; hosting chair of Plantwise steering committee
	MoANR	National	Agricultural development	
	Council of ministers	National	Policy	
	Bureau of Agriculture	Regional		Local implementing organization, responsible for plant clinics

(based on Williams and Efa, 2016)

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