ICT4BXW

REPORT ON BASELINE SURVEY OF BANANA FARMERS IN RWANDA

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Introduction

The ICT4BXW project was officially launched in January 2018, with funding from the German development cooperation (BMZ). The goal of this project is to use citizen science and ICT to develop (cost)-effective and scalable tools for advancing the prevention and control of Banana Xanthomonas Wilt (BXW) in East and Central Africa, with initial focus on Rwanda. The project is centred on 2 major objectives – (1) To provide up-to-date knowledge on BXW diseases to extension service providers and a decision-support tool to identify labour- and cost-effective BXW Control methods; (2) Provide real-time data on BXW spread that supports governments in targeting their BXW prevention efforts in a more cost-effective way.

Based on the project's implementation framework, we conducted a baseline survey of farmers and farmer promoters (FPs) in Rwanda. The survey provides a critical input to meet the objectives and demonstrate impact over time. In the first stage (19th June – 3rd July 2018) a team of representatives from IITA and RAB's banana programme visited eight selected districts in four of Rwanda's provinces to select banana producing villages which would be enlisted in the survey. By design, half of the selected villages were earmarked as intervention villages for the project, and the other half were designated as control villages which would be visited two times during the project's lifespan: once during the baseline survey, and once during the end-of-the-line survey. In this report, we provide broad overview of the sampling strategy for sector, cell and village selection in each district, brief insights from the data collected, and field notes/observations on the sampling and survey process.

The baseline survey

The ICT4BXW questionnaire survey was collaboratively developed, with contributions from project partners and thematic collaborators. The finalized questionnaire was formatted for deployment on mobile-based Open Data Kit (ODK) software through its ODK-Collect application. The ODK is an open-source software for collecting, managing, and using data. The software was deployed on Tablet mini-computers and this offered flexibility of collecting data with or without active internet or phone connection, and upload into cloud-based server, when internet connection exists. The seamless collection, upload, and access of data is beneficial for rapid checking of data quality and analyses.

Content of the survey

The ICT4BXW baseline survey covered a broad range of topics related to the banana farming system, rural livelihoods, and penetration of digital technology among smallholder farmers. Our goal was to capture a variety of relevant information that will be valuable for the project's research, monitoring, and evaluation needs.

The content of the ICT4BXW baseline survey is as follows:

- Introduction of the project
- Location data
- Demographics of respondent
- Demographics of household head
- Household population
- Household assets, including livestock
- Access to credit
- General farm land size
- Banana farm land size
- Crops grown, sold and consumed, especially banana, cassava and soya
- Agricultural Inputs
- Off-farm income
- Food security in past year
- Food nutrition in past 24 hours
- Banana disease experience and knowledge
- Cost-benefit of different BXW control

options
- BXW prevention strategies (Inge???)
- Extension in general and for banana specifically
- Experience with ICT
- Experience with and use of mobile phones
- Use of mobile agriculture services
- Impact of mobile phone use
- Measurement of incidence in currently BXW affected plot
- Registration of respondent for follow up
- Assessment of survey quality

Sampling strategy

Selection of districts

The baseline survey targeted 8 districts (Burera, Rulindo, Gatsibo, Kayonza, Gisangara, Muhanga, Karongi and Rubavu), within 4 provinces in Rwanda. The two criteria for selecting districts include; (1) coverage/representation of the major agro-ecological zones in Rwanda, and (2) representation of different types of banana producing farmers (Table 1). Together, the eight selected districts represent diversity in production typologies ranging from small-scale subsistence production to large-scale commercial production. Selection of districts was conducted based on expert knowledge (mainly through multiple consultations of Banana Programme Leader at RAB), and raw data from a countrywide rapid assessment of BXW status conducted by RAB in 2017-2018.

Table 1: Selected districts per province and their agroecological zones

Province	Agro-ecological zone	Districts selected
Northern province	Northern highlands	1. Rulindo 2. Burera
Eastern province	Eastern savannah	1. Kayonza 2. Gatsibo
Southern province	Central plateau	1. Gisagara 2. Muhanga
Western province	Kivu lake border	1. Rubavu 2. Karongi

At district level, BXW incidence levels and distance to extension district headquarters were classified into 3 levels (Table 2). This resulted in 9 strata which guided the sampling of villages. We hypothesize that distance to the district headquarters affects access to agricultural/banana extension services. BXW incidence levels were considered important because the project aims to see reduction in disease outbreaks and need for mat uprooting, as well as improvements in banana management and BXW disease control and prevention. In each district 18 villages were sampled, 9 intervention and 9 control villages, according to the 9 strata. However, in Karongi district the number of villages was limited to 12 (6 intervention and 6 control villages). This was due to the absence of village(s) that match(es) the criteria for long distance to district headquarters. Therefore, the total number of villages included in the baseline was 138 (i.e. (7x18)+(1x12)).

Table 2: Sampling scheme based on disease incidence levels, distance to district headquarters, and control versus intervention.

Distance from district headquarters	BXW incidence level			
		Low incidence	***Medium incidence***	***High incidence***
	Short distance	Village 1: Intervention Village 2: control	Village 3: Intervention Village 4: control	Village 5: Intervention Village 6: control
	Medium distance	Village 7: Intervention Village 8: control	Village 9: Intervention Village 10: control	Village 11: Intervention Village: 12: control
	Large distance	Village 13: Intervention Village 14: control	Village 15: Intervention Village 16: control	Village 17: Intervention Village 18: control

Selection of sectors, cells, and villages

Sector selection

In each district sectors were selected based on expert input from the district and sector agronomists. The total number of sectors from which villages were selected ranges between three and five depending on the district. The selection criteria include: 1.) Distance between the sector and the district headquarters (Figure 1), 2.) Dominance of banana in the sector (the sector had to be considered a banana producing area, meaning that banana is produced for both household consumption and commercial value) and 3.) presence of BXW: the disease had to be present in the sector. There were no restrictions to the total number of villages that could be sampled from one sector.

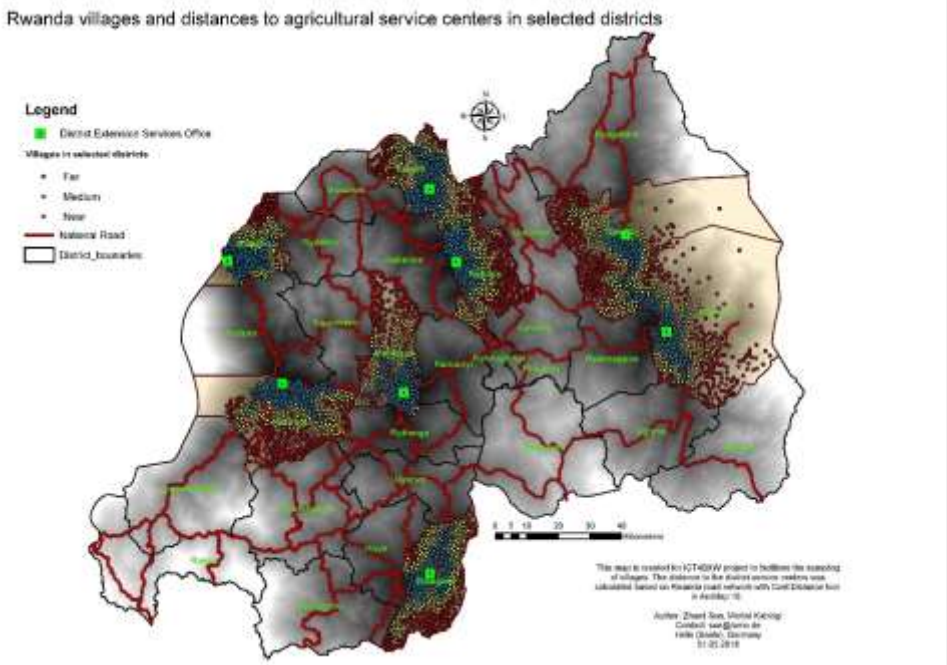


Figure 1: Map with overview of all districts from which villages were sampled. Colour codes represent short (blue), medium (yellow) and long (red) distance to the district's headquarters.

Cell selection

Cells were selected based on the same criteria as the sectors, based on expert input from sector and cell agronomists. The sampling team aimed for a good balance between geographical spread in the district and efficient access to the cells. There were no restrictions to the total number of villages that could be sampled from one cell.

Village selection

Three criteria were considered when selecting villages: (1) distance between the village and the district headquarters (figure 1). A three-point scale was used (close, medium, far). (2) Level of BXW incidence. A three-point scale was used (low, medium, high). Incidence levels were determined based on reports from sector and cell agronomists and field observations from RAB banana experts and technicians when passing through the village. Incidence levels are fluid and there is a chance that some villages move up or down on the scale between the time of sampling and the time of survey execution. This is due to ongoing disease eradication efforts (organized mat and plantation uprooting) and potential increase in incidence levels due to continued poor management and/or insect vectors. (3) Distance between villages. The sampling team aimed for selection of villages with a minimum distance of 5km or a non-intervention and non-control village in between two selected villages. In some districts these requirements were relaxed to reach the required total number of villages. Villages were randomly assigned to the intervention or control group.

Sampling of households

In both intervention and control villages a total of five households were sampled based on the gender of the household head. A weighted sample was taken from each stratum: 60% from the male-headed (3 households) and 40% from the female-headed stratum (2 households). Male enumerators were assigned to survey the male-headed households, and female enumerators surveyed female-headed households (Figure 2a).

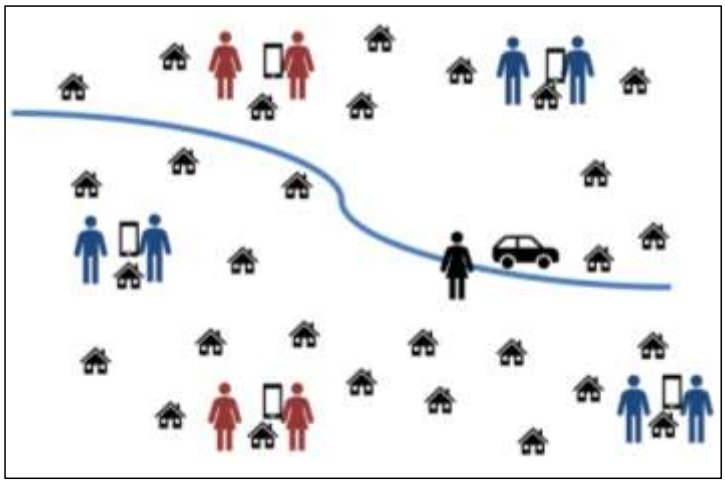


Figure 2: Graphical representation of household sampling strategy.

Sampled villages where the survey is conducted

A simple protocol was followed to sample villages, considering three levels of distance to the district headquarters (short, medium, large), and three levels of BXW incidence at village level (low, medium, high). For each category, two villages were sampled, one was the intervention village and the other was designated as the control village. In total there should be 72 intervention villages (9 per district) and 72 control villages (9 per district). However, due to unavailability of villages that

falls within the 'long distance to the district headquarters' category in Rubavu, the baseline was conducted only in 69 intervention and 69 control villages. In each village, 5 households were interviewed, resulting in a total of 690 households surveyed (Figure 2b). Further details on the overview of the villages selected in each district, including observations from field visits can be found in the Appendix section of this report.

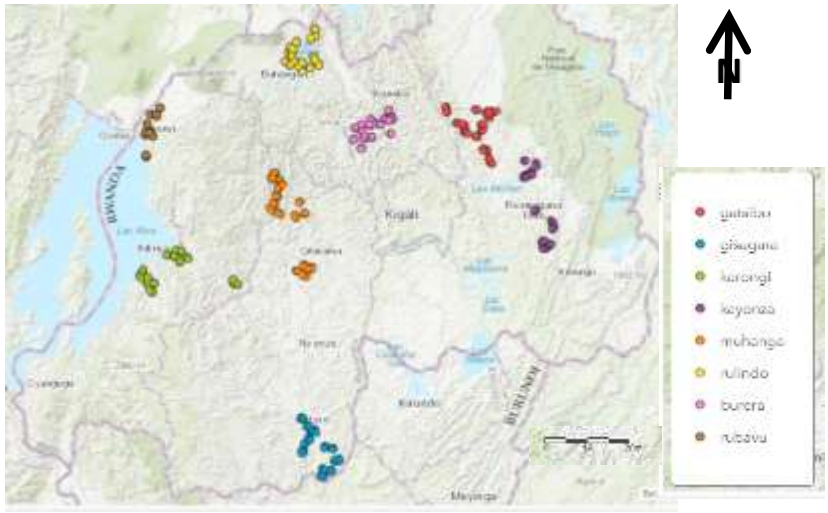


Figure 2b: Map showing villages where baseline survey of banana farmers was conducted in Rwanda

Baseline Survey of Farmer Promoters

Upon completion of baseline survey of farmers, a separate survey of FPs (Farmer Promoters) was conducted to assess their technical knowledge about BXW, ICT competencies and perspectives on delivery of extension service among farmers for BXW control. The major goal is to understand the critical gaps existing in the expertise and capabilities of the "next-users" of anticipated BXW tool and build on the major insights during the participatory and inclusive technology design (PITD) process. The survey, which lasted from late August to early September 2018, was conducted remotely over phone call and included 136 FPs across the surveyed villages. Following similar approach adopted for the farmers' survey, questionnaire was developed and deployed on smartphone-based ODK, and the enumerator recorded each FP's response to each question on the ODK form during each phone call session. The FPs within the intervention villages were assigned unique barcode IDs and cards which can be used to link information as the project intervention progresses.

Tentative Results from Farmers Survey

Demographics

The household survey covered 692 respondents, with 40% female and 60% male. Most of the surveyed respondents are in their middle ages (30 – 60 years;**Figure 3**). The size of the household varies between 1 and 18, with an average of 5 (**Figure 4**). Most respondents speak only Kinyarwanda, although some are knowledgeable in a second language, usually French (10%; Figure 5). With regards to education, 85% of the respondents has an education level of primary school or lower.

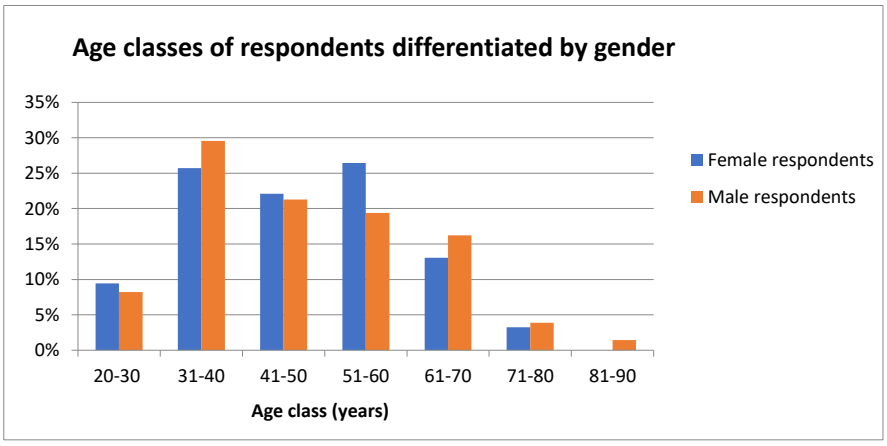


Figure 3: Respondents' age differentiated by gender.

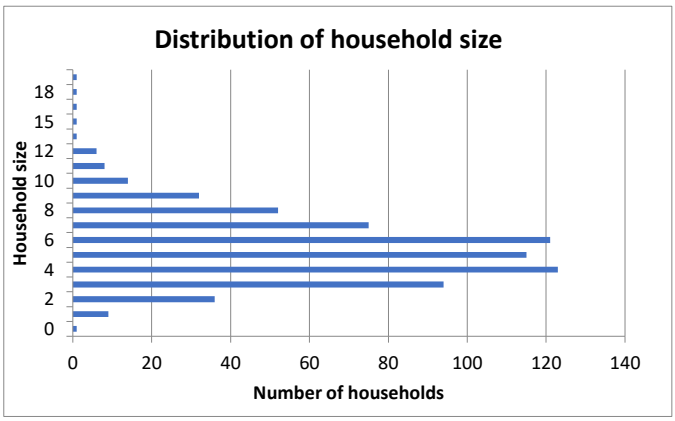


Figure 4: Distribution of household size.

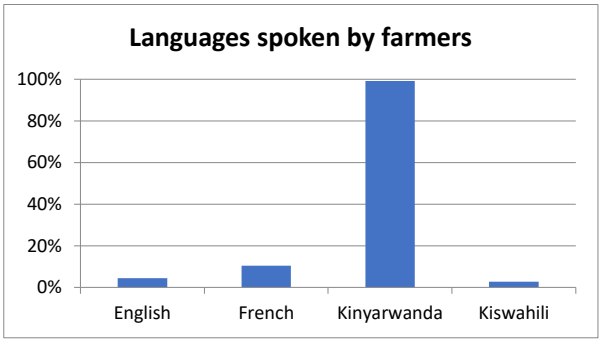


Figure 5: Percentages of farmers knowledgeable in English, French, Kinyarwanda and Kiswahili.

Assets

On average, farmers own 85% of the land they cultivate with the average cultivated land being 2,6 ha. Male farmers more often own land than female farmers, indicating that female farmers tend to rent land in addition to the land in their possession (Figure 6). Majority of the farmers (69%) have no means of transportation (Figure 7). More than half of the farmers has access to credit, in most cases provided by microfinancing (Figure 8).

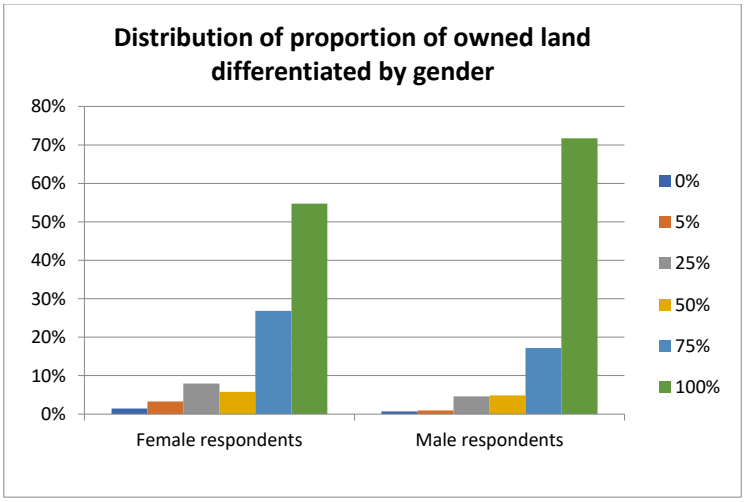


Figure 6: Distribution of the land farmers possess differentiated by gender.

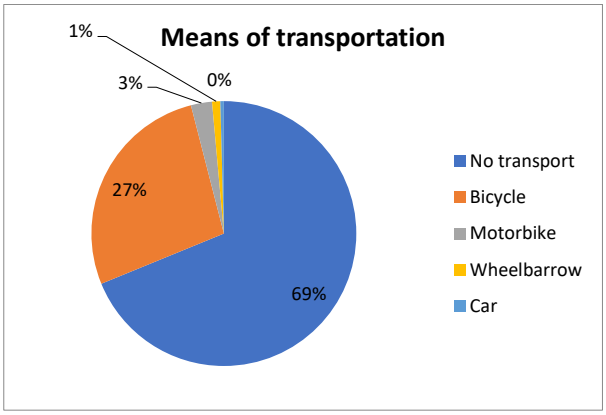


Figure 7: Means of transportation in possession of the surveyed farmers.

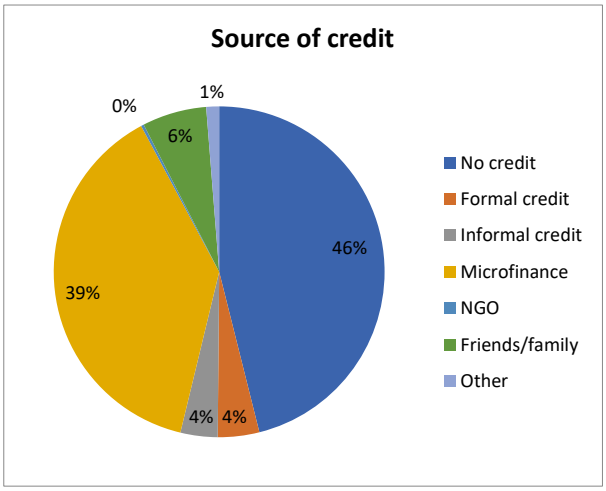


Figure 8: Access to and source of credit.

Farming activities

Most of the farmers own animals, mainly Cattle and goats (64% and 43%, respectively; Figure 9). Number of animals per farm are however low with an average of 1,6 cattle and 2,66 goats. The most commonly cultivated crop is food banana, followed by beer banana. It can be noticed that beer banana is more commonly cultivated by male farmers (Figure 10). The required labour for banana production is usually provided by the household head (mainly males) and supplemented by labour contribution of the spouse. In addition, 41% of the farmers hire additional labour (Figure 11).

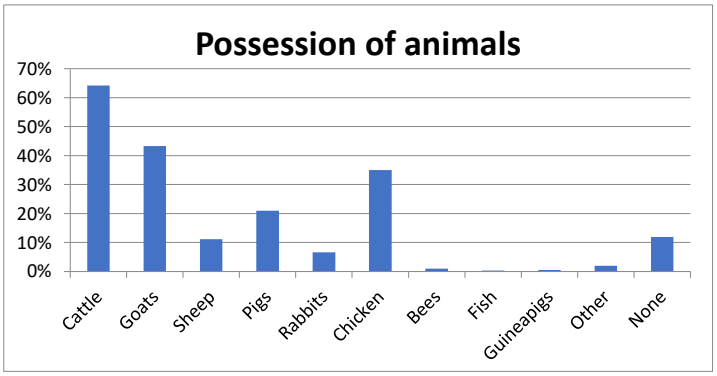


Figure 9: Percentages of farmers owning cattle, goats, sheep, pigs, rabbits, chicken, bees, fish, Guinea pigs or other animals.

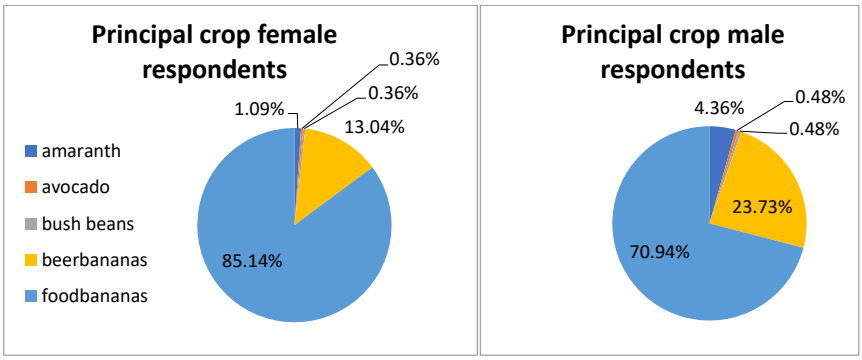


Figure 10: Principal crops cultivated by female and male farmers.

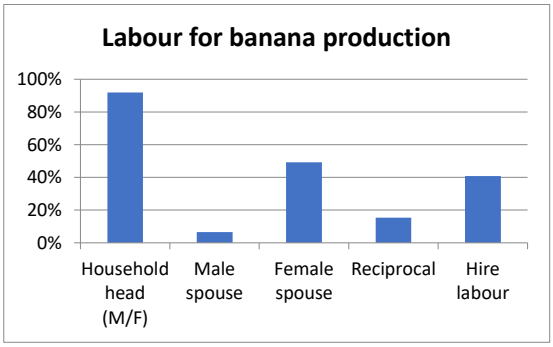


Figure 11: Source of labour for banana production.

Status of BXW

67% of the farmers has ever experienced BXW in his/her farm and 59% did so in the past year (Figure 12). No difference can be recognized between male and female farmers. Except for BXW, the most common disease on banana is Fusarium wilt (Figure 13). Infection in a farm seems to be strongly correlated with infection in neighbouring farms, as 95% of the infected farms also have neighbouring farms which are infected (Figure 14).

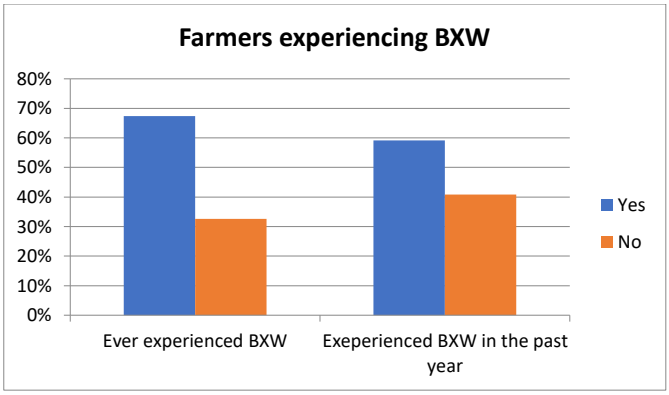


Figure 12: Percentages of farmers having ever experienced BXW and having experienced BXW during the past year.

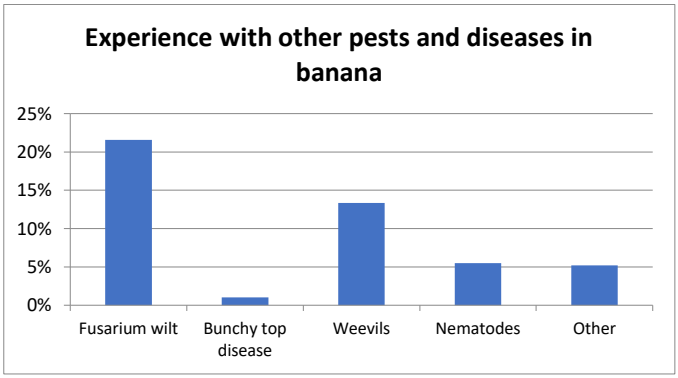


Figure 13: Pests and diseases on banana, other than BXW, ever experienced by farmers.

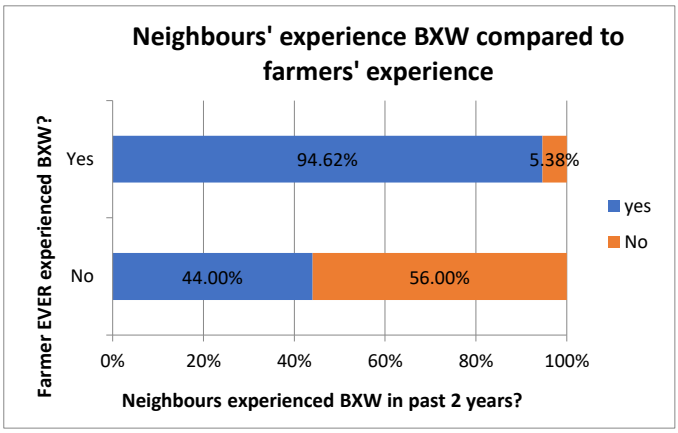


Figure 14: Relationship between ever infected farms and infection in neighbouring farms during the past 2 years.

Knowledge of BXW and control – and prevention measures

Most of the farmers seems to be well-aware of prominent symptoms of BXW. The very early symptom of leaf discoloration is only known by 27% of the farmers (Figure 15). No strong differences occur between the knowledge of male and female farmers. Farmers with a history of experiencing BXW do however tend to have a better knowledge as indicated in Figure 16 for 'brownfruit' symptom. With regards to knowledge on control methods, results strongly differ. Certain methods (CMU and burning/destroying) are well known whereas others (SDSR and CFU) are known by less than a quarter of the consulted farmers (Figure 17). As could be seen for symptoms, male farmers have a better knowledge on BXW control methods (Figure 18). This is translated in the control farmers perceive in the decision process of controlling BXW. 22% of female respondents indicates to have no control in this process, whereas this is only the case for 5% of the male respondents (Figure 19).

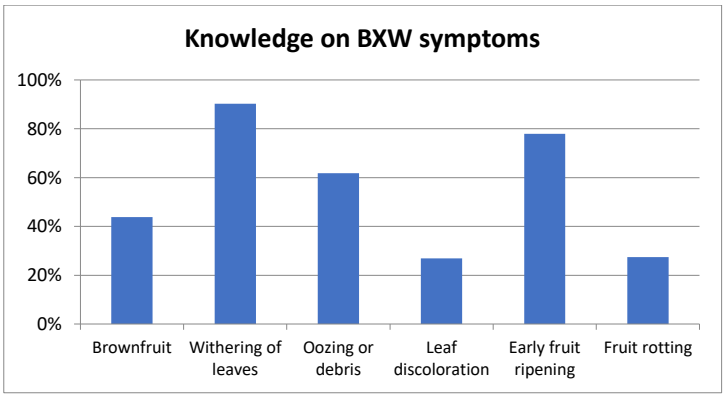


Figure 15: farmers' knowledge of both early and late symptoms of BXW.

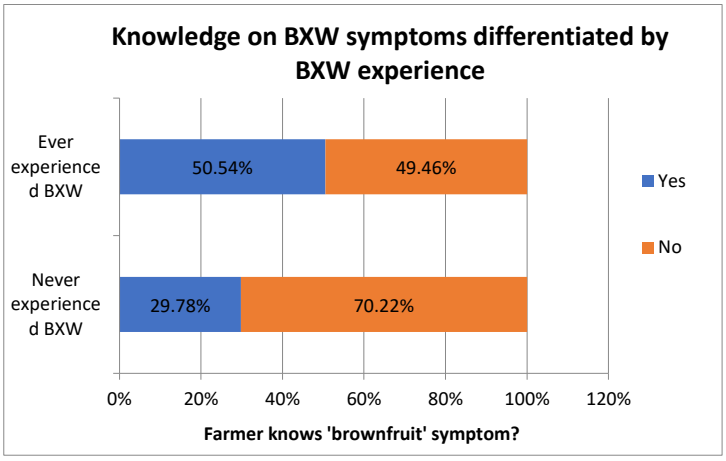


Figure 16: Farmers' knowledge on 'brown fruit' symptom, differentiated by gender.

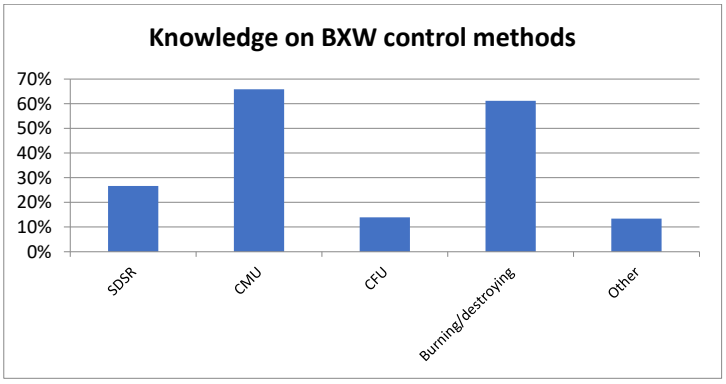


Figure 17: Farmers' knowledge on single-diseased stem removal (SDSR), complete mat uprooting (CMU), complete field uprooting (CFU), burning and destroying of infected stems and other control methods.

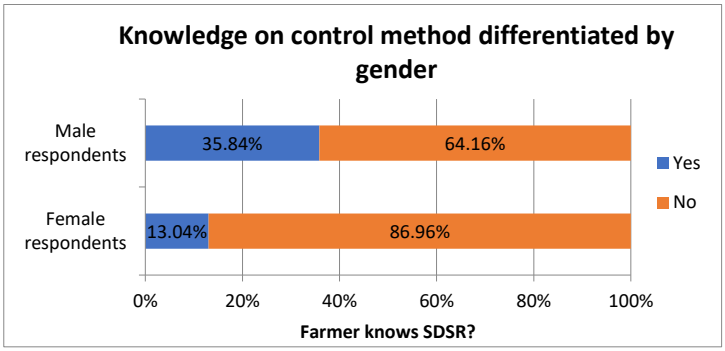


Figure 18: Farmers' knowledge on SDSR as a control method, differentiated by gender.

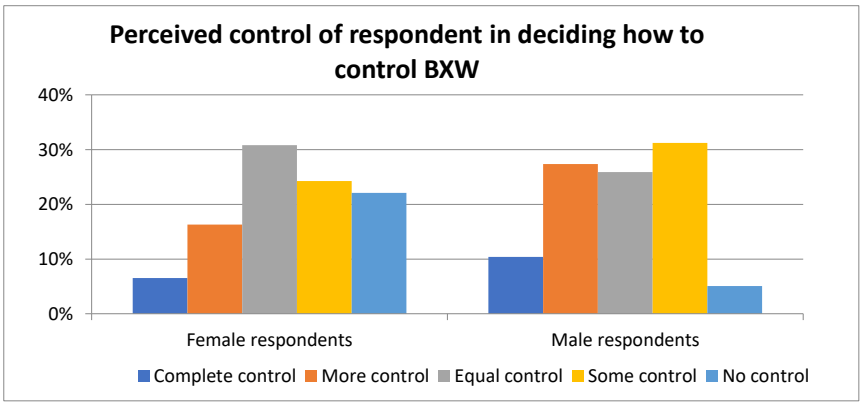


Figure 19: Gender-related perceived control by respondents in the decision process of controlling BXW.

Knowledge on the causes of BXW is limited. Only 57% of the farmers is aware that insects and tools can transmit BXW and less than 20% is aware of other important transmitters like animals and infected plant material (Figure 20). These results are translated in farmers' knowledge on prevention measures, as can be seen in Figure 21. The most well-known prevention methods are male flower debudding and tool-related practices, whereas very few farmers are aware of the importance of selecting healthy plant material or preventing the roaming of animals. Whilst the knowledge on causes and prevention methods of BXW is similar for male and female farmers, control in decision process is not equal. Female respondents indicate to have less control in deciding on prevention measures than male respondents (Figure 22).

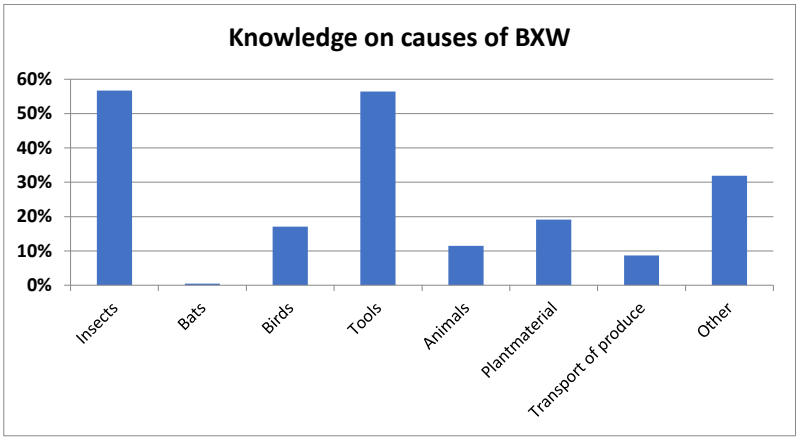


Figure 20: Farmers' knowledge on potential causes of BXW.

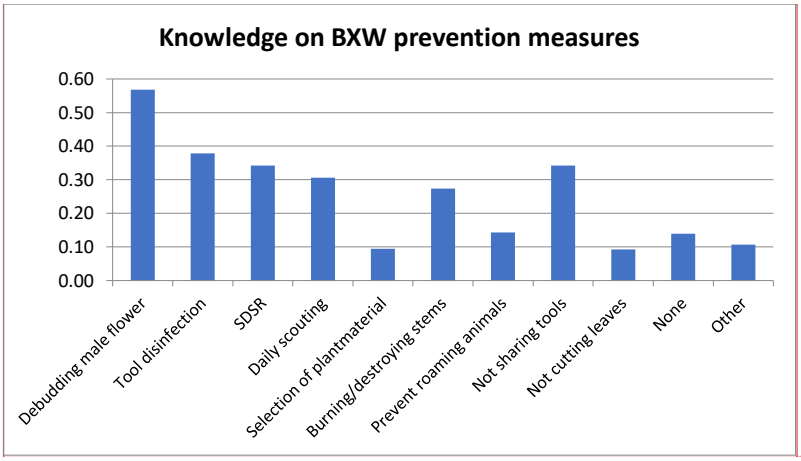


Figure 21: Farmers' knowledge on BXW prevention measures.

Comentado [mv1]: Should I add a graph on the APPLICATION of prevention measures? It gives the exact same trend as can be seen in this one.

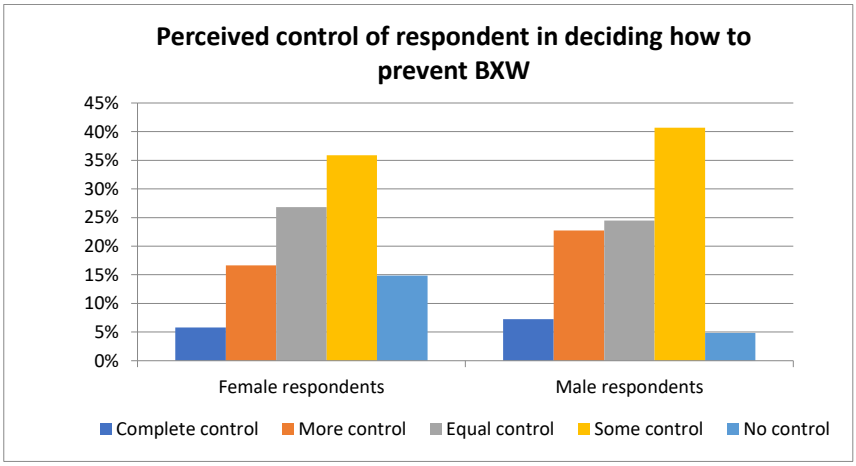


Figure 22: Gender-related perceived control by respondents in the decision process of preventing BXW.

The most important overall challenge for farmers to implement BXW prevention and control measures seems to be a lack of knowledge on these measures (Figure 23). Female and male farmers however experience different challenges. Male farmers indicate labour, cost and access to material as important challenges as well, whereas these are not at all perceived as important challenges by female farmers (Figure 24).

As indicated earlier, few farmers are aware of the importance of selecting healthy plant material. Accordingly, it is common practice to share and receive plant material and not buying and selling it (

Figure 25). This is true for both male and female farmers. When looking into the source of plant material, the usual origin is through a fellow farmer (Figure 26).

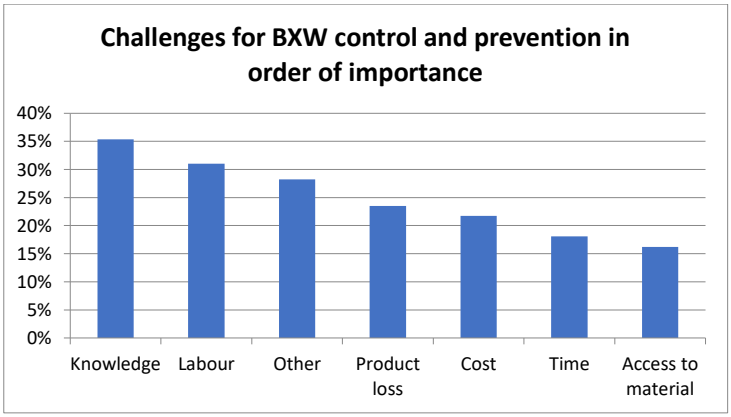


Figure 23: Most important challenges for the implementation of BXW control and prevention methods, as indicated by farmers.

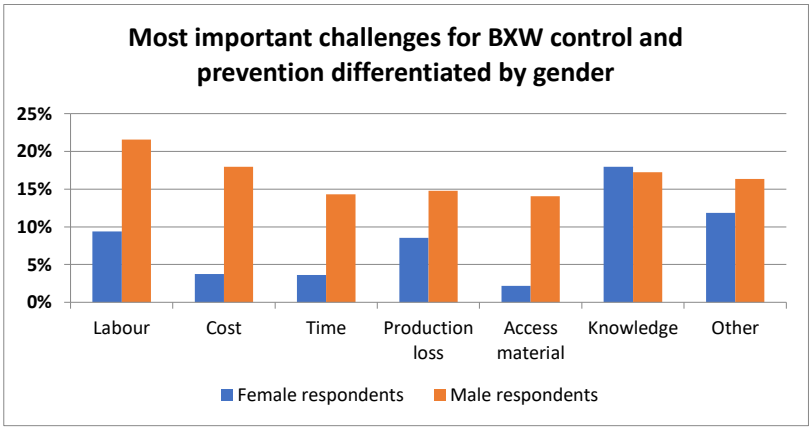


Figure 24:Most important challenges for the implementation of BXW control and prevention methods, as indicated by male and female farmers.

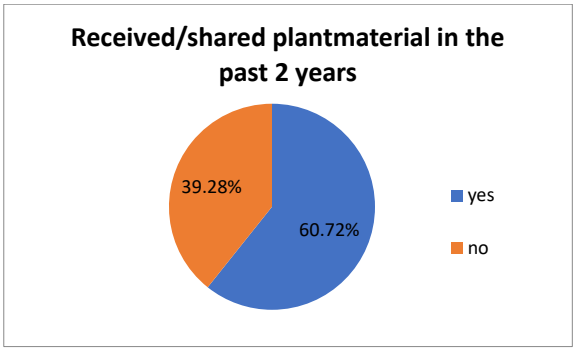


Figure 25: Percentage of farmers having received or shared banana plant material during the past 2 years.

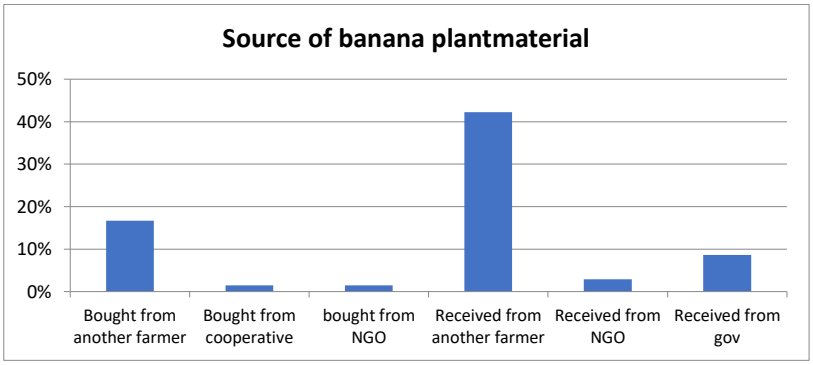


Figure 26: Sources of farmers' banana plant material.

Access to information

61% of the consulted farmers has ever received extension services (Figure 27). No notable difference between male and female farmers exists. The most important providers of extension services, in case received, are government agronomists, farmer promoters and Farmer Field School facilitators (Figure 28). In addition to extension services, farmers receive information from a group. 49% of the respondents is member of a group (Figure 29). Nonetheless, 73% of the farmers identifies the radio as the most important source of agriculture-related information (Figure 30). Other important sources are extensionists (66%) and fellow farmers (36%).

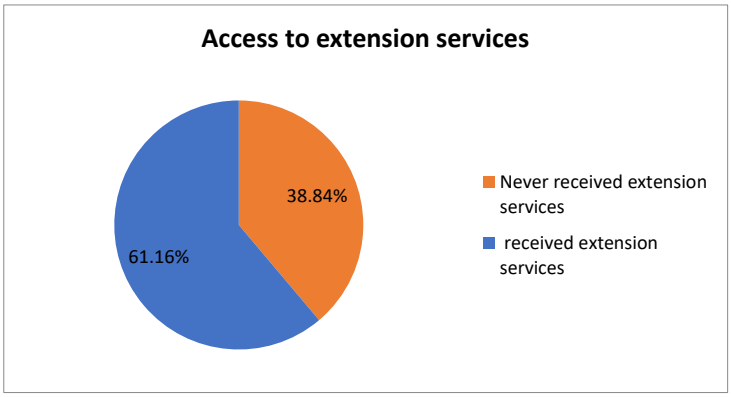


Figure 27: Percentage of farmers having received extension services.

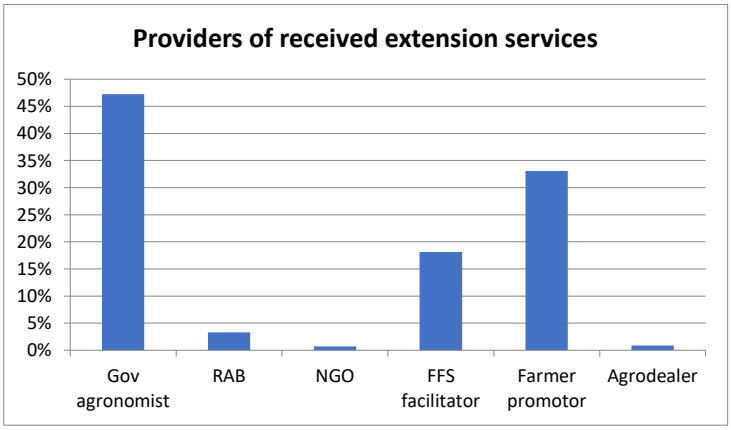


Figure 28: Sources of the received extension services.

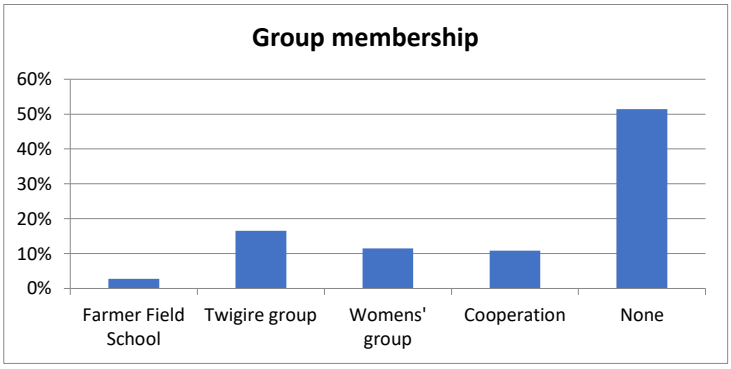


Figure 29: Farmers' membership of an agriculture-related group.

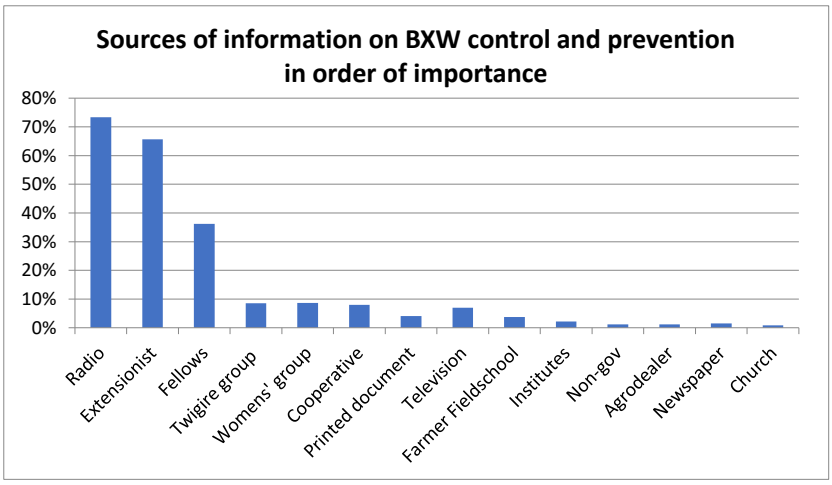


Figure 30: Most important sources of the information farmers receive on BXW control and prevention measures.

ICT assets and interest in ICT-based agricultural services

Radio and basic phone are the most commonly used ICT-devices used by farmers (Figure 31). One out of every ten of the farmers has not used any ICT-device within 30 days prior to the survey. Focusing on phones, 72% of the farmers owns a basic phone and 3% own smartphone(s) (Figure 32) while the most common subscribed service provider is MTN (Figure 33).The likelihood of owning a phone is clearly determined by both gender and age. Male and young farmers are most often in possession of a phone (Figure 34; Figure 35). About 1 in 5 farmers has used a phone for any agriculture-related service and this is again most common among young farmers (Figure 36).

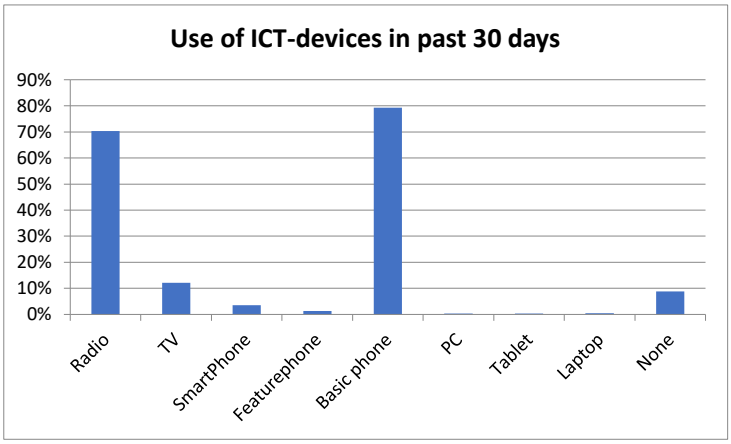


Figure 31: ICT-devices used by farmers during the past 30 days.

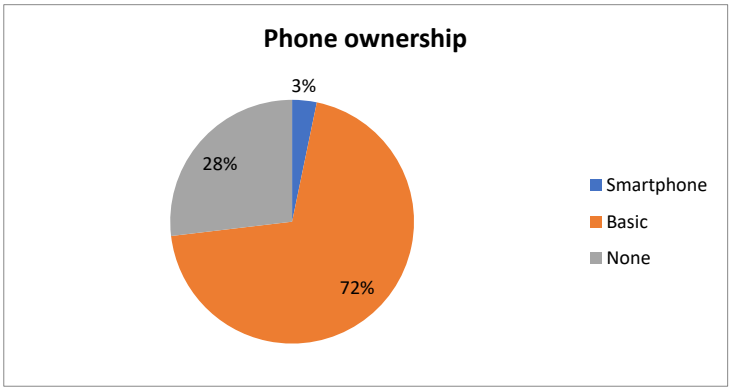


Figure 32: Phone ownership among farmers.

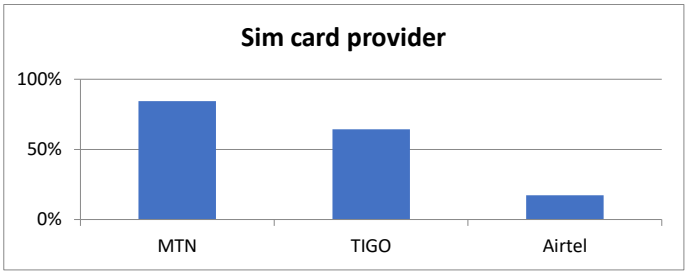


Figure 33: SIM card service providers on farmers' phones.

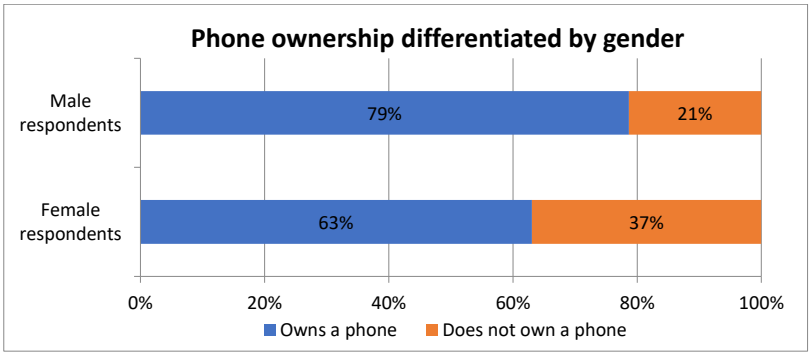


Figure 34: Percentages of male and female farmers owning a phone.

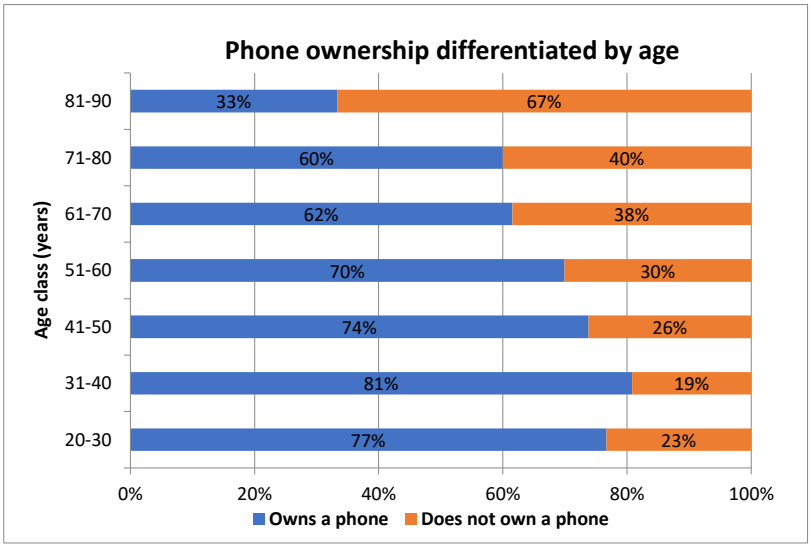


Figure 35: Percentages of farmers in different age classes that owns a phone

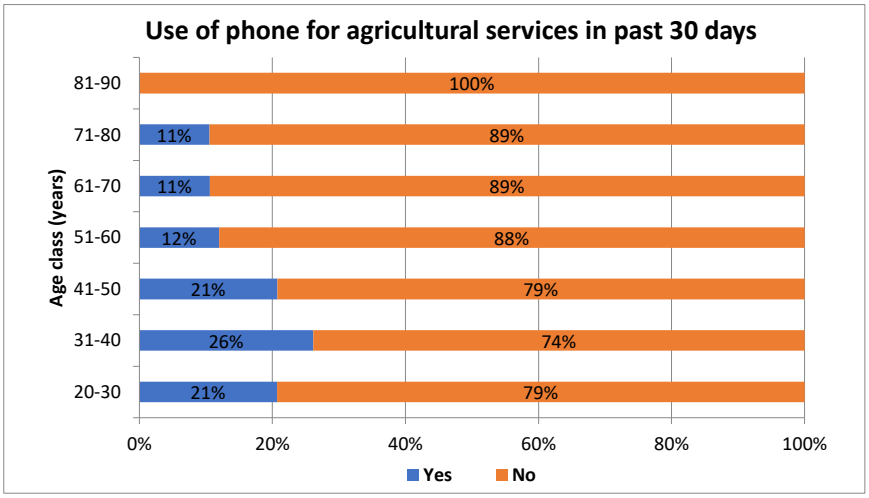


Figure 36: Percentages of farmers in different age classes which have used their phone for agricultural services during the past 30 days.

Three out of every five farmers believed that electronic devices could help in preventing and controlling BXW. Nonetheless, they currently experience several barriers to the usage of such services, the most important barriers include non-awareness of mobile-based tool existence and lack of know-how on their use (Figure 37). For farmers who indicated that they would use mobile-based services, their preferred mode of communication were voice calls (82%), radio (52%) and SMS (32%) (Figure 38). Majority of the farmers (72%) indicated willingness to pay for such services and the amount that they would be willing to spend varies between 100 and 600 RWF (Figure 39; Figure 40).

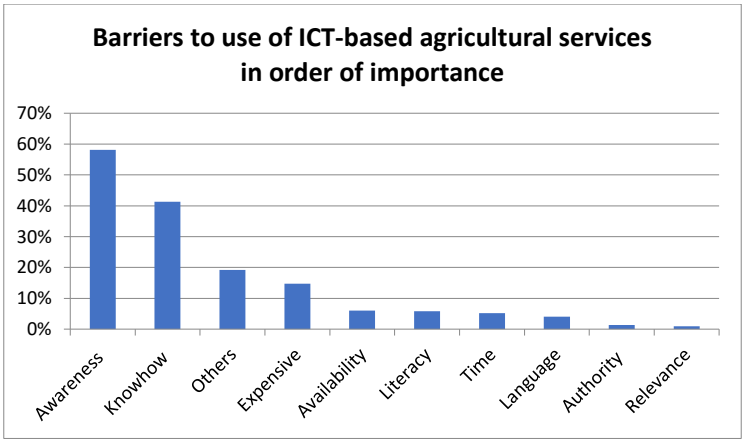


Figure 37: Most important barriers to using ICT-based agricultural services as indicated by farmers.

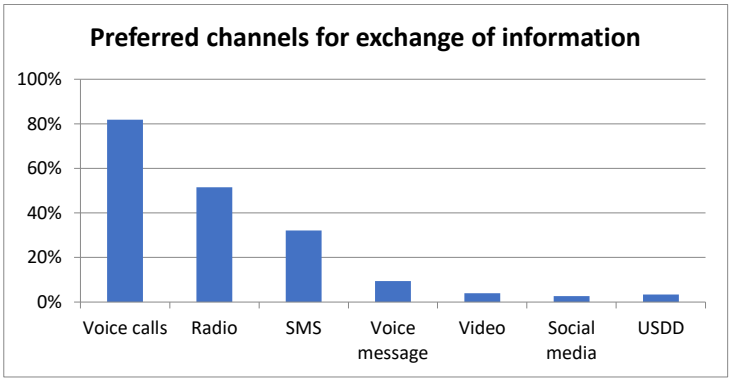


Figure 38: Channels farmers would prefer to receive ICT-based agricultural services.

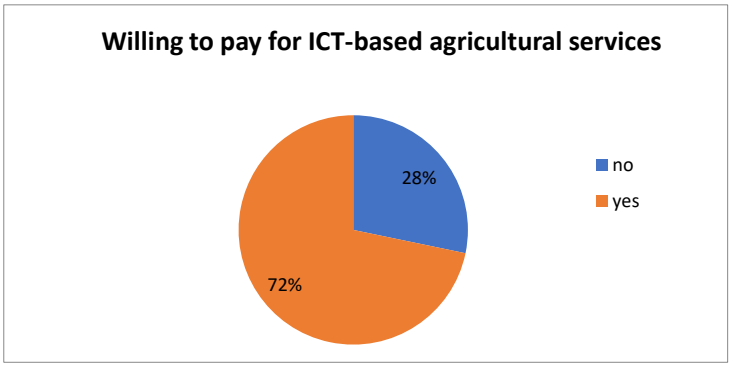


Figure 39: Percentage of farmers that are willing to pay for ICT-based agricultural services.

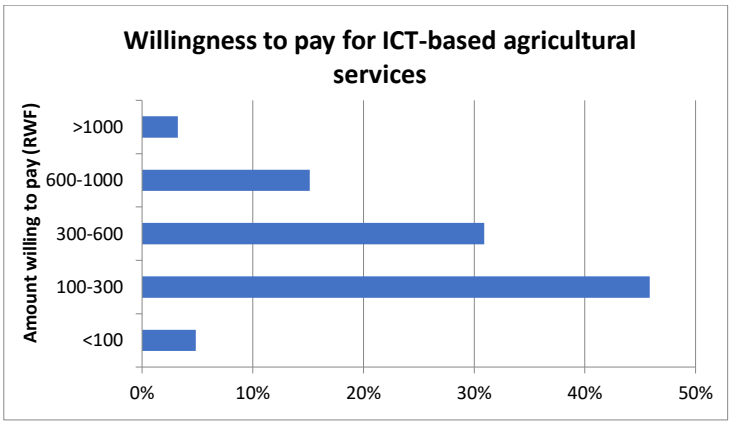


Figure 40: Farmers' willingness to pay for ICT-based agricultural services in monetary terms.

BXW incidence and initial heat map

Approximately 60% of the farmers reported that they have observed BXW in their farm within the past 12 months, and similar percentage indicated that they have observed BXW in the past 2 years and 6 years. Heat map rendition of the reported BXW frequency (Figure 41a-c) suggests that the severity of BXW may have changed within the surveyed districts when comparing BXW incidence rate in the past 2 years to past 12 months. The severity of BXW in the past 2 years seems comparable to the past 6 years, with prominent hot-spots in the north-central and south-eastern districts.

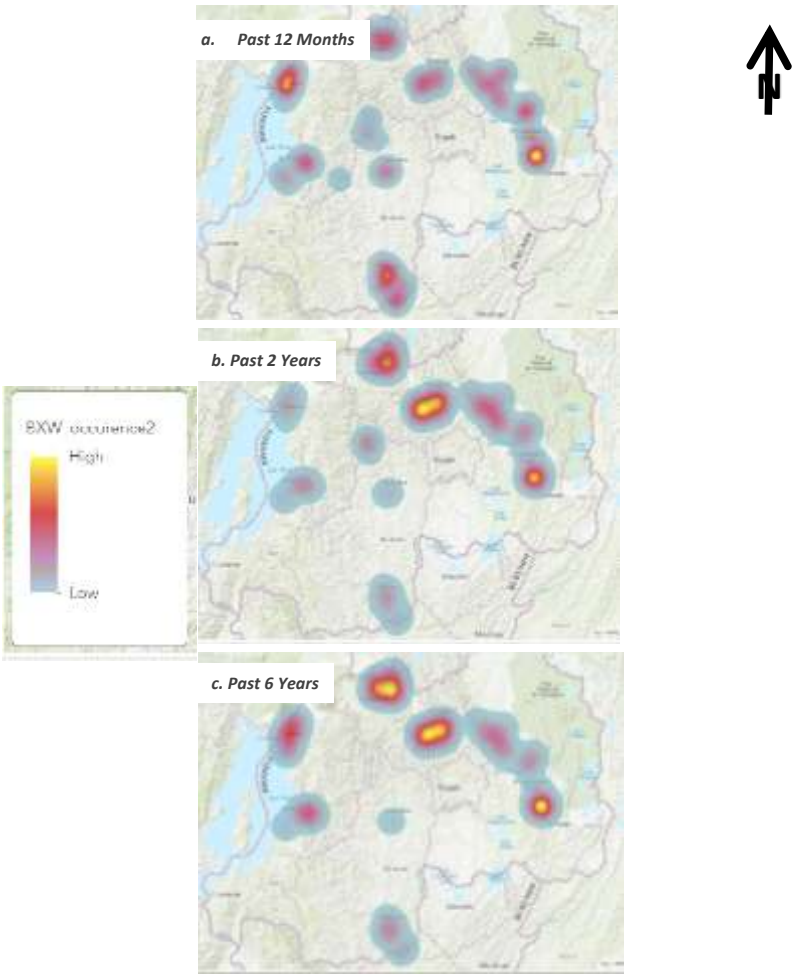


Figure 41a-c: Heat map showing hotspots of reported BXW incidence among surveyed Banana farmers

Tentative Results from farmer promoters Survey

Demographics

The farmer promoters' survey was carried out among 138 farmer promoters, 112 male and 26 female respondents. Majority of the FPs (~57%) are 30-50 years old, while 38% are over 50 years old, and the rest are less than 30 years old. Similar aged-based distribution was observed in both gender (**¡Error! No se encuentra el origen de la referencia.**2).

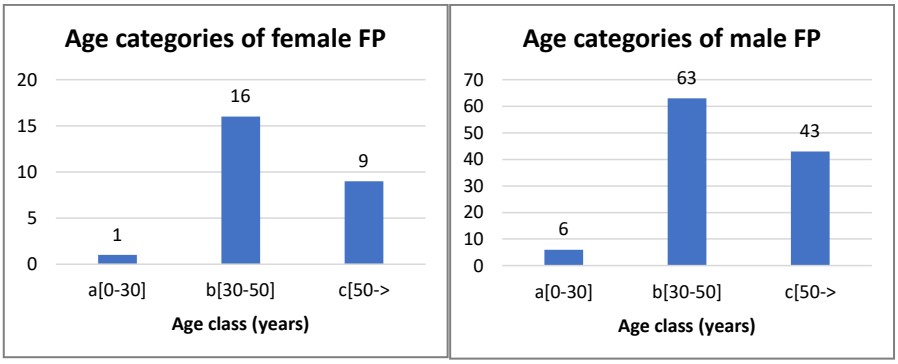


Figure 42: Age distribution differentiated by gender.

Education and professional experience of farmer promoters

Majority of the farmers (66%) have attended primary school (Figure 413) and the distribution of educational status was similar among male and female FPs (Figure 424). Most the FPs (64%) have acquired more than 4 years of professional experience (Figure 435), although this is differentiable by gender. A highest proportion (38%) of the female FPs have less than 2 years of experience, in contrast to male FPs who mostly have greater than 6 years' experience. This reflects the recent inflow of women into the profession of female promoters (Figure 446).

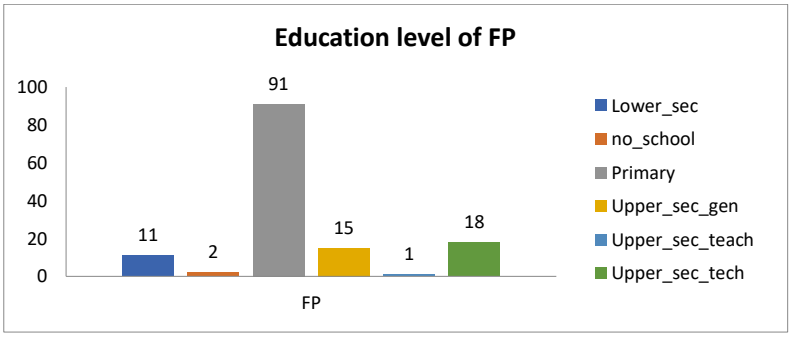


Figure 413: Education level of farmer promoters: lower secondary (Lower_sec), no school (no_school), primary (Primary), general upper secondary (Upper_sec_gen), teachers' upper secondary (Upper_sec_teach), technical upper secondary (Upper_sec_tech).

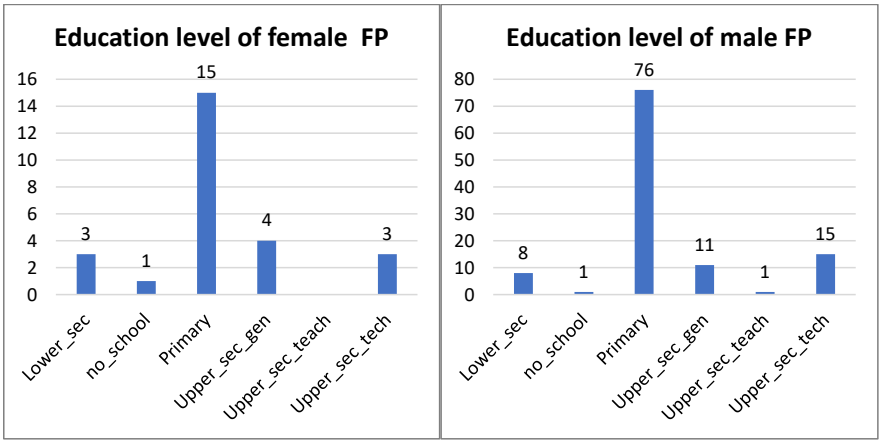


Figure 424: Education level of farmer promoters differentiated by gender.

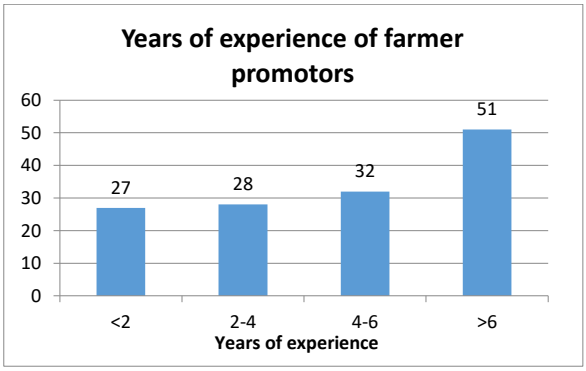


Figure 435: Years of professional experience of farmer promoters.

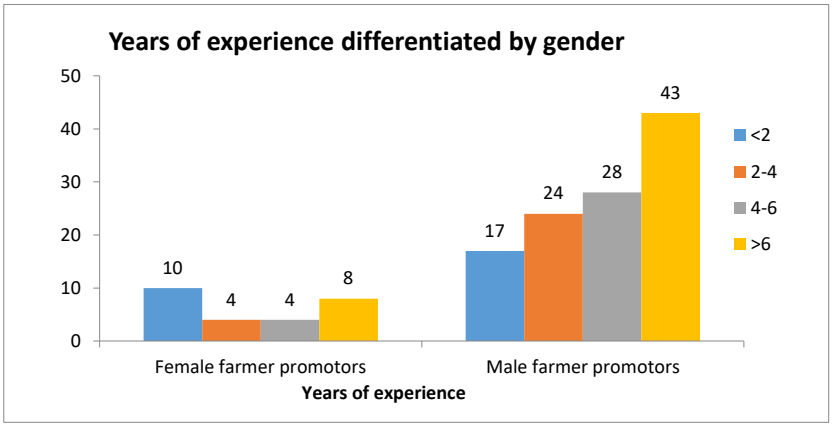


Figure 446: Years of professional experience of famer promoters differentiated by gender.

Expertise of farmer promoters

Half of the FPs rated their expertise with BXW as "Good" (Figure 457) and 22 FPs indicated that they have a poor or very poor experience. The distribution of expertise among female and male farmer promoters is considerably similar. The experience of FPs with Banana was similar to their experience on BXW, and although this is differentiated by gender category, the distribution is comparable (Figure 48; Figure 4649). This suggests that expertise on banana and BXW are strongly related.

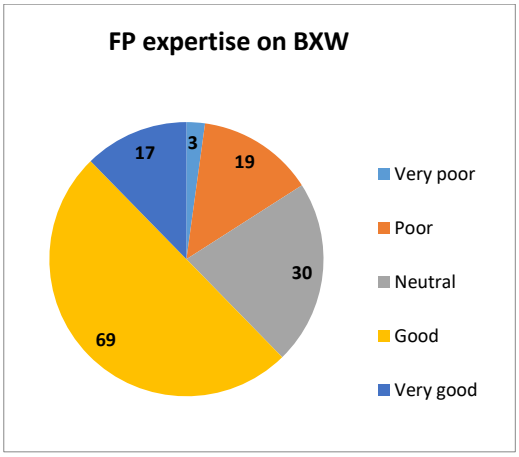


Figure 457: Expertise levels of farmer promoters on BXW.

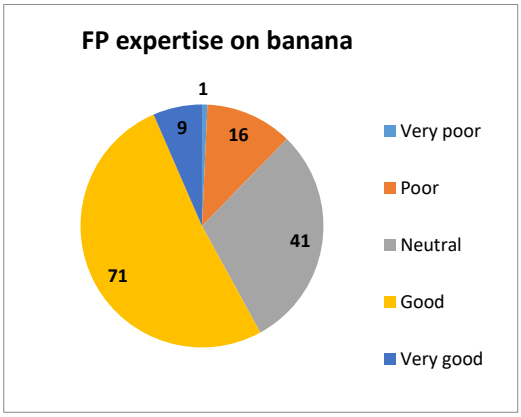


Figure 48: Expertise levels of farmer promoters on banana production.

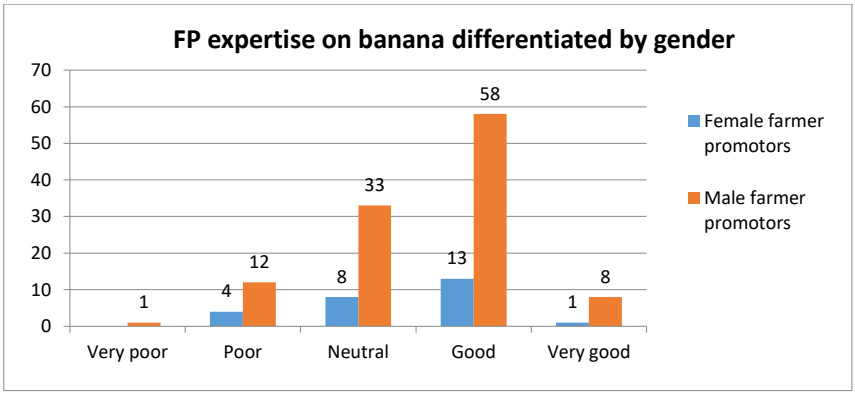


Figure 469: Expertise levels of farmer promoters on banana production, differentiated by gender.

ICT assets and interest in ICT-based agricultural services

Almost all FPs possess a phone, which are mostly basic phone, except for 5 respondents who indicated that they have a smartphone (Figure 50). The most commonly used ICT-devices are the radio and basic phone (Figure 51). This is true for both male and female farmer promoters (Figure 52). Less than half of the farmers use their phone for job-related purposes, mostly by calling (Figure 483). If an ICT-based agricultural service would exist, the preferred media channel for farmer promoters would be voice calls or SMS (Figure 494). There is some interest as well in USSD codes or video communication.

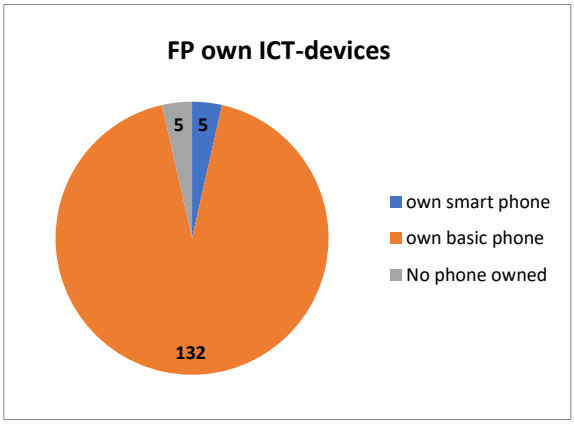


Figure 50: Farmer promoters owning smart and/or basic phones.

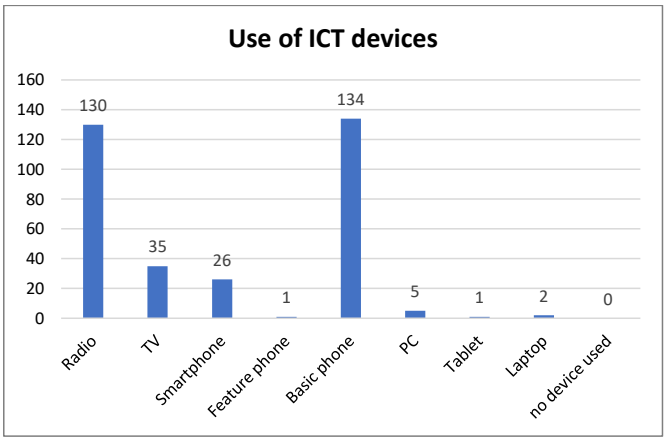


Figure 51: Farmer promoters who have previously used ICT-devices.

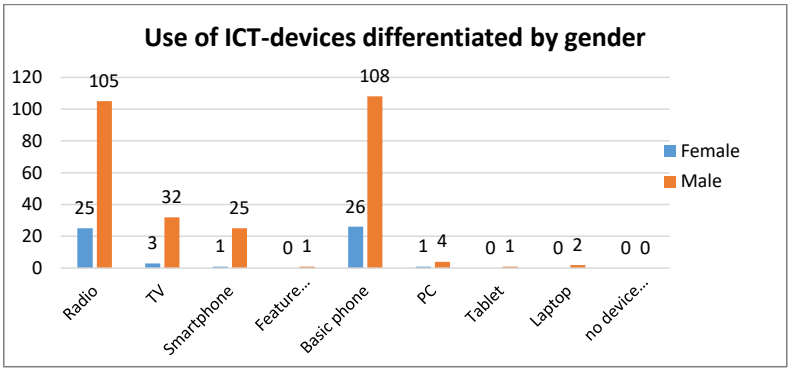


Figure 472: Farmer promoters using ICT-devices by gender.

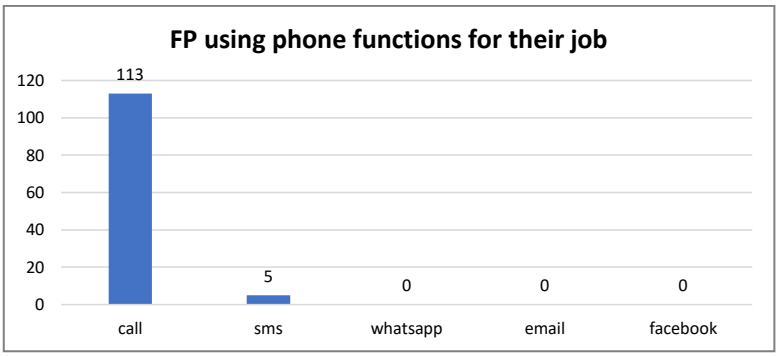


Figure 483: Farmer promoters using phone functions for their job.

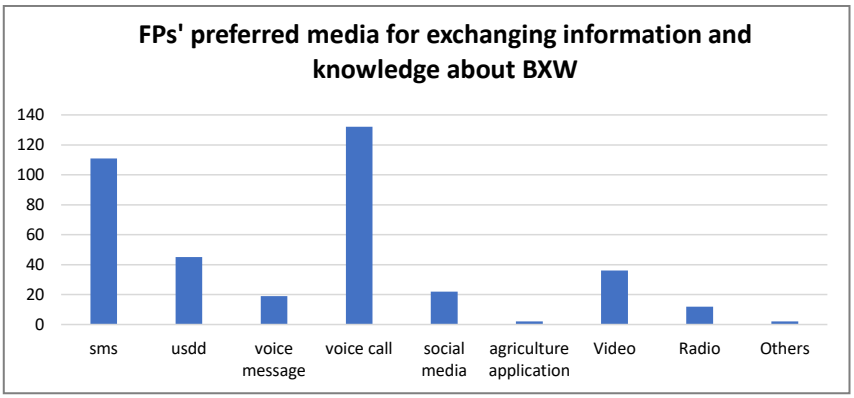


Figure 494: FPs' preferred media for exchanging information and knowledge about BXW.

APPENDIX 1: Overview of village sampling and field notes during the baseline survey

Eastern province

Kayonza district

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Kamajigija Rukara **Rukara**	Rurama Rusera **Kabarondo**	Rusera Rusera **Kabarondo**
	Control	Village: Cell: Sector:	Butimba II Kawangire **Rukara**	Kinkoronko Gikaya **Nyamirama**	Butogbagire Rusera **Kabarondo**
Medium	Intervention	Village: Cell: Sector:	Kinunga Rwiminshiya **Rukara**	Kinunga II Rwiminshiya **Rukara**	Nyabikenke II Kabura **Kabarondo**
	Control	Village: Cell: Sector:	Akabare I Rwiminshiya **Rukara**	Muzizi Rukara **Rukara**	Agashar Kabura **Kabarondo**
Large	Intervention	Village: Cell: Sector:	Murambi Kabura **Kabarondo**	Kabeza Kabura **Kabarondo**	Rubira Kabarondo **Kabarondo**
	Control	Village: Cell: Sector:	Nyabikenke Kabura **Kabarondo**	Agatare Kabura **Kabarondo**	Gisoro Kabura **Kabarondo**

Map showing geographical spread of sampled villages in Kayonza district

Field notes

Kayonza is an important banana producing district with bananas produced throughout the district except for the areas close to Akagera National park. BXW is present in all banana producing areas and the sampling team found it most challenging to locate villages with low BXW incidence. The district has a flat terrain and road conditions are generally good, including off principal tarmac road.

Kabarondo sector

- This sector covers "near" to "far" distance gradient from the district headquarters.
- The sector has all gradients of BXW incidence.
- Initially the tarmac road from Kayonza towards the Tanzania border can be followed. In the sector you drive one murram roads. Primary murram roads are in good condition, secondary ones are poor but motorable without using 4x4.
- Phone connectivity on both Airtel and MTN is medium to poor in most cells.
- Internet connectivity in Kabarondo is poor. WhatsApp can send and receive messages occasionally. Use of online Google Maps is not possible. In Rusera (near district headquarters) connectivity is better. Google Maps is slow but can be used. WhatsApp works well in this cell.
- Rusera cell is located directly next to the principal tarmac road to Kayonza.
- Rusera has good phone connectivity, especially for MTN.
- Rusera is grid connected with a direct line from Kayonza.

Nyamirama sector

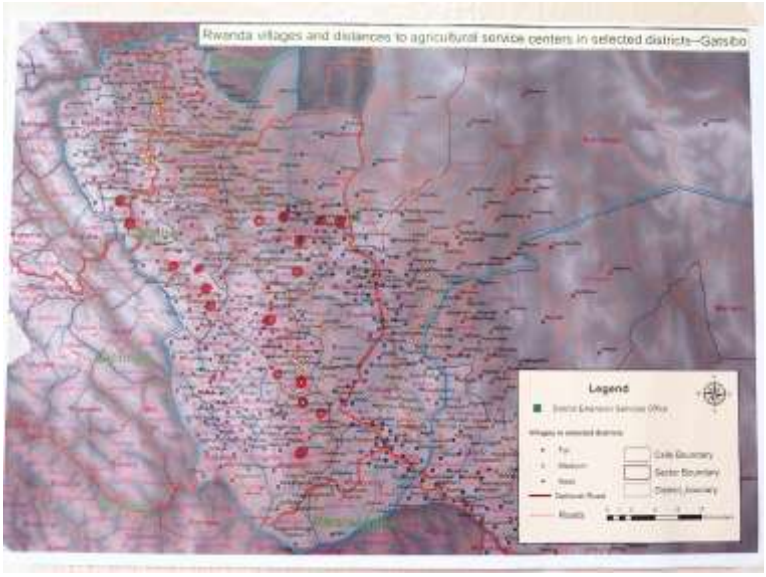
- Gikaya cell present in sample with one village in short distance to district headquarters and medium BXW incidence gradient.
- Generally medium to high BXW incidence in the cell
- Cell located close to the principal road to Kayonza. Roads in Gikaya are unpaved yet murram conditions are good.
- Phone reception is good
- Internet reception is good enough to send and receive via WhatsApp and use online Google Maps
- The cell is grid connected

Rukara sector

- Included in sample for short distance to headquarters and low BXW incidence (2 villages) and medium distance to headquarters and low to medium BXW incidence (4 villages).
- To reach the cell you drive on the principal tarmac road from Kayonza past Lake Muhazi. Roads in the sector are murram and in good condition.
- The further away from the principal tarmac road the poorer the cell reception becomes. Receiving and sending WhatsApp messages becomes difficult and Google Maps no longer works.
- In the center of the cell there is no powerline visible and villages are likely off-grid.
- Once reaching Muzizi village the powerline returns, with improvement in phone and internet reception. From this village it is easy to reach the tarmac road again.

Gatsibo

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Nyabikenke Nyabigiri **Gitoki**	Rushashi Cyabusheshe **Gitoki**	Rukiri Nyamirama **Gitoki**
	Control	Village: Cell: Sector:	Kwishaba Nyabigiri **Gitoki**	Sata Karubungo **Gitoki**	Kinteko Nyamirama **Gitoki**
Medium	Intervention	Village: Cell: Sector:	Rushenyi Rwarenga **Remera**	Rubare Nyagakombe **Remera**	Mataba Rwarenga **Remera**
	Control	Village: Cell: Sector:	Kabuye Rwarenga **Remera**	Byimana Murambi **Murambi**	Agacyamo Muambi **Murambi**
Large	Intervention	Village: Cell: Sector:	Rukira Nyagisozi **Kageyo**	Rugarama Nyagahanga **Gatsibo**	Kizinga Nyagahanga **Gatsibo**
	Control	Village: Cell: Sector:	Gakeri Nyagisozi **Kageyo**	Nyagisozi Nyagisozi **Kageyo**	Kageyo Nyagisozi **Kageyo**



Map showing geographical spread of sampled villages in Gatsibo district

Field notes

Generally, Gatsibo is flat with small elevation changes. Bananas are an important crop in the district and are farmed commercially and at large scale in some of the district's sectors. Primary and secondary roads are unpaved but road conditions are good. The district shows all levels of BXW incidence. District agricultural officer appears well informed about BXW presence in the district.

Gitoki sector

- All six villages in the short distance to district headquarters category are located in this cell.
- The cell has good murram roads
- There is full phone reception in Gitoki
- Mobile internet works, WhatsApp can be used for sending and receiving messages including pictures.
- The sector has large scale, commercial banana farms. BXW is mostly present at medium to high incidence rates.

Remera sector

- Four of the six villages in the medium distance to headquarters category were sampled in this sector.
- Remera has good murram roads.
- Phone reception is generally good in Remera
- Internet has medium reception. WhatsApp works, Google Maps can be used to limited extend.
- All incidence levels of BXW are present in the sector which is reflected in the sample.

Murambi sector

- Murram roads in good conditions.
- Sector typically has high incidence of BXW
- Phone connectivity is very poor

- Internet connectivity is nearly absent (E level maximum)

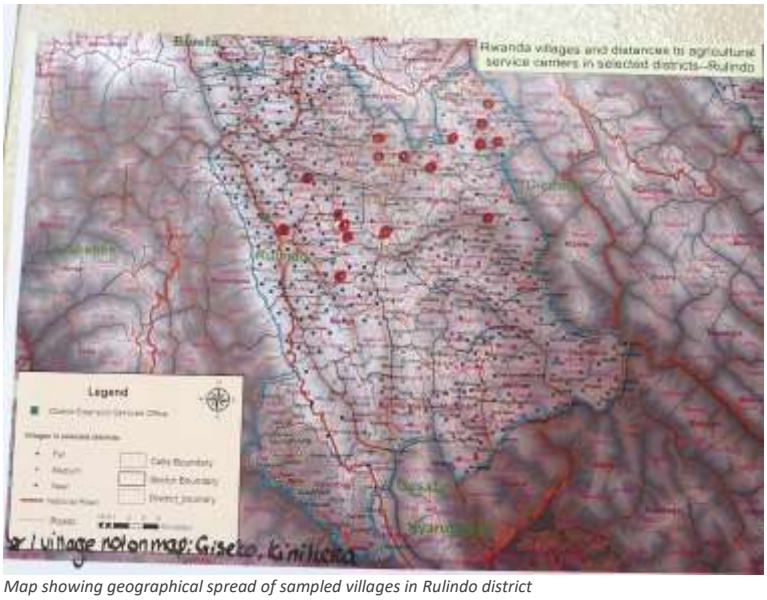
Gatsibo sector

- Two villages were sampled in this sector, representing the far from district headquarters medium and high incidence categories.
- Murram roads in good condition
- Internet connectivity is poor
- Generally, the sector has low BXW incidence except for the southern area.

Northern province

Rulindo

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Gaseke Barari **Tumba**	Rugando Nyirabirori **Tumba**	Karambi Mirezero **Tumba**
	Control	Village: Cell: Sector:	Marembo Mizezero **Tumba**	Ruvumba Taba **Tumba**	Kagusa Gahabwa **Tumba**
Medium	Intervention	Village: Cell: Sector:	Cyasenge Karama **Buyoga**	Ndusu Rebero **Kinihera**	Giseko Butunzi **Kinihera**
	Control	Village: Cell: Sector:	Kagozi Ndarage **Buyoga**	Bwishya Karegamazi **Kinihera**	Mutoyi Karegamazi **Kinihera**
Large	Intervention	Village: Cell: Sector:	Rusugati Sayo **Kisaro**	Buberano Gitatsu **Kisaro**	Akamanamana Mumama **Kisaro**
	Control	Village: Cell: Sector:	Songa Kamashenyi **Kisaro**	Murambi Muhuga **Kisaro**	Nyantabo Kigarama **Kisaro**



Map showing geographical spread of sampled villages in Rulindo district

Field notes

Rulindo is mountainous and therefore moving around in the district is slow. Road conditions are good however with new murram feeder roads constructed throughout the district. Cell reception in the district is generally good, internet medium to poor (E to H+ network). From Bushoki it is easy to link with the main road coming from Musanze towards Kigali.

Tumba

- Tumba sector is the district next to Bushoki and to get there it takes a few minutes only, mostly on a tarmac road.
- The sector has all types of BXW incidence levels
- Phone reception is good in Tumba
- Internet gives H+ reception which is enough to use WhatsApp, online Google Maps, and simple browsing.

Buyoga

- This sector generally has a low BXW incidence since all affected plantations were uprooted just last year.
- Two villages were sampled in this sector, representing the medium distance low BXW incidence category (control and intervention). In these two villages too BXW affected plantations were uprooted last year.
- The sector has good phone reception, and internet connectivity ranges between E and H+.
- Road conditions are good, with new murram feeder roads as primary roads.

Kinihira

- For the medium distance medium and high incidence category villages were sampled in Kinihira sector.
- BXW is present throughout this sector.

- In the recent past affected plots have been uprooted, yet it appears that BXW returned.
- Banana production in this sector is mostly on smaller plots.
- The sector has acceptable cell reception, basic phone use is possible.

Kisaro

- The team started sampling in this northern sector as it can be reached from Gatsibo after crossing through Gicumbi. This sector is furthest from Bushoki town, where the district headquarters are located.
- Only villages in the far distance category could be sampled, those located in the medium distance category are all in the highlands where there is no banana production.
- There is a brand-new tarmac road that leads to the sector office. Inside the sector roads are of murram quality.
- Kisaro has good phone reception (making calls and using WhatsApp is possible, internet gives H signal).

Burera

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Gitovu Ndago **Rusarabuye**	Ndago Ndago **Rusarabuye**	Murambo Kaganda **Kinyababa**
	Control	Village: Cell: Sector:	Burehe Ndago **Rusarabuye**	Gashiru Musasa **Gitovu**	Gatare Bugamba **Kinyababa**
Medium	Intervention	Village: Cell: Sector:	Nyarubuye Ntaruka **Kinoni**	Cyogo Bugamba **Kinyababa**	Buhembe Mariba **Gitovu**
	Control	Village: Cell: Sector:	Kabaguma Nkumba **Kinoni**	Kigugu Nkenke **Kinoni**	Shyamba Musasa **Gitovu**
Large	Intervention	Village: Cell: Sector:	Rwambeho Rurembo **Rugarama**	Nyagafunzo Gafuka **Kinoni**	Karambo Nkumba **Kinoni**
	Control	Village: Cell: Sector:	Basumba Gafuka **Kinoni**	Nyakiriba Rurembo **Rugarama**	Birwa II Nkenke **Kinoni**

Map showing geographical spread of sampled villages in Burera district

Field notes

- There are no tarmac roads in Burera. The district's principal road is murram and in bumpy condition.
- The district headquarters is located central in the district, an hour drive from the tarmac road between Kigali and Musanze/Cyanika (both from north and south end).
- All banana producing sectors in Burera district are located around Lake Burera. The sectors can be reached by following the principal road.
- Banana production ranges from small scale to large, consolidated plantations (latter especially in the western sectors).
- Sector offices are located not too far from the principal road.
- Reaching villages by car is sometimes difficult, via dirt tracks. Some villages can only be reached by foot.
- Mobile network coverage is medium to poor. Not all areas have cell reception for either calling or use of internet. Sending and receiving of WhatsApp messages is intermittent).

Western province

Rubavu

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Schwemu Gisa **Rugerero**	Rukukumbo Kabilizi **Rugerero**	Nkama Kabilizi **Rugerero**
	Control	Village: Cell: Sector:	Bambiro Gikombe **Rubavu**	Ndobogo Rwaza **Rugerero**	Byima Rwaza **Rugerero**

Medium	Intervention	Village: Cell: Sector:	Kanyamagare Ryabiziga **Cyonzarwe**	Hanika rwangara **Cyonzarwe**	Kanembwe Busigari **Cyonzarwe**
	Control	Village: Cell: Sector:	Mukingo Makurizo **Cyonzarwe**	Butango Cyonzarwe **Cyonzarwe**	Kanyentambi Kinyanzovu **Cyonzarwe**
Large	Intervention	Village: Cell: Sector:			
	Control	Village: Cell: Sector:			

Map showing geographical spread of sampled villages in Rubavu district

Field notes

In Rubavu district, the sampling team experienced several challenges when sampling villages. Firstly, it was difficult to sample villages in the short distance to headquarters low BXW incidence category. The team observed a lot of high and medium incidence plots near Rubavu town where the district headquarters are located. Those villages assigned by informants as low incidence were assessed as at

least medium incidence by the team. Secondly, all far distance to district headquarters sectors were unsuitable for sampling. These sectors are either located in Volcanoes National Park or highland areas that don't produce bananas. The team tried to alternatively sample from the furthest medium distance sectors as a replacement for the far distance villages. They did not succeed because interactions with the sector agronomists taught them that those are again sectors at high altitude where any significant banana production is absent.
The district benefits from rich volcanic soils. Farmers don't manage the size of their banana mats. The team observed mats with up to 15 stems, where 4-5 stems would be normal. Spacing between mats is also limited. As a result, there is high chance of disease transmission.

Rubavu and Rugerero sectors

- Generally, in Rubavu and Rugerero sectors the BXW incidence is high. The team observed entire mats with clear BXW infection symptoms.
- In Rubavu and Rugerero sectors banana production is of peri-urban nature, with medium sized plots directly adjacent to the homesteads.
- When asking villagers why they did not remove visibly BXW affected banana mats next to the homestead, they stated to be waiting for the Umuganda groups that remove BXW infected mats from villages during the dry season.
- BXW infection takes place both due to insect vectors (recognizable from shredding male buds and fruit decolouration and deformation) and tool contamination (brown, withering leaves without fruit deformations).
- Male buds not removed in plantation, neither from healthy nor from diseased stems. Thus, high chance of insect vector transmission.
- Villages are easily accessible on murram/dirt roads from the principal Rubavu road.
- Cellphone connectivity is good in this peri-urban area. However, phones sometimes switch to a DR Congo network.

Banana fruits affected by BXW due to insect vector transmission of the disease. The leaves do not yet show disease symptoms.

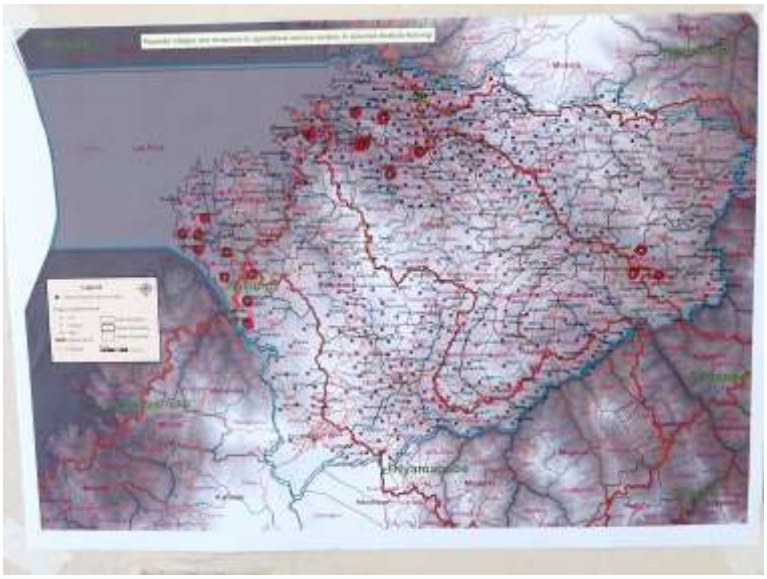
Cyanzarwe

- Sector agronomist very well informed about presence and incidence rates of BXW in her sector.
- Wide variety of incidence rates in this sector
- In infected plantations management is generally poor and there is visible high chance of tool transmission (e.g. due to skinning of banana stems in infected plots using tools).
- Besides tool transmission there is visible insect vector transmission (shredding male buds) and chance of animal transmission (roaming goats, sheep, and cattle were observed).
- Roads in the sector are all murram and in good condition. Most of the sampled villages are located along these roads. Sometimes a short walk to the village may be required.
- Cell reception in the sector is variable, at times absent or poor. Additionally, the phone switches to a DR Congo network and roaming mode which makes the use of internet or calls expensive or impossible (e.g. the team did not manage to reach the sector agronomist by phone since it was not operating on the Rwandan network).

Observed presence of both fusarium wilt (left) and BXW (right) in Cyanzarwe sector

Karongi

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Gitega Kayenzi **Bwishuyra**	Gisayo Gasura **Bwishuyra**	Josi Gitarama **Bwishuyra**
	Control	Village: Cell: Sector:	Nyamarebe Burunga **Bwishuyra**	Majuri Burunga **Bwishuyra**	Gomba Gitarama **Bwishuyra**
Medium	Intervention	Village: Cell: Sector:	Muramba Nkoto **Murambi**	Gitwa Kigarama **Gishyita**	Bwakira Muhororo **Murambi**
	Control	Village: Cell: Sector:	Kagano Cyanya **Gishyita**	Kananira Muhororo **Murambi**	Mpatsi Cyanya **Gishyita**
Large	Intervention	Village: Cell: Sector:	Ngugu Munanira **Gishyita**	Gisoro Munanira **Gishyita**	Kubutare Kigarama **Gishyita**
	Control	Village: Cell: Sector:	Uwingabo Ngoma **Gishyita**	Mataba Ngoma **Gishyita**	Nyakabuye Munanira **Gishyita**



Map showing geographical spread of sampled villages in Karongi district

Field notes

Similar to Rubavu, the sampling team struggled to identify villages in the large distance to headquarters category. Most of the sectors belonging to this category are highland areas that do not grow banana (southern part of the district). Those in Gishyita sector (eastern Karongi) are mostly coffee growing. Sector agronomist of Murambi stated that the large distance villages are BXW free. Murundi sector is completely BXW free according to its sector agronomist. The latter was perceived as unlikely by RAB technician on the sampling team and would rather be a sign that the agronomist is not well informed about BXW symptoms and/or reports about BXW presence in his sector. Regardless, the team decided not to sample from the sector.

Bwishuyra sector

- Sector office located in Kibuye town and easily accessible.
- Sector easily reached from district headquarters via a new principal tarmac road.
- Phone reception for calls and internet medium to good.

Gishyita sector

- Sector located in medium distance from district headquarters category.
- Sector easily reached from Kibuye town on new principal tarmac road.
- Sector office located directly next to the tarmac road.
- Banana producing villages mostly located along the lake shores.
- Team had to sample villages close to one another because especially far distance category villages do not all grow banana (Those on the peninsula grow coffee).
- Cell phone reception medium to poor. In some areas there is no internet signal.

Murambi sector

- According to the map this sector is comparable to Gishyita, with both medium and far distance villages. In reality the comparability stops at distance. The principal road leading to Gishyita is

entirely unpaved, ranging from murram to dirt roads, and is generally in poor condition. This makes this sector difficult to access
- The sector office is located at the far end of the sector.
- Sector agronomist appeared not to know BXW symptoms well and was not able to clearly point out the presence of BXW in her sector.
- According to the agronomist there is no BXW in any of the villages belonging to the far from district headquarters category.
- Cell phone reception in the sector is good, both calling and use of WhatsApp is possible (H internet signal).
- The team sampled three villages that fall in the medium distance category and are located near to the principal road.

Southern province

Muhanga

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Songa Mbare **Shyogwe**	Nyakaguhu Kinini **Shyogwe**	Rubuye Mbare **Shyogwe**
	Control	Village: Cell: Sector:	Mapfundo Mubuga **Shyogwe**	Gasharu Mubuga **Shyogwe**	Matsinisi Mubuga **Shyogwe**
Medium	Intervention	Village: Cell: Sector:	Karambo Butare **Kabacuzi**	Gasiza Kavumu **Kabacuzi**	Gitwa Sholi **Kabacuzi**
	Control	Village: Cell: Sector:	Mataba Kiboga **Rugendabari**	Ngando Nsanga **Rugendabari**	Ntonde Kanyana **Rugendabari**
Large	Intervention	Village: Cell: Sector:	Musarara Gitega **Kibangu**	Butare Rukyiniro **Kibangu**	Rwesero Gisharu **Kibangu**
	Control	Village: Cell: Sector:	Musekera Ryakanimba **Kibangu**	Matoshya Mubuga **Kibangu**	Musambagiro Gitega **Kibangu**

Map showing geographical spread of sampled villages in Muhanga district

Field notes
(no field notes)

Gisagara

	Incidence		Low	Medium	High
Distance					
Short	Intervention	Village: Cell: Sector:	Rubazi Ruturo **Kibirizi**	Akagarama Mugombwa **Mugombwa**	Rususa Nyabisagara **Mukindo**
	Control	Village: Cell: Sector:	Rwuya Duwan **Kibirizi**	Nyarukeri Baziro **Mugombwa**	Munyegera Runinya **Mukindo**
Medium	Intervention	Village: Cell: Sector:	Shenyeri Kibirizi **Kibirizi**	Gitwa Bwiza **Kansi**	Itaba Runinya **Mukindo**
	Control	Village: Cell:	Nyabununi Ruturo	Ruhuha Akaboti	Nyakazana Mukiza

		Sector:	**Kibirizi**	**Kansi**	**Mukindo**
Large	Intervention	Village: Cell: Sector:	Gasagara Kibirizi **Kibirizi**	Nyabitare Rwanza **Save**	Joma Gitega **Mukindo**
	Control	Village: Cell: Sector:	Akabuhuzu Ruturo **Kibirizi**	Gahora Rwanza **Save**	Akagarama Mukiza **Mukindo**

Map showing geographical spread of sampled villages in Gisagara district

Annex 1: overview of mobile internet signals and symbols

Symbol	Standard	Full Name	Maximum Download Speed	Maximum Upload Speed
2G	GSM	Global System for Mobile Communications	14.4 Kbits/s	14.4 Kbits/s
G	GPRS	General Packet Radio Service	53.6 Kbits/s	26.8 Kbits/s
E	EDGE	Enhanced Data rates for GSM Evolution	217.6 Kbits/s	108.8 Kbits/s
3G	UMTS	Universal Mobile Telecommunications System	384 Kbits/s	128 Kbits/s
H	HSPA	High-Speed Packet Access	7.2 Mbits/s	3.6 Mbits/s
H+	HSPA+	Evolved High-Speed Packet Access - Release 6	14.4 Mbits/s	5.76 Mbits/s
H+	HSPA+	Evolved High-Speed Packet Access - Release 7	21.1 Mbits/s or 28.0 Mbits/s	11.5 Mbits/s
H+	HSPA+	Evolved High-Speed Packet Access - Release 8	42.2 Mbits/s	11.5 Mbits/s
H+	HSPA+	Evolved High-Speed Packet Access - Release 9	84.4 Mbits/s	11.5 Mbits/s
H+	HSPA+	Evolved High-Speed Packet Access - Release 10	168.8 Mbits/s	23.0 Mbits/s
4G	LTE	Long Term Evolution	100 Mbits/s	50 Mbits/s
4G	LTE-A	Long Term Evolution -Advanced	1 Gbits/s	500 Mbits/s

Overview of different mobile internet signals. Adapted from http://rechargehut.blogspot.com