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CABI plantwise

Plant clinic data management

An assessment of the use, management and functioning of the Kenyan Plantwise Data Management System

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Cover photo

Embu Plant Clinic, Kenya. Plant doctors advising farmers visiting for the first time. *Photo*: Jacqueline Sluijs

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Abbreviations

AAK	Agro-input dealers Association Kenya
CABI	Centre for Agriculture and Biosciences International (UK)
CC	Cluster Coordinators
CDA	County Government Director of Agriculture
CDO	Plantwise County Desk Officer
DMS	Data Management System
FEO	Farmer Extension Officers
FGD	Focus Group Discussion
ICT	Information and communication technology
IPM	Integrated Pest Management
KALRO	Kenya Agricultural and Livestock Research Organisation
KEPHIS	Kenya Plant Health Inspectorate Service
KM	Knowledge Management
M&E	Monitoring & Evaluation
MLND	Maize Lethal Necrosis Disease
MOALF	Ministry of Agriculture Livestock and Fisheries
NSC	National Steering Committee
PC	Plant Clinic
PCPB	Pest Control Products Board
PD	Plant Doctor
PHIS	Plant Health Information System
PMDGs	Pest Management Decision Guides
PPSD	Plant Protection Services Division
PW	Plantwise
PW-K	Plantwise Kenya
SCAO	Sub-County Agricultural Officer
VFM	Value for Money

Summary

This report presents the findings of a study carried out in Kenya in order to: 1. understand how plant clinic data are managed, perceived and used by partners; 2. identify key challenges and opportunities for improving systems for plant clinic data management and use; and 3. identify key criteria and variables for future assessments of data management systems. The report is part of a larger study covering two countries: Kenya (where the first CABI supported plant clinics started operations in 2010) and Myanmar (first CABI supported plant clinics started in 2014).

In a period of two weeks in November 2016, the research team visited four counties and spoke with about 70 respondents, who are either technically or organisationally engaged in the Plantwise Kenya (PW-K) data management system (DMS), about their views on the functioning of the DMS and wider Plantwise programme. Through in-depth interviews and focus group discussions (FGDs) their perceptions, motivations and incentives were discussed with regard to their institutional mandates in general, and their role in the Plantwise DMS in particular. They were also asked about their views on the benefits and challenges of the DMS. The qualitative data were complemented with quantitative data retrieved from the Plantwise Online Management System (POMS).

In order to obtain a complete picture of the factors that influence the effective use and management of plant clinic data, ideally the views and perceptions of actors engaged in all DMS stages – data collection, processing and sharing/use – should be assessed. In this study, the majority of respondents consisted of actors involved in data collection. This was purposefully done, to gain detailed insight in this stage, as Kenya has recently transitioned from a paper-based data recording system to an e-clinic system using tablets. In practice this meant that we mainly spoke with plant doctors and the people coordinating and managing extension work at county levels. It also means that this report does not present a complete assessment of the Kenyan DMS.

Since the field work took place late 2016, there may be elements of DMS progress that are not captured in this reports.

The idea of a plant clinic data management system

Within less than a decade, PW-K has evolved from establishing pilot plant clinics in two sub-counties with a paper-based data system to a wider programme covering 14 of the 47 counties with 122 plant clinics and 380 plant doctors who currently operate an almost full-fledged e-system. In essence, the Plantwise method serves demand-driven extension with information directly collected from farmers and stored in a repository to assist evidence-based/tailored research and extension.

The aim of an up-to-date DMS as part of a wider plant health information system is embraced by all stakeholders interviewed. Local and national stakeholders acknowledge these benefits, actual and potential, and appreciate the system in supporting their mandates of controlling plant health through sustainable pest management.

The functioning of the DMS in Kenya

Proper functioning of the DMS requires smooth data and information flows at all levels. The roles of the different actors in the DMS are generally clear. Since the introduction of tablets for data collection, data entry and harmonization have become more smooth and efficient

processes and the quality of the data has improved. Remaining challenges include problems with internet connectivity and data bundles for some plant doctors. A flipside of the e-system is that the SCAOs (the plant doctor supervisors) risk being left out of the data flow, which may eventually undermine their buy-in to the plant clinic work.

Data validation is a major bottleneck and currently done to a limited extent. The obstacles comprise technical aspects (tedious procedures, incompatibility with POMS for upload), financial aspects (costly procedure, dependency on CABI funds) and organisational aspects (whose roles is it/ should it be in a Kenya-owned system?). As the backlog of un-validated data grows and discussions on transferring data validation to the counties have started, it is pertinent to revisit the concept of quality management of data. What standards are required by whom? How can the system be simplified and made more feasible in a Kenyan context?

Data use

So far the plant clinic data has mainly been used by CABI and national level stakeholders, notably from MOALF and KALRO. Analysis of the clinic data has led to observing trends in pest-infested crops and taking immediate action when needed, e.g. when MLND and *Tuta absoluta* were affecting Kenya's maize and tomato production, respectively. A considerable number of factsheets and pest management decision guides have been prepared. KALRO has warmly embraced the DMS and uses the data extensively for research, extension materials and to underpin new project proposals. According to one of the respondents Plantwise had facilitated multi-institutional collaboration between scientists and policy makers at the various governance levels within the country.

Despite the positive opinions about the DMS, the plant clinic data are still not used much, especially at county level. Of the 55 POMS accounts issued, 41 are active. Yet, only 17 users entered POMS in 2016 and of these, two persons account for most login sessions (70%). The people at (sub-)county levels involved in the coordination and management of agricultural extension activities do have access to POMS but are not using it because of confusion about use (authority levels), lost passwords and limited confidence in data use. Lack of time constrained further investigation into the reasons of the limited use of POMS data in Kenya. More buy in to and use of the plant clinic data by the counties is imperative for the system to create the promised value and be sustained. Lack of ownership and commitment to the DMS will inevitably restrain the functioning of the system.

Feedback is needed

Communication and feedback mechanisms are key for having the Plantwise DMS run smoothly. While data management systems can be technically designed to enable flow of quality data, in practice, their functioning will depend on people fostering proper management, use and sharing of data. Although the implementation of e-clinics has led to a more rapid and efficient flow of clinic data, systematic feedback mechanisms to plant doctors on data supplied are lacking. PDs in Kenya would prefer revival of the previously more frequently held feedback meetings (cluster meetings) in which information on pest management was exchanged, based on the data they gathered. Such feedback mechanism was mentioned by many people as highly motivational. One of the reasons for fewer meetings was a reduction in the Plantwise budget as well as a general decline of (financial) resources for agricultural extension following the devolution of extension from national to county levels. Alternative feedback mechanisms, e.g. using e-platforms/ social media are being explored.

ICT opportunities

The rapid developments in ICT are considered opportunities to explore ways to increase the compatibility with other existing data/information management systems currently applied in agricultural development. Such ICT developments might also be incentives for young(er) people to engage themselves in agricultural extension.

Ownership and sustainability

The study revealed that a functioning DMS does not only depend on human resources (e.g. extension workers, coordinators, data (validation) managers), materials and infrastructure (e.g. plant clinic equipment, tablets, electricity, internet connectivity, POMS). It also requires an enabling institutional environment with clear communication and management structures, as well as high-level commitment to allocate budgets for agricultural extension, including data management and use.

The devolution process is impacting on PW activities: some people referred to budget allocations for extension activities depending largely on the personal ambitions of county governors. This includes then the willingness to manage and facilitate a DMS. Although CABI is withdrawing more and more from the day to day management and coordination, there is still a degree of financial and technical dependency on CABI. Some informants expressed their anxiety about CABI's impending phasing out and handing over Plantwise activities to MOALF at regional and county levels.

Despite the remaining challenges, respondents are hopeful about the future developments of the DMS. They believe that the system has the potential for upscaling and institutionalisation, and with rapidly increasing ICT developments could be compatible with or complementary to other existing information systems containing agricultural (crops) data designed to contribute to improved plant health. Whether this will materialise depends to a large extent on government budgets allocated for extension as well as demonstration of the feasibility of the system and the value of the data.

The assessment framework

Based on the results from Kenya and Myanmar and further discussions and analysis of POMS data, a generic assessment framework has been developed wherein each of the DMS phases – data collection, processing and sharing/use – are assessed against the key indicators: *efficiency, feasibility and quality* (Posthumus et al., 2017).

1. Introduction

Plantwise is a global programme led by CABI, which works to help farmers lose less of what they grow to plant health problems. Working closely with national agricultural advisory services the programme supports the establishment of networks of plant clinics, run by trained plant doctors, where farmers can find practical plant health advice. To control pests and diseases, Plantwise focuses on disseminating good agricultural practices (GAP) and Integrated Pest Management (IPM) through targeted plant doctor training and development of locally relevant green and yellow lists[1].

To achieve its goal, Plantwise uses a system approach which focuses on three core and inter-related areas:

- **Plant clinic networks**, at the core, by working with existing extension providers;
- Systems for **management and use of plant clinic data (POMS)** and **provision of plant health information (Knowledge Bank)**;
- **A systems approach**, improving the capacity and responsiveness of (national) plant health systems.

Building effective systems for management and use of plant clinic data is thus a core element of the Plantwise intervention strategy. A fundamental assumption is that good use of the data can help strengthen plant health systems making them more responsive to existing and emerging plant health threats in addition to contributing to improving quality of advisory services and decision making at various levels.

Similarly, the importance of strong *health information systems* in human health has been highlighted by many, for example Teklegiorgis (2016): “A health information system is a system that integrates data collection, processing, reporting, and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services. Maintaining a good health information system is an essential part in strengthening a health system” (Box 1).

Box 1. Data vs. information

It is important to make a distinction between data and information; data are bits of information, facts and figures. When data is processed, interpreted, organized, or presented to make it meaningful and useful, one obtains information. In the case of the Plantwise DMS, data is thus collected from plant clinics, processed, organized and interpreted within POMS in order to create and share information on plant health amongst stakeholders.

The Plantwise Knowledge Bank plays a key role in the programme’s effort to strengthen plant health information systems (PHIS) nationally and globally. In addition to providing a comprehensive open access online resource developed according to user needs for pest diagnosis and distribution, as well as plant health management, the Knowledge Bank supports the plant clinics by providing secure data and information tools for managing and analysing clinic data, and by working with them to learn to handle data (Finegold et al., 2014). These two parts of the Knowledge Bank are illustrated in Figure 1.

[1] Green and yellow lists, a concept first developed by the Commission on 'Guidelines for Integrated Production' of the International Organization for Biological Control's (IOBC) West Palearctic Regional Section (WPRS) to provide indirect and direct pest control options. It has been adopted and expanded through Plantwise (source: http://www.iobc-global.org/news_20160121_Plantwise.html, latest access on 6th February 2017).

This study focuses on the closed access part of the Plantwise data management system (DMS) (left part of the figure). The DMS is set up to enable systematic real-time collection, processing and analysis of plant clinic data.

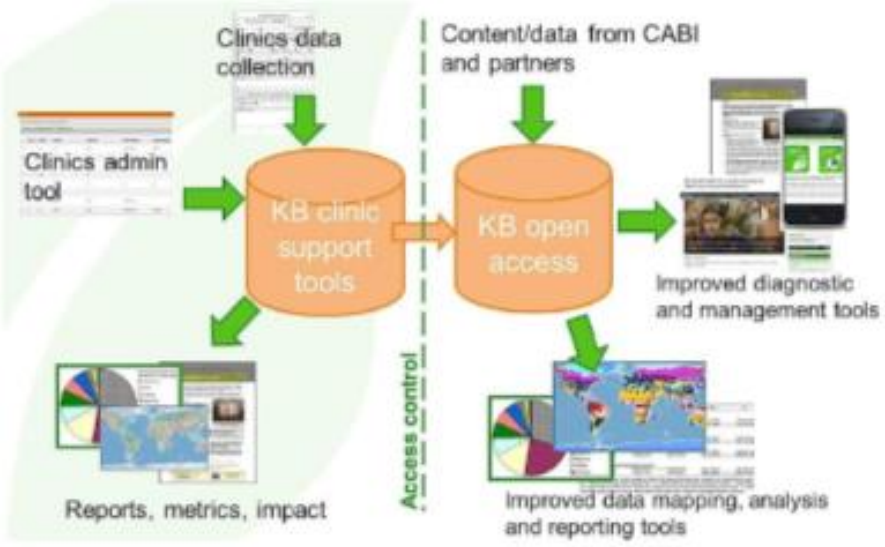

Figure 1. Schematic diagram of access controlled and open access sections of the Plantwise Knowledge Bank (Finegold et al., 2014)

The purpose of the DMS is to provide data that can **a)** inform actions (decisions) by plant health system (PHS) stakeholders, and **b)** be used for M&E by the programme and partners. Among the possible uses of plant clinic data, the following are mentioned in the Plantwise training materials[2]:

- Identify *farmers' plant health problems* and their *distribution* (snapshot of pests causing farmers problems)
- Provide *early warning*, i.e. identify new and emerging pests (pests vigilance)
- Shape *priorities for extension* (identify topics for campaigns and other actions)
- Identify needs for *further research* (technology development)
- Identify need for *plant doctor training* and *backstopping*
- Assess plant *clinic performance* (regularity, attendance, coverage, quality)

Experiences from a number of Plantwise countries have indeed shown that plant clinic data can be used to strengthen performance monitoring of plant doctors, inform research about demands for new technologies, target extension activities and to support early warning systems and their responses. Yet, for this potential to be fully exploited, a number of basic conditions need to be in place.

Establishing new ways of managing, sharing and using data involves substantial organisational changes, within and between organisations. Lessons from human health indicate that establishing effective health information/data systems in low-income settings is

[2] Trainings on e.g. *Data Management, Data into Use* and *Monitoring Plant Clinic Performance*

complex and highly context specific (Braa et al., 2007). Among the factors that influence the functioning of health information systems are: Organisational mandates, procedures, resources and capacity, governance and management structures, incentive systems and attitudes towards data use and sharing (Lippeveld and Sapirie, 2000; Danielsen and Matsiko, 2016; Teklegiorgis et al., 2017).

The establishment of effective systems for plant clinic data management and use requires thorough knowledge of the people (both users and suppliers) and processes involved, existing information/ knowledge systems/ tools, and how country partners perceive the Plantwise intervention.

The study

In order to assess the functioning of the Plantwise data management system and gain insight into the factors influencing the effective management and use of plant clinic data, a study was carried out in two countries, Kenya and Myanmar.

Specifically, the study aimed to:

1. Understand how plant clinic data are managed, perceived and used by partners at different levels (local, county, national). This includes looking at processes for managing, capturing, processing, sharing and using data; roles, perceptions, motivation and incentives along the data management chain; compatibility with existing data/information management systems as well as effects of the context.
2. Identify key challenges and opportunities for improving systems for plant clinic data management and use.
3. Identify key criteria and variables for future assessments of plant clinic data management systems (e.g. efficiency, feasibility, quality).

The two countries represent different stages of development of the DMS, with Kenya operating a tablet-based DMS and Myanmar a paper-based DMS.

This country report mainly describes the findings from Kenya with regard to the first two points. The third point will be dealt with in the general report in which a generic assessment framework will be presented based on the results from both countries. It was initially the aim also to assess the value for money (VFM) aspects, which was however not feasible in the time frame given and may require a follow-up study.

2. Plantwise Kenya

Kenya is one of the countries in which Plantwise started its first pilots setting up 25 plant clinics in 2010[3] in Central, Eastern, Western, and Rift Valley regions. To date, there are 122 clinics in 14 sub-counties run by more than 380 trained plant doctors (PDs) (Plantwise Kenya Annual report 2015).

In 2014, PW-K started training a first group of PDs in how to manage e-clinics (based on tablets). By the end of 2016 more than 200 PDs had been trained in using the tablets, thus completing PW-K's full transition to an electronic data management system.

Plantwise collaborates with various organisations with roles and responsibilities distinguished at different levels: National Responsible Organisation (NRO), National Steering Committee (NSC) and Local Implementation Organisation (LIO). In Kenya they include:

National Responsible Organisation:

- Ministry of Agriculture, Livestock and Fisheries

Local Implementation Organisations (plant clinic implementers)

- County governments
- Katoloni Mission Community Based Organization
- NGOs

National Steering Committee, expert support, technical subject teams

- Kenya Agriculture and Livestock Research Organization (KALRO)
- University of Nairobi (UoN)
- Kenya Plant Health Inspectorate Service (KEPHIS)
- Pest Control Products Board (PCPB)
- Agrochemical Association of Kenya (AAK)
- Croplife Kenya

Table 1 shows the functions /titles of Kenyan partners within Plantwise as well as the formal positions they have. Most partners are employed by the county governments. Other partners come from research institutes (KALRO) or from local NGOs, such as in the case of Machakos county where the Plantwise cluster coordinator's formal position is within Biovision. The Annex provides more details about the roles and activities that fall under each function, including those of CABI staff.

[3] A pre-pilot phase prior to 2010 took place in 2009 in which the very first two plant clinics were established in two sub-counties.

Table 1. Kenyan partners, their roles in Plantwise and formal positions.

Plantwise function/ title	Formal position	Based in
Plant doctors (PD)	• Agricultural Extension Officers • Sub-county Agribusiness Officers • Field Extension Officer • Agribusiness Development Officer • Farmers Resource Centre manager	• County government • Biovision/ Katoloni CBO – Machakos county
Sub County Agricultural Officer (SCAO)	Sub County Agricultural Officer	County Government
Cluster Coordinator (CC)	• Sub-County Horticultural Crop Officer • Sub county Crops Officer • Crops Development Officer • Community Information Facilitator	• County Government • Biovision Africa Trust (NGO)
Plantwise County Desk Officers (CDO)	• Assistant Director of Agriculture • Crop Protection Officer	County Government
County Government Director of Agriculture (CDA)	County Government Director of Agriculture	County Government
National Coordinator (NC)	Technical Officer Pests and Diseases	Plant Protection Services Division (PPSD), MOALF
Assistant National Plantwise Coordinator	Senior technical staff	MOALF, Nairobi
National Data Manager (NDM)	Senior technical staff	MOALF, Nairobi
Plantwise M&E Manager	Senior technical staff	MOALF, Nairobi
Data validation team leader	Principal Research Officer	KALRO, Nairobi

3. Approach and methodology

When assessing the functioning and use of the Plantwise DMS, the human factor is central. Even when data are automatically stored in a system, it will be people using the data and managing the system. Therefore, the direct interaction with the Kenya DMS actors was considered important to gain insight into how the people who make the DMS work perceive the functioning of the system they are part of. To obtain as much relevant information as possible in a short time period, KIT considered qualitative methods (in-depth interviews and focus group discussions) the most suitable.

To understand how the processes for capturing, processing, sharing and using data work in practice, a mapping exercise was carried out with "information chain" actors, as well as interviews and Focus Group Discussions (FGDs) with selected informants. A preliminary evaluation matrix was used wherein each of the DMS phases were assessed against the key indicators: *efficiency, feasibility and quality*.

For the mapping exercise and the interviews/FGD we prepared questions aimed to gain insight into the roles, perceptions, motivation and incentives of the different information chain actors. Besides these socio-organisational aspects of the functioning of the DMS, contextual/ infrastructural facets were incorporated as well, e.g. the compatibility with existing data/ information management systems, challenges and opportunities. A description of these exercises and tools are included in the generic assessment framework (Posthumus et al., 2017).

At 'local level', we included the people engaged at ward, (sub)-county, and divisional levels, i.e. extension workers/plant doctors (PDs), sub-county agricultural officers (SCAOs), Cluster Coordinators (CCs), Plantwise County Desk Officers (CDOs) and County Government Director of Agriculture (CDAs) (see Table 1), a total of 58 individuals. At 'national level' we included MOALF staff, research institutions, Pest Control Products Board (PCPB) and CABI PW-K staff in Nairobi, a total of 8 individuals. To obtain as much information from as many people as possible in two weeks' time we split into two teams visiting in total 4 counties: Nakuru, Kiambu, Machakos and Embu. Tables 2 and 3 summarise the DMS stakeholders interviewed at the various levels.

Table 2: Plantwise DMS actors at local level interviewed for the study

County \ Actors	FGDs Plant Doctors	Individual Pant Doctors	Cluster Coordinators	Sub County Agricultural Officers	County Desk Officer/ M&E	County Gov Director of Agriculture
Nakuru	1 (9 pax) F: 4; M: 5	2 F: 1; M: 1	2 F: 1; M: 1	1 (M)	1 (F)	
Kiambu	1 (8 pax) F: 5; M: 3	2 F: 1; M: 1	2 F: 1; M: 1	1 (M)	1 (F)	1 (F)
Machakos	1 (8 pax) F: 5; M: 3	2 F: 1; M: 1	2 F: 1 M: 1	1 (M)	1 (M)	
Embu	1 (6 pax) F: 5; M: 1	2 F: 0; M: 2	3 F: 1 M: 2	2 (M)	1 (M)	
Totals	4 (31 pax) F: 19; 12	8 F: 3; M: 5	9 F: 4; M: 5	5 (M)	4 F: 2; M 2	1 (F)

F: Female; M: Male; Pax: # of persons

Table 3: Plantwise DMS actors at national level interviewed for the study

Institute / actors	Interviewee
MOALF	Plantwise National Coordinator
	Plantwise Assistant National Coordinator
	National M&E/KM Manager
KALRO	Lead of Plantwise data validation team
CABI Kenya	CABI Plantwise Country Coordinator
	CABI Knowledge Bank Coordinator
	Knowledge Bank Content Developer
	Entomologist / IPM-expert

To complement the qualitative study component, quantitative data were acquired by examining plant clinic data and POMS login statistics during one year. Data summaries included: # farmer queries per month by clinic, POMS login user statistics, % harmonized and validated data, and % frequency each field in the prescription form had been filled.

The quantitative data are obviously key to providing information about the functioning and use of the DMS. They can also be used to prompt deeper discussions with different stakeholders and to triangulate with the information collected from the informants. However, in this first step of the study the main focus was on the qualitative aspects. Due to a very tight interview and FGD schedule in Kenya, we lacked sufficient time to discuss, validate and further develop the assessment matrix, in particular with regard to defining the indicators and key variables (for more details see Posthumus et al., 2017).

4. Results and discussion

This chapter describes the main findings of the study and is structured as follows. First, an explanation is given of how the DMS currently works and who is involved at the different stages. Then, an overview is presented of data/ information flows between the different DMS stakeholders, followed by a description of POMS with examples of data analyses. Thereafter a more detailed description of stakeholders' perceptions of the different processes for managing and using data is given. Finally, challenges and opportunities for improving systems for plant clinic data management and use will be presented.

As we have mainly met and interviewed stakeholders at the local (county) level, their views are more elaborated on than those of the people interviewed at national level.

4.1 The Plantwise data management system in Kenya

The flow diagram for the DMS in Kenya (Figure 2) formed the basis for a joint validation exercise with PW-K stakeholders which helped to describe the different steps in the data management process, focusing on data collection and processing. The following questions were discussed:

- Is this diagram a true picture of the Plantwise DMS?
- What (if any) changes need to be made to make it up to date?

The flow diagram depicts the paper-based data management process established at the beginning of the Plantwise programme. At the time of this study, PW-K was phasing out the paper-based data management system. By the end of December 2016, the plant doctors of all counties involved in Plantwise would be using tablets, thereby fully converting to an e-clinic system. Kenya was the first country in which e-clinics were implemented (Plantwise, 2015). In 2014, the first group of plant doctors was trained in how to use the tablets and the final group finished their training session in October 2016.

Data collection

Data recording, transfer and entry. The replacement of printed prescription forms with tablets introduces a change in the initial data flow (Figure 2). With the e-clinics, data sheets are filled on a tablet by the PDs and directly uploaded to POMS (when online). The three first steps are now managed by the PDs. Previously at least three actors were involved: PDs, couriers, and trained data clerks in so-called 'data entry hubs' (spots/places where the typing up of data from the paper-based description forms took place; in the current e-system this has become an automated process). As such, the data entry hubs have become redundant in most cases, as well as the activities "photocopies" and the "transfer of originals through courier or other manual delivery". However, there is still a need to roll out the newly developed desktop version of the data collection app (DCA) to Kenya because some counties have set up clinics on their own initiative, but don't have funds to transfer the data, so they want to use the desktop DCA to manage the data.

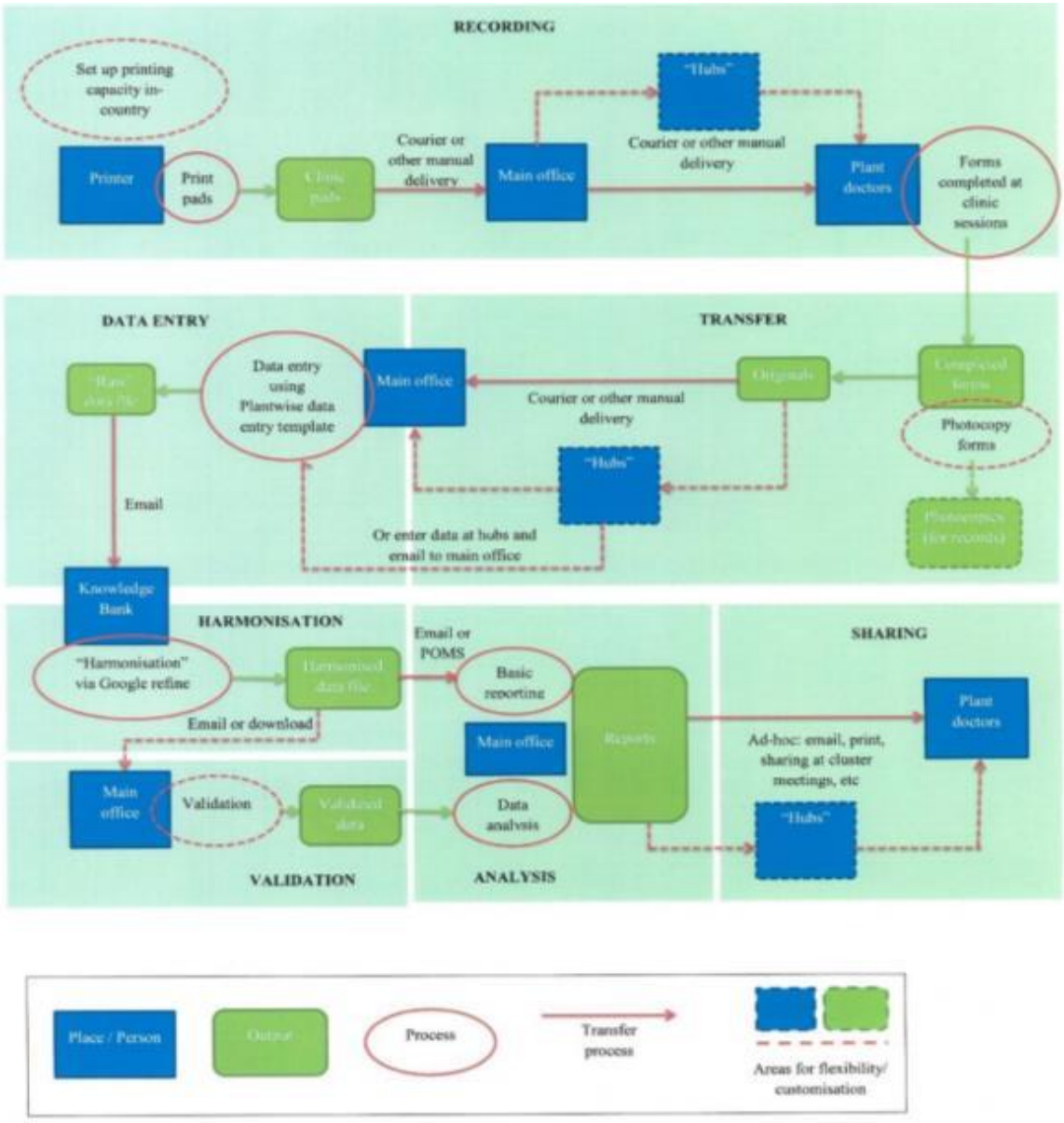

Figure 2. Flow diagram of paper-based Plantwise DMS in Kenya.

Data processing

Data harmonisation concerns the cleaning of keyed data (clinic codes, plant doctor names, crop names and diagnoses are mandatory fields to harmonise). This was done by trained data clerks in the paper-based system. Within the e-system, data are submitted to the harmonization tool of the POMS from the data collection app, and checked regularly by the Plantwise M&E Manager based at the MOALF headquarters (paid by MOALF and seconded to Plantwise).

Data validation (assessment of quality of diagnosis and advice) is done by a National Data Validation team, led by KALRO and consisting of 10-15 people, including the Plantwise Knowledge Bank Coordinator for East Africa, researchers of various institutes, e.g. KALRO, KEPHIS, AAK, PCPB and the University of Nairobi who involve MSc students under the supervision of their professors. Further, CDOs occasionally participate in validation exercises on behalf of the county level.

Box 2. Evolution of the Kenyan data management process

When plant clinics were initially established in Kenya, the prescription forms were provided for by CABI PW-UK, shipped by courier to Kenya and after having been manually filled out by the plant doctors, the forms were transferred data entry hubs where the data were entered into an Excel data entry template, sent by email to the UK where they were harmonised and uploading into the POMS.

This process however was soon taken over in-country by Plantwise staff in collaboration with government and research partners, e.g. MOALF, KEPHIS and KALRO. Prescription forms were printed in-country and both data harmonisation and validation were taken over by special teams consisting of experts from the aforementioned stakeholders.

The introduction of the e-clinics has resulted in a shorter and faster data chain as the recording, data entry and transfer stages, are now incorporated in one electronic operation. In addition, data are more accurate and clean as the electronic prescription form provide drop-down menus with pre-filled fields for PDs to choose from (Wright et al., 2016). The e-system is likely to improve the cost efficiency of data collection since the intermediate stages in the data collection process are no longer separate cost items.

Table 4 summarises the actors involved in the seven steps of the Plantwise DMS process under the paper-based and e-clinic system, respectively (see the Annex for more details).

Table 4: Stages in the DMS process and actors involved in the paper-based and e-clinic systems

DMS category	DMS step	Actors involved	
		Paper-based	**E-clinic**
Data collection	1. Recording	PDs and data entry clerks	PDs
	2. Transfer	PDs, Via data entry hubs	Automatic via tablet
	3. Data entry	Data clerks	PDs (recording and data entry is one step)
Data processing	4. Harmonisation	Trained data clerks	Plantwise M&E Officer
	5. Validation	National Validation Team consisting of technical experts from national level research institutes, government ministerial representatives and technical-content experts from CABI Plantwise	
Data use	6 Analysis	M&E manager/ National Data Manager/ National Coordinator MOALF, CABI KB, CABI CC	
	7 Sharing	PDs; county coordinators; research and government institutes	

4.2 Plantwise Online Management System (POMS)

POMS functions as a global repository of plant clinic data from Plantwise countries. Due to the sensitivity of plant health data, access to POMS is secured and restricted to certain users requiring a password to enter the system. The Knowledge Bank Development Manager, responsible for POMS, explained that POMS is used for the stages of harmonization, analysis and sharing. It also holds information necessary for the maintenance and analysis of clean data i.e. a people form including plant doctor name and clinic code.

POMS is on the interface between data entry and harmonization (clients use the upload page in the POMS to upload their data (paper-based clinics), or press 'submit' on their tablets to upload data to the harmonization tool (e-plant clinics).

The plant clinic data kept in POMS can be used and analysed in different ways. Firstly, there is an option to create an automated report in PDF with simple analyses (e.g. # plant clinic sessions held, farmer queries by gender, crops and diagnoses) for a selected period (see Figure 3). Secondly, it is possible to download a data set that works with an offline data analysis tool, downloadable from the POMS, allowing for more in-depth analyses. Thirdly, the data can also be downloaded as an Excel file, either the whole dataset or parts of it, for individual tailor-made analyses.

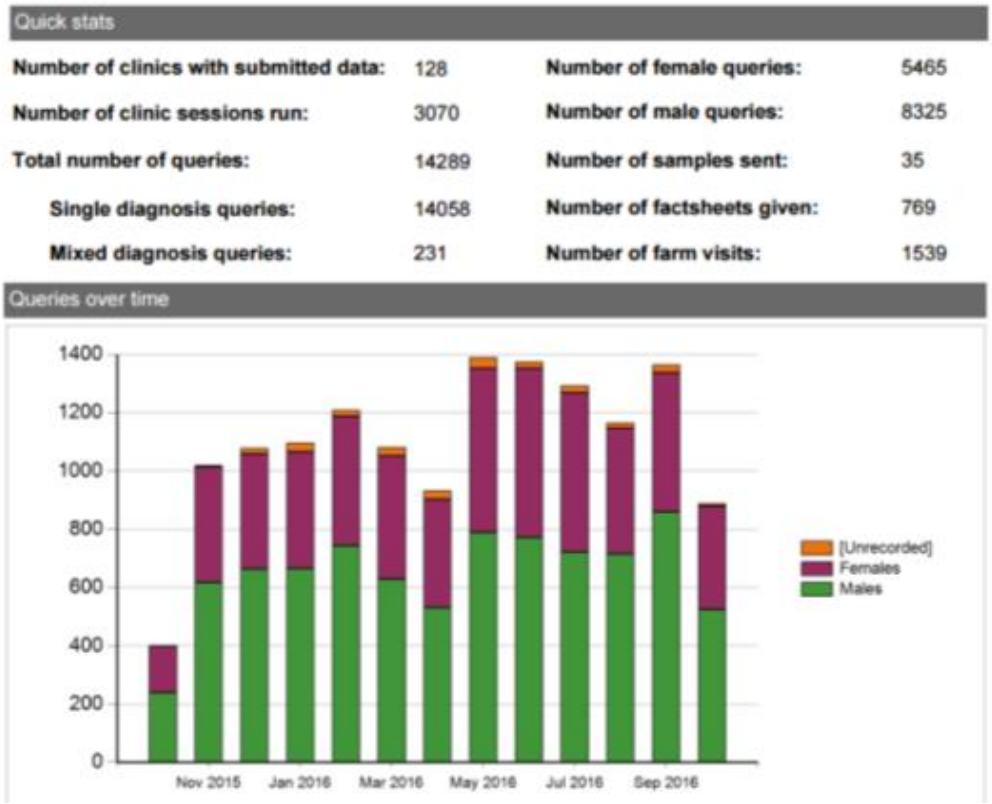

Figure 3. Excerpt from automated report created in POMS based on Kenya data from Oct 2015–Oct 2016

In 2016, POMS underwent a major overhaul to make it more user-friendly. There are now 5 options for downloading data, one of which concatenates field outcomes from the prescription form into fewer columns (from ca. 130 columns to 40) for 'viewing or analysing', compared with a download that allows users to reharmonise data and thus requires all field outcomes to be in separate columns. The user interface has been improved and the dashboard is more informative.

The following shows a few additional examples of POMS data analyses to illustrate how the data can contribute to assessing the functioning of both the plant clinics and the DMS itself. These data summaries were made after the visit to Kenya. It was therefore not possible to include them in the discussions with stakeholders referred to in section 4.3. For future DMS assessments the data analyses should be made first so that they can be used to enrich the discussions with partners.

Plant clinic activity and speed of data uploading

Plant clinic data covering the period Oct 2015 to Oct 2016 were downloaded on 19 Oct 2016. The dataset consisted of 11,379 queries, representing approximately 20% of all global POMS data (from 22 countries worldwide) for that period. A summary of the Kenyan data shows that over a one-year period:

- 117 clinics had submitted data to POMS
- 12% of the queries were from farm visits or field days
- 1.2% of the queries had no clinic assignation
- 43 clinics had more than 100 queries/ year, comprising 71.5% of all queries (Table 5)
- 61 clinics had less than 50 queries, of these 35 clinics had ≤10 queries (data not shown)
- 46 clinics had queries recorded for only 4 months or less in the period

Table 5 summarises the number of queries recorded by clinic per month for the 43 clinics having a total of 100 queries or more. Such data patterns raise a number of questions that should be addressed by the relevant authorities (programme/data/extension managers) as part of the regular monitoring procedures:

Do the data give an accurate picture of clinic regularity and queries attended?

- **If yes**, how do they reflect on plant clinic performance?
    - What influences the observed patterns (low vs. high attendance)? E.g. clinic placement and timing, plant doctor availability, funds, commitment, seasonality, degree of crop problems
    - What management decisions are required to improve (if any)?
- **If no,** how inaccurate are the data?
    - What are the causes of the inaccuracies? Are there any issues with the DMS itself? E.g. procedures, capacity, resources and infrastructure, incentives, motivation, management, policy environment etc.
    - What management decisions are required to improve?

As part of the transition to e-clinics a new data collection app (DCA) with several improvements was introduced in mid-2016. An analysis of plant clinic data since the switch to the new DCA, shows a steady increase in the number of devices (tablets) being used, number of sessions carried out and number of forms being submitted. According to a UK-based KB staff member, there were some initial problems with the new DCA:

> *"We found that some plant doctors were not connecting to the internet to send their records or not synchronising their tablets before reinstalling a newer version of the app. So unfortunately there were quite a lot of records lost if they installed the new app before submitting any saved records from the previous version. We've been trying to address these issues in training and guidelines to technical support staff."*

Table 5. Number of queries recorded in POMS Oct 2015–Oct 206 by month (downloaded 19.10.2016). Only the 43 clinics with 100 queries or more are included (74 clinics omitted).

	2015			2016									
Clinic Code	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
FARMVISIT	89	100	116	115	94	83	47	121	94	62	68	128	**1117**
KEAUUU	20	24	46	17	38	33	24	38	34	51	33	31	**389**
KEMKMM	21	37	21	31	42	37	1	42	35	49	32	4	**352**
KECINA	32	20	29	31	17	22	10	47	43	40	37	12	**340**
KEMKKE	26	25	35	31	43	23	44			25	35	41	**328**
KEENKB	14	34	13	14	28	28	27	27	46	35	21	27	**314**
KEENMA	13	20	37	42	41	14	11	25	18	18	13	32	**284**
KEEWKT	14	30	24	25	41	17	29	20	18	18	30	12	**278**
KEEWEM	25	25	23	19	21	13	21	40	14	17	22	16	**256**
FIELDDAY	32	35	17	22	14	30	21	14	18	9	8	29	**249**
KECIKU	11	31	5	19	26	55	15	24	13	13	17	10	**239**
KEKYLS	22	28	23	27	18	20	17	15	19	23	8	17	**237**
KEKLKT	12	31	26	25	18	11	14	23	14	21	10	18	**223**
KEMENB	8	15	10	15	17	12	15	11	11	50	36	18	**218**
KESBSB	15	26	31	20	20	10	1	5	9	14	25	42	**218**
KEKAWG	10	7	32	22	17	11	23	18	17	19	18	12	**206**
KERJKV		3	11	10	17	8	12	12	66	30	20	8	**197**
KEKYRI	19	14	14	22	13	3	20	23	17	21	14	9	**189**
KEWPTA	10	31	21	16	15	15	6	11	9	13	12	17	**176**
KEMKKA	7	9	17	16	19	9	10	21	14	15	18	12	**167**
KESH08	10	9	1	14	10	9	12	18	24	22	20	18	**167**
KEBTKT	4	21	27	26	3	2	13	14	9	23	15	7	**164**
KEMKRU	10	19	16	5	29	2	18	20	7	13	10	10	**159**
KESBKZ	14	17	22	20	17	13	9	7	13	6	10	6	**154**
KEEWKR	4	3	23	22	27	50	16	3				3	**151**
KEOLNJ		12	15	22	5	21	9	22	18	8	8	11	**151**
KETEKS	7	11	24	9	9	6	12	13	23	9	17	9	**149**
KEKYDG	6	13	16	14	16	12	12	10	15	15	11	8	**148**
KETETG	11	14	7	16	20	11	9	18	15	11	3	13	**148**
KEMKGT	17	13	15	23	10	10	6	11	12	12	6	7	**142**
KEMKKI								57	57	23	1	4	**142**
KEBTMT	9	11	9	17	13	12	7	15	11	14	15	7	**140**
KEMWKM	12	11	11	12	7	15	11	12	7	12	15	12	**137**
KESH07	2	21	16	11	16	8	12	5	17	6	4	13	**131**
KEKAKV	6	9	5	11	8	14	4	20	19	15	10	8	**129**
KEWPKI	6	12	6	7	12	11	7	18	10	25	13		**127**
KEMKGI	7	10	16	4	16	16	11	14	14	5	6	7	**126**
KEMWKD	13	19		20	8	12	19	15	3	3	9	3	**124**
KEMKMU						32		20	16	18	15	22	**123**
KESH01	6	5	12	3	12	5	8	12	11	17	13	10	**114**
KEMACH	13	20	11	14	15	13	11	5	8	2			**112**
KETWKN	2	10	5	2	10	15	10	10	18	7	10	2	**101**
KECIDI	8				6	5	15	14	20	14	7	11	**100**
Total	**570**	**805**	**808**	**811**	**828**	**748**	**613**	**928**	**879**	**833**	**713**	**715**	**9,116**

Although the increased use of tablets for recording data has enhanced the speed of data entry into POMS, a certain lag time was still noted. Downloading the same dataset 5 months later, the number of clinics increased to 125 and the number of queries increased to 14,020 (an increase of ca. 23%), indicating a certain lag time in getting the data into the system (Table 6). The exact lag time was not established by this study. It is likely that part of the delay is due to some plant doctors still using the paper-based prescription form at the time. Another reason could be that some plant doctors delay in submitting data from the tablets.

Table 6. Plant clinic data covering the period 19 Oct 2015 to 19 Oct 2016, downloaded from POMS on two different dates

Variable	Date of download from POMS	
	19 Oct 2016	27 March 2017
# plant clinics	117	125
# queries	11,379	14,020

Data quality

Data quality was not analysed in great depth in this study. This section addresses a few aspects: proportion of harmonised and validated data and completeness in form filling.

The proportion of harmonised crop names in POMS has been high since 2015, although there is a slight decrease from the second half of 2016 (see Table 7 for percentage harmonised crop names. *Note*: a different data set was used here to compare the trend over a longer period).

The percentage of harmonised diagnoses is in general also high with around 95% (data not shown), yet the diagnoses for some of the most frequently presented crops tend to be more 'unharmonised' than the average. For example, of the 562 coffee queries from 1st half of 2017, around 15% of the diagnoses were not harmonised. This may weaken the analyses slightly since the frequencies of each diagnosis will not be correctly calculated. It was not possible to establish whether the unharmonised data were e-clinic, paper forms or both.

Table 7 shows that more than half of the data were validated in 2015. Towards the end of 2016 the amount of validated data recorded in POMS had dropped to zero. The KB Content Developer explained why no POMS data appear as validated:

> *"Earlier in the year (2016) Kenya validated close to 3,000 records. The Excel tool used to validate the records was an older version which is no longer compatible with POMS. We are currently in the process of migrating the records to the current version. Once this process is completed, the validated records will be uploaded onto POMS."*

Table 7. Percentage harmonised and validated plant clinic data from Kenya from different periods as recorded in POMS from 2015 to mid-2017.

Processing step	1st half 2015 (n=4,293)	2nd half 2015 (n=5,726)	1st half 2016 (n=6,943)	2nd half 2016 (n=7,468)	1st half 2017 (n=3,330)
%harmonised (crop names)*	100	99.9	99.0	96.7	97.7
%validated	57	60	4	0	0

* Entries that are spelled according to the agreed terms (picklist)

A CABI Senior Diagnostician explained that data validation is a challenge across the entire programme:

> *"Despite our best efforts relatively few countries have received data validation training and fewer still regularly validate their data. There is also a delay in getting validation results published in POMS as it is a manual process. Plantwise is not able to invest resources into automating this at present."*

The transition from paper based to mainly e-clinics (before and after 18.03.2015) has increased the completeness of the data for some of the variables: variety name, area planted, farmer gender, sample brought, area planted and % crop affected, while completeness has decreased for others, e.g. year first seen, practices used, lab sample sent, factsheet given and field visit arranged (Table 8).

Table 8. Kenya POMS data: Frequencies of selected data fields filled before and after transition to e-clinics (18/03/2015).

*How frequently are each of the fields below **used** in the form?*

Data field	Pre 18/03/2015	Post 18/03/2015
Day	100%	100%
Month	100%	100%
Year	100%	100%
ClinicCode	98%	99%
PlantDoctor	99%	79%
FarmerName	97%	99%
Farmer age	N.A.	100%
FarmerCounty	100%	99%
FarmerLocation	98%	98%
FarmerVillage	96%	98%
FarmerTelephone	78%	88%
Crop	99%	99%
Variety	91%	97%
YearFirstSeen	94%	53%
AreaPlanted	89%	96%
YieldLoss	90%	98%
ProblemDescribed	89%	99%
PestDiseaseWeed	96%	99%
PracticesUsed	96%	52%
Recommendations	90%	99%

*How frequently has the plant doctor **not ticked**/ filled the field below?*

Data field	Pre 18/03/2015	Post 18/03/2015
Farmer Gender	7%	2%
Sample Brought	13%	3%
Area Planted (unit)	14%	2%
Crop Affected (%)	11%	2%
Lab Sample Sent	13%	48%
Factsheet Given	13%	48%
Field Visit Arranged	12%	48%
Development Stage	8%	1%
Part Affected	22%	2%
Symptom Type	19%	9%
Distribution (in field)	12%	2%
Diagnosis (Biotic/Abiotic)	16%	3%
Recommendation Type	19%	3%

Source: Compiled by Tim Beale, March 2017

The Kenya assessment did not go deeply into discussion on design and use of the prescription form data fields, yet future DMS assessments should address questions such as: What information is collected? Who uses it, how, and for what?

Use of POMS by partners

Of the 55 POMS accounts issued to Kenyan partners, 41 were activated as of 12 June 2017. Those with access include the coordination and data management team in Nairobi and a small number of people operating at county and sub-county levels, such as SCAO's, CC's, CDO's and CDA's. The login statistics in Table 9 show that POMS data were consulted 217 times by 17 Kenya stakeholders in in 2016. However, two individuals alone accounted for 70% of the POMS login sessions. The most regular POMS user (87 login sessions) was the Plantwise M&E Manager who is responsible for data harmonization and issuing of monthly data summary reports for the head of Plant Protection. The other one is the County Desk Officer from Nyeri (66 login sessions). The interviews held with the Plantwise DMS actors confirmed limited use of POMS (see section 4.3.3).

Table 9. Summary of POMS user logins in 2016. Plantwise Kenya.

Plantwise function	Organisation	Location	# logins (total=217)
M&E Manager	MOALF	Nairobi	87
County Desk officer	Local Gov	Nyeri	66
County Desk officer	Local Gov	Nakuru	14
County Desk officer	Local Gov	Kirinyaga	10
Head of data validation	KALRO	Nairobi	10
County Desk officer	Local Gov	Bungoma	6
County Desk officer	Local Gov	Kajiado	6
County Desk officer	Local Gov	Machakos	4
Cluster Coordinator	Local Gov	Oloitoktok	3
County Desk officer	Local Gov	Narok	2
Cluster Coordinator	Local Gov	Kajiado North	2
Cluster Coordinator	Local Gov	Marakwet West	2
Cluster Coordinator	Local Gov	Mwea West	1
Cluster Coordinator	Local Gov	Mukurweini	1
Former National Coordinator	MOALF	Nairobi	1
Cluster Coordinator	Local Gov	Mbeere North	1
County Desk officer	Local Gov	Embu	1

4.3 Stakeholder views on the Plantwise DMS

In the following sections the views of the different stakeholders' engagement in the Plantwise DMS are described, based on the outcomes of in-depth individual interviews and FGDs. First, the plant doctors' and other actors' views on the different steps within the Plantwise DMS are described (4.3.1-.4.3.3) followed by a description of the challenges and opportunities encountered including a few comments on the context in which the Kenyan agricultural extension is implemented.

4.3.1 Data collection: recording, transfer and data entry

Data collection: Plant Doctors views

Tablets make it easier. All PDs interviewed make use of the tablet system; some used the paper-based system for more than 4 years (those involved since the pilot phase), while others joined Plantwise recently and were introduced to the e-system and tablets straightaway. All PDs that were interviewed highly appreciate working with the tablets. Advantages mentioned are the ease with which data are entered in the system, in particular the option to choose from predefined fields (picklist) was mentioned by those who worked with the paper-based system before. Besides being able to quickly tick off different symptoms at different stages, these predefined fields and the automatic spelling control function prevent PDs from making spelling mistakes which is considered a clear advantage compared to the paper-based system.

Despite the overall enthusiasm of their engagement with the plant clinics, PDs also reported challenges in the implementation of their work. Some PDs mentioned that insufficient data and/or airtime bundles to send and receive data[4] as well as bad internet connectivity in remote areas hamper or delay the uploading to POMS. Lack of power was also mentioned as a constraint; some PDs expressed the need for (extra) chargers when their batteries run out of power. The current use of the tablets is felt to support more efficient flows of information.

***Distance diagnostics*.** Another benefit of the tablet-system mentioned is the possibility of making pictures of infested crops which can be shared for consultation with colleague-PDs in case a PD is not sure about the diagnosis. Further, all PDs highly value the Telegram function (an instant messaging service) within the tablet system, for similar reasons: consulting other PDs for support in diagnosis and recommendations and/or simply sharing of general information on, for instance, (emerging) pests and diseases in (new) crops. Some PDs also liked the telegram function to exchange social messages whereas others disliked this use of telegram and prefer to use it for the purpose it was initially meant to have: peer-to-peer exchange of information on pest and disease management in crops.

***Frequency of data collection*.** Data collection and entry mainly take place on days when PCs are held, usually fortnightly. Most PDs mentioned carrying their tablets wherever they go. Yet, not all of them would report and record pest and disease problems in crops when in the field for other/regular extension activities, due to lack of time or (battery) power. However, some PDs do take notes of these and enter their data at a later stage.

***Farmer attendance*.** The PDs indicated that the average number of famers visiting PCs vary from 4 to 12 farmers per clinic day depending on the weather, and /or farmers' social obligations like attending weddings or funerals. But during the cropping season, for example when planting needs to be done, farmers are too busy to visit PCs or they don't see the need (in this case reference was made to the planting stage in which crops have not germinated yet and thus pests and diseases incidences may not have been widespread). Plant doctors think that the numbers of farmers visiting clinics could be increased though, for instance, by

[4] Not all PDs mentioned lack of/insufficient airtime and data bundles as a difficulty. Some PDs consider the 125 KSh airtime and 350 KSh data bundles sufficient to carry out their work. The difference is mainly explained by location. In the more remote areas, lack of/ low internet connectivity explains airtime and/or data bundles rapidly running out.

having clinics positioned more strategically, i.e. closer to farmers' fields. Some plant doctors mentioned that not all of the current clinics are strategically positioned which discourages farmers to come. They expressed their concerns but were told that translocation of clinics to – in their opinion – more strategic places closer to farmers' fields, was not possible due to GPS located clinic positioning for research purpose. This concerns specifically those plant clinics that have been selected (30 in total) for the impact evaluation of PW-K (AIR, 2015). Further, PDs mentioned that farmers would prefer more frequent PCs, once a week for example. On the other hand, PDs also mentioned that farmers prefer PDs visiting them in their fields as a crop problem could then more easily be diagnosed *in situ*. Changing the way extension services are delivered seems to be a general challenge.

Data collection: other Plantwise DMS actors' views

Like all PDs, the other actors interviewed at both local and national levels, though not involved themselves in data gathering, found that the transition to the Plantwise tablet system has made more accurate capturing of plant health data even easier. Their views on the concept of a DMS to facilitate pest and disease management might be summarised in the following quote of the Plantwise National Steering Committee (NSC) member leading the data validation team:

> *"Whoever invented the Plantwise extension system should receive a great applause as it really contributed to uplifting the Kenyan extension system when it comes to promoting crop and plant protection through the establishment of a Plant Health Information System".*

4.3.2 Data processing: harmonisation and validation

Plant Doctors' views

Although not being involved in data harmonisation or validation, PDs think that the greatest benefit of the tablet system is the ease with which data are harmonised within the Plantwise DMS. Whereas the paper based system required a team of data clerks entering and harmonising data in the digital data base, the e-system provides - almost- instantly more clean and correct data thanks to the digital format of prescription forms. Plant doctors simply click their tablets to find prescription forms with drop-down menus to choose from and will still have enough space to enter additional notes when needed. With the e-clinics data collection has become faster and more efficient and should theoretically contribute to a quicker turnaround time of data.

Other DMS' actors' views

Harmonization. With the e-system in place, data harmonisation has become less time-consuming and requires less people involved at national government level. Now, there is one person designated at the Plant Protection Service division at MOALF managing data harmonisation compared to a team of four at the time of the paper-based system, of which two were responsible for entering data and two for harmonisation. This person is seconded to CABI as the Plantwise M&E Manager.

Data validation. Data validation has shown to be a challenging step. Cluster coordinators, who are the formal supervisors of PDs, said they were unable to validate the data (check quality of diagnoses and advice) due to lack of skills to use the current validation protocol.

A MOALF representative, who was until recently leading the national data validation team, regrets that due to Plantwise budget cuts the number of data validation workshops has declined from 5-6 times a year (3-5 day meetings) to (so far) one session in 2017. National level representatives wanted the data validation meetings to be revived because there were a lot of data that had not been validated.

The leader of the data validation team (principal research scientist of KALRO) explained that CABI plays a key role in the process by convening for data validation workshops, preparing the data for validation and subsequently uploading the data to POMS (although this does not seem to be happening at the moment, ref. Table 7). She further said:

> *"We need training in how to download the data from POMS ourselves and insert them in the validation tool. It would be difficult to do validation without support from CABI."*

The simplification of the initial prescription form and improvements of the validation tool have contributed to a quicker validation procedure compared to the earlier version. Yet, there are still some notable bottlenecks in the system. A KB Content Developer told that the attempts from 2015 to simplify the prescription form have led to very little change in Kenya. Actors at the different stages of the data management chain were consulted, but in the end they didn't shorten the form except for a few fields. In contrast, some of them wanted to add more fields.

The leader of the data validation team finds the validation protocol tedious and time-consuming:

> *"I have tried to simplify the process to speed up, for example by filtering for similar crops and pests, or take a random sample. But the template is not easy. There is too much information. 5,000 queries are the most we have ever done at a 5-day validation session. It was very exhausting."*

At the same time she finds data validation greatly motivating for herself personally as a scientist. The validation workshops enable the participants to discuss, learn, read and revive their knowledge. On the other hand, she recognises that others have different perspectives:

> *"People in the ministry and the counties don't have that same motivation. They see data validation as a burden. It doesn't add value to their work in the same way it does to us. It is a challenge, especially with the devolution of extension. Many things are not clear yet about how counties will work with the ministry and national institutions, including the financing. Plant health is serious business; validation is key and therefore always needs experts' eyes. But I am worried that it will be difficult to maintain the quality of the data."*

CABI is exploring ways to devolve the validation/ quality control to the counties by training county staff and have national experts to backstop them. One of the informants also suggested that the image option the tablets provide could help improve the validation

process. E.g. plant doctors, accompanied by plant scientists, could be trained in photographing those parts that will be most beneficial for validation purposes.

The KB Content Developer said that too much prominence is placed on 'high level' experts to carry out the process. It is necessary to 'demystify' and simplify the process. Otherwise it could easily be intimidating for county staff. He suggested that this should go hand in hand with data demonstrations and training in data use so that stakeholders get to see the value of the data and take ownership.

Apart from the unsolved challenges with technical, financial and organisational aspects of data validation, there seem to be some unanswered questions about the need for and purpose of data validation. What data quality standards are required by whom and for what? What quality management scheme is feasible and relevant in a Kenyan context where agricultural extension is being decentralised? As explained by the KB Content Developer and several others, un-validated data can be and are being used for many valuable purposes (e.g. accountability, performance monitoring, research, extension materials, pest tracking). Much of the information captured in the prescription form is only used for data validation. Yet, since only a minor proportion of the data are validated, and with the persistent challenges mentioned above, the question is how much information needs to be collected by the plant doctors at all?

CABI and the Kenyan DMS partners need to address these questions as part of the debate on institutionalisation and sustainability.

4.3.3 Data use: analysis and sharing

Plant Doctors' views

Data sharing opportunities are observed to have been minimal and declining. Although the implementation of the e-platform has eased data entry and upload, systematic feedback mechanisms to plant doctors on data supplied are lacking. Plant doctors would like to occasionally receive feedback on the data they submit, for learning purposes. At the moment PDs don't have access to POMS. According to the KB Content Developer, that would require a decision from the programme coordination.

Plantwise used to host and fund quarterly 'cluster meetings' as spaces to follow up, discuss and exchange views and experiences on plant clinic activities. These meetings were also used to give plant doctors feedback on the clinic data. Due to reduced budgets, cluster meetings are not held with the same regularity (if at all) since counties are expected to fund and organise them. Plant doctors regretted this development since it was "*denying them opportunities for group discussions, exchanges and discovering of solutions*."

A PD in Embu came up with the idea of not only involving scientists in the development of factsheets but to engage PDs as well, as they are doing the work on the ground and are constantly in contact with the farmers. The involvement of plant doctors in some basic analysis of plant clinic data and development of factsheets might help them conveying pest management messages with even more conviction and enhance their motivation.

Plant doctors participating in FGD stated the plant clinic data help "maintain proper documentation of our work – diagnosis and advice", which helps in:

- Managing follow ups to farms and cases
- Monitoring common and emerging (trends and seasons) pests and diseases
- Instilling professionalism since they know their observations (diagnosis and recommendations) can be scrutinized as they are documented
- Learning from self and peers

Box 3. Why plant doctors like being part of Plantwise

Plant doctors feel that with their presence at plant clinics the visibility of agricultural extension has increased. The interaction with farmers is what motivates them most and the fact that they can support in solving farmers' problems makes them feel proud of their work.

Plant doctors like working with the tablets. Among the advantages mentioned were the ease and speed with which data are entered in the system compared with the more tedious paper-based system. They further consider it very easy to take the tablets along in their daily work as general extension officers. They carry their tablets wherever they go and as such collect plant health data even beyond plant clinic hours.

Most plant doctors said that thanks to their engagement in Plantwise their performance in advising farmers on plant health has improved through: more precise diagnosis, more specific recommendations and delivery of Integrated Pest Management (IPM) options. They appreciated the provision of plant doctors' equipment like lenses, reference material and the tablets for plant clinic data collection.

Other DMS actors' views

Cluster Coordinators (CC). Since the introduction of the e-system plant clinic data are now uploaded directly to POMS and harmonisation, validation and analysis are done in Nairobi, where after the CCs receive feedback on the analysed data. It was not possible to establish how regularly feedback on the data is given. CCs are allowed access to POMS and they should be able to analyse these data themselves. However, not many of the CCs met actually do so (see Table 9). Among the reasons mentioned was the loss of passwords[5] and insufficient knowledge of the use of POMS and analysis tools. More training seems to be needed although, according to CABI Plantwise staff in Nairobi, a capacity building process was implemented in 2015 to train county level actors (e.g., SCAOs, CCs, CDOs, CDAs) on how to analyse POMS data. So far 30 individuals have been trained in data analysis and use.

Sharing of data has been taking place during annual stakeholders meetings organised and funded by the Plantwise programme. Some CCs reported that such a stakeholders meeting for data sharing took place in 2015 with cluster coordinators, researchers, regulatory bodies, CABI, plant doctors, various institutions representing county, sub-county departments as well as farmers. They considered that a very useful meeting and found once a year too limited and prefer such meetings to take place, for instance, three times a year. For the time being, it is not possible to sustain such activities without external funding.

[5] Apparently the respondents are unaware that there is a line on the POMS sign in page that says 'forgotten your password' which allows users to reset their passwords

The Sub-County Agricultural Officers (SCAO) have a formal role in facilitating the dissemination and implementation of national and county agricultural programmes at the sub-county level. They are also the formal supervisors of the plant doctors. SCAOs consider the plant clinic a useful extension method and the e-system a helpful tool to provide backstopping to both CCs and PDs. The system facilitates the monthly reports (prepared by Plantwise desk officers (CDO)) and helps getting insight into the number of farmers reached and problems encountered. The SCAO from Nakuru put it like this:

> *[..] "it is helping us remain visible and relevant to our primary clients: farmers as well as to other stakeholders".*

With the introduction of the e-clinics, however, PDs are uploading their data directly to POMS and SCAOs no longer have access to this information flow. Under the paper-based system, the information from the PDs passed through the SCAOs, which allowed them to monitor activities. Some SCAOs would like to be informed when PDs are uploading their data to POMS. The issue of data flow vs. formal reporting lines needs to be included in the discussions about institutionalisation of plant clinics and data management.

Although SCAOs are allowed to access POMS, only a few of them actively use POMS data themselves (see Table 9). Someone mentioned confusion about passwords and authorities to access POMS. However, the SCAOs do appreciate the DMS, for example: when *Tuta absoluta* appeared as an emerging pest in tomato, the POMS data (analysed by MOALF and CABI staff) helped to identify the presence of the pest in different regions. Subsequently the plant doctors, through their PCs, contributed extensively in disseminating information about how to recognise and control the pest.

The Plantwise County Desk Officers (CDO) are responsible for oversight of Plantwise activities at county level. As county employees, they act as the formal link between the County Government Director of Agriculture (CDA) and MOALF and CABI at national level. CDOs are in principle able to access POMS data before and after validation and they are expected, as part of their job as County officials, to the data to analyse trends in pests and diseases, estimate related food losses and provide advice on interventions to manage pests and diseases, and to further customise analysis of data with other stakeholders according to their plant health needs.

However, the CDOs reported that their tasks have become challenging due to financial instability since the devolution. They remain to take ownership of the data. A general feeling among CDOs is that the current devolved county institution seems to prioritise investments in "hardware" (e.g. bridges) over "software", like farmer extension. In time, as one of the CDOs commented, the value of e-extension for the coordination of agricultural extension activities in the counties might be acknowledged which may result into priority shifts in budget allocations as well.

Although data sharing is of strategic relevance to the system it has been very weak which was a reason for Embu county to "put plant health information sharing to the forefront in planning and budgeting". They appreciate the Plantwise DMS as a practical tool that provides them with up-to-date plant health information. This stimulates them to continue delivering quality work in order to contribute to crop protection in their counties. One of the CDO's interviewed reported his involvement in the development of green and yellow lists as highly motivating – showing that the collection of data supports the development of pest management guidelines.

At national level the Plantwise DMS is highly appreciated as a tool supporting and strengthening research and government institutes in executing their mandates within pest and disease management. For instance, the Plant Protection Services Division (PPSD) of MOALF, which is in charge of controlling emerging pests and diseases at trans-boundary and national levels, appreciates Plantwise for narrowing the division's previous much broader spectrum to one that focuses on plant health.

Plantwise is being acknowledged for having helped identify and prioritize extension messages, at both grass roots and national levels. The MOALF representative who just started as the Plantwise National Coordinator at the time of interviewing mentioned as an example that when plant clinic records showed that farmers experienced powdery mildew as a problem, targeted extension campaigns were conducted on how to manage the pest. Another example is the dissemination of extension materials when Maize Lethal Necrosis Disease (MLND) was affecting the maize crop a few years back.

The head of the Plant Pathology Department of KALRO also highlighted the usefulness of plant clinic data when developing green and yellow lists and factsheets in which IPM comes out very strong. In that sense, "*Plantwise has functioned as an 'eye-opener' by 'banning', or at least restricting the use of chemicals in pest management and promoting IPM practices instead"*, as she explained. KALRO scientists also use clinic data to support the writing of scientific publications and conference presentations.

Furthermore, lecturers from University of Nairobi make reference to the Plantwise programme in their curricula for MSc students, and in some cases have their students analyse plant clinic data. The head of the Plant Pathology Department of KALRO encourages the sharing of information and establishment of feedback mechanisms between actors at the county levels and the people responsible for data validation at national levels. She also mentioned that in order to reverse the current under-use of data, more training is needed on how to use the data and the various tools, both for county and national level people. She added, "*We need to ask the counties: what is the value of the data for you? What do you want the data to do*?"

Telegram as a platform for peer-consultation is also becoming useful to CABI as a platform to inform about changes in data tools and formats, i.e. a space for remote guidance and support on data management and support instead of face-to-face training. The KB Content Developer recognises that a lot of investment in data sharing and use is still required. "*We have this goldmine of information, but seemingly we haven't yet got the ownership by partners we would like to see. The data needs to get out there*."

According to the principal research scientist of KALRO (head of data validation team), KALRO has bought in to Plantwise in a big way and is now engaged in expanding plant clinics to new areas. The plant clinic data are being used extensively to underpin the development of new project proposals (World Bank, EU, USAID) on e.g. citrus crops, climate smart agriculture and rice-irrigation schemes. New plant doctors will be trained as part of these projects (e.g. 'rice plant doctors'). KALRO intends to establish a Rice Knowledge Bank as an off-spring of the Plantwise Knowledge Bank. She further explained:

> *"With the new project money we have got, we will anchor the data collection to the KALRO server so that we don't depend on CABI UK. We can still share the data but we want to control the data from here."*

4.4 Sustaining the DMS – challenges and opportunities

In addition to the details rendered above on data collection, processing and use, the informants discussed the wider issues related to sustaining Plantwise activities including the DMS, in the Kenyan context.

Institutionalization of Plantwise under a devolved extension system was perceived by several informants as a major challenge. The roles and responsibilities of counties vs. national institutions are not yet clear, leaving a number of pending budgetary, technical and organizational issues. It is still in transition and with the upcoming (re-)elections further delays are expected. A KALRO scientist also mentioned that there are big differences between the counties in terms of interest and buy in to Plantwise. The counties' response depends on the people, their individual attitude and the importance given to agriculture.

The SCAOs and CDOs observed that, eventually, budget allocations depend on cash flow and the priorities attached by the policy makers at county government level. Someone put it like this: "*If, to sustain political support, the preference is on hardware and tangible events rather than on software and processes, a person's desk influence becomes docile*."

The county people consider the existing extension structure well-suited to incorporate the Plantwise extension approach though some expressed their anxiety about CABI's impending phasing out and handing over Plantwise activities to MOALF at regional and county levels. They would rather see CABI stay for a few more years to guide this process and allow the devolved government longer time to prepare for a full takeover. This opinion is underlined at national level as well where the Plantwise programme is highly valued and considered to have largely contributed to improving Kenya's PHIS. CABI's extended support would therefore be well-appreciated to identify needs and gaps with regard to human and financial resources to have the system mainstreamed.

In order to formalise the interaction between the counties and ministry regarding plant clinics and data management, MOALF has signed MoUs with each county involved in Plantwise, thus establishing the roles and procedures of engagement. This has helped CABI to step back and become more 'invisible' and less seen as the key driver of the programme. Yet, the secondment of key MOALF staff to Plantwise and the dependency on Plantwise funds for certain operational activities, still leave a question about sustainability of the system.

Wider collection of data. The KB Content Developer proposes wider data collection as a means to ensure sustainability of the data management system: "*Records from farm visits and field days hold the key to sustainability because it is something the plant doctors do without facilitation to run a clinic. It is part of their normal work. If that can be embedded into the regular practices we have come a long way*."

As show in Section 4.2, around 12% of all POMS data are currently from farm visits and field days. Further enquiry is needed with county extension managers to find out what they think about recording extension activities in this way, i.e. the perceived value and function of the system, as well as its compatibility with existing reporting systems.

New synergies. Despite the challenges, some of the county people also see the institutionalization of the Plantwise extension approach, including the DMS, into the county system as an opportunity. One of the CCs proposed to make the link between pests and diseases with climate change more pronounced and investigate the possibility of adding fields in the prescription form to indicate this. Yet others value the more efficient flow of

information that the tablets brought about and mention the possibility for desk officers, CCs and CDA's to access the POMS which enables improvement on data sharing and tailored analysis to inform policy and practice right from the county level. However, efficient management and use of the data require a system that is easy to use and aligned with the existing reporting lines. These aspects need further attention.

ICT platforms could be fostered by further investigating the compatibility of other e-extension systems. ICT is increasingly being used in agriculture in Kenya and a variety of existing programmes have been mentioned, e.g. SHEP-Plus, E-extension, Upper Tana, etc. Among these, Plantwise has a clear focus on crop health whereas the government E-extension programme is broader, dealing with agricultural and nutrition services in general. Among the many opportunities for the DMS, a CDO mentioned exploring collaboration with other stakeholders in the agricultural sector and keep abreast with the newest technologies in crop protection and see to what extent knowledge, data and e-systems can be integrated into other extension services e.g. on livestock or soil health information.

5. Recommendations

A number of ideas to improve and optimize the DMS in Kenya were shared during the interviews and meetings held. These are summarized below in a bulleted list of recommendations and complemented with observations by the research team.

1. CABI and the Kenyan DMS partners need to revisit the data validation scheme and discuss how the future quality management should look like, including purpose, quality standards, data requirements (prescription form), protocols, financing and institutional roles.
2. Further inquiry is recommended to better understand the challenges that CCs, SCAOs and other county people face with regard to the use of POMS.
3. To stimulate the analysis of POMS data at county levels to support the planning and monitoring of extension activities.
4. Involving plant doctors in (some basic) analysis of plant clinic data and the development of factsheets might help them to convey the messages on pest management with even more conviction and enhance their motivation.
5. In order to expand the relevance and value of the plant clinic data, potential synergies between the Plantwise DMS and other ICT systems/ e-initiatives should be further explored.
6. To further explore the image option the tablets provide and have plant doctors, accompanied by plant scientists for instance, trained in photographing those plant parts that are most relevant for data validation purposes and distance diagnostics.
7. Establish a way to consistently inform CCs and SCAOs when PDs upload their clinic data to POMS.
8. To explore to what extent the building in of technical functionalities which could function as digital feedback mechanisms would support the felt need by the actors at county level who are involved in the organisation and steering of extension activities on the ground.

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Annex. Roles and activities of PW-K actors in the data management system

DMS stages (see Table 4): 1. Recording – assigning PC codes; **2.** Transfer – any logistical support; sometimes call in the cluster coordinators**; 3.** Data entry / digitisation – development of the tool for data entry collection + collection app; **4.**Harmonisation –training national data managers; data harmonisation; **5.** Validation –train data validation team; subdividing the data into categories and collating them; coordinate uploading of validated data into POMS; **6.** Analysis – development of analytics; training on analysis methods; review analysis and papers; **7.** Sharing of information with users

Role	***Organisation***	***Activities***	***DMS Stage***
Plantwise CABI County Coordinator Plantwise Knowledge Bank Coordinator East Africa	CABI Plantwise Kenya	✓ Supervise plant clinic codes ✓ Coordinate the data flow from cluster to the national data centre ✓ Train on data collection, analysis and sharing and data validation ✓ Develop tools for data collection, analytics, e.g. data entry template, data collection app ✓ Oversee data flow in POMS (status & feedback) ✓ Coordinate activities with National Data Manager ✓ Coordinate information upload into POMS and Plantwise Knowledge Bank	1.-7.
Plantwise Monitoring & Evaluation and Knowledge Management	Ministry of Agriculture, Livestock and Fisheries (MOALF)	✓ Follow up on submission of prescription forms to the National Data Centre ✓ Give feedback on who has submitted data or not and reasons as to why data has not been submitted ✓ Harmonisation of data on POMS ✓ Training of PDs on their roles in data recording and accuracy of diagnosis and recommendations ✓ Pick up information requiring review, e.g. incidences of certain pests for stakeholders consideration ✓ Coordination of cluster meetings to share experiences ✓ Post Plantwise information and updates on to the Ministry's website ✓ Report writing on data analysed	1. 2. 4. 7. 7. 4. 7. 7.
National Data Manager and Team	KALRO (lead) and various institutions e.g. KEPHIS, University	✓ Mobilize validation team to meet and validate data; write reports and send to CABI and other partners ✓ Analyse the validated data and make recommendations for PMDGs, training, etc. ✓ Mobilize for data writeshops (sharing) ✓ Publish/share the information synthesized for the analysed data	5.-7.
Assistant National Plantwise Coordinator	MOALF	✓ Facilitate Plant Doctor self-assessment: ✓ Take up the gaps in diagnosis and recommendation and retrain plant doctors ✓ Get feedback from plant doctors during cluster meetings on challenges ✓ Train plant doctors on data management systems ✓ Organisation of county data sharing forums ✓ Depending on data check which are the most common pests per county being brought to clinics ✓ Design plant health rallies/ extension campaigns targeting to train farmers on how to handle those pests ✓ Write green and yellow lists ✓ Distribute reference materials and prescription books (paper based)	1.-7..

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