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Farmers' willingness to pay towards the sustainability of plant clinics: evidence from Bangladesh, Rwanda and Zambia

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ABSTRACT

Fee-based agricultural extension programmes have been proposed in response to the constraints of funding public extension services. This has piqued researchers' interest in determining farmers' willingness to pay (WTP) for extension services in recent decades. The current study examines farmers' WTP to ensure the sustainability of plant clinics. Smallholder farmers in over 30 countries benefit from this demand-driven extension method, which delivers plant health diagnostic and consulting services. External funders are now paying the plant clinic operations, which raises worries about their long-term viability if the funding stops. We used survey data from 602, 637, and 837 households in Bangladesh, Rwanda, and Zambia. We discovered that roughly 64% of the sample farmers were willing to pay an amount sufficient to cover the operational costs of an established plant clinic using the iterative bidding technique of eliciting WTP. Farmers in Bangladesh, Rwanda, and Zambia were willing to spend an average of 0.27USD, 0.85USD, and 2.25USD per visit to plant clinics. According to our findings, farmers appear to value the plant clinic extension method and are eager to contribute to its long-term viability. Therefore, piloting fee-paying plant clinic services to determine farmers' actual WTP and preferred payment options would be beneficial.

KEYWORDS
Plant clinics; willingness-to-pay; agricultural extension; smallholder farmers; sustainability; adoption

1. Introduction

Farmers in many developing countries, especially in Africa, practice mainly subsistence agriculture and face crop pests and diseases that affect their livelihoods and socio-economic status (Rweyemamu et al., 2006; Thornton et al., 2008). To address these pest and disease problems for increased food security and improved rural livelihoods, farmers require timely access to extension and advisory services. For many years, agricultural extension services have provided farmers with an array of information and innovations that can improve productivity, increase income, and enable a better living standard (Anderson & Feder, 2007; Ogunmodede & Awotide, 2020). However, in many developing countries, public/conventional extension systems often fail to address the various needs of resource-poor farmers (Danielsen & Matsiko, 2016). For instance, farmers require more knowledge and awareness on how to manage new invasive pests; however, the public extension systems may not be able to provide such support to farmers because

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of inefficiencies and resource constraints (Anderson & Feder, 2007).

The Food and Agriculture Organization (FAO) suggests that the ideal extension agent-to-farmer ratio for effective extension delivery is 1:500-800. Unfortunately, the realization of this ratio has continued to be a challenge in many developing countries. For example, the extension agent-to-farmer ratio is estimated to be 1:1500 in Ghana (Duo & Bruening, 2007), 1:2500 in Nigeria (Ajala, Ogunjimi & Farinde, 2013; Ogunmodede et al., 2020), and 1:1200-3000 in Zambia (Republic of Zambia, 2015). The weaknesses of the public extension systems have led to calls for private sector involvement in providing efficient extension services to farmers (Anderson & Feder, 2007). According to Rivera and Sulaiman (2009), the commercialization of extension services is only possible if farmers are willing to pay for these services, particularly when the services have previously been provided free of charge. Consequently, there has been an increased interest in understanding farmers' willingness to pay (WTP) for extension services in recent decades (e.g. Daniel and Teferi (2015); Mwaura et al. (2010); Smart et al. (2011)). However, these studies have largely focused on traditional methods of delivering blanket extension services. Here, we provide evidence on farmers' WTP towards the sustainability of plant clinics— a demand-led extension approach that responds to farmers' specific plant health needs.

Under a donor-funded extension programme called 'Plantwise', about 5000 plant clinics have been set up in 34 countries across Africa, Asia, and Latin America (CABI, 2020a). The literature is replete with evidence on how these plant clinics have positively promoted behavioural changes and increased crop yields among farmers in Bolivia (Bentley et al., 2009), Bangladesh (Rajendran & Islam, 2017), Uganda (Brubaker et al., 2013), Kenya (Kansiime et al., 2020), Rwanda (Majuga et al., 2018) and Zambia (Tambo et al., 2021), as well as improved household food security in Rwanda (Tambo et al., 2020) and farmers' livelihoods in Bangladesh (Ghosh et al., 2019). Given these positive impacts, and after ten years of donor support for the plant clinics, it is necessary to understand the sustainability of this extension approach once the donor funding ceases.

The questions addressed in the current study include: 1) would farmers be willing to pay towards the sustainability of plant clinics, which they previously received free of charge? 2) what proportion of farmers are willing to pay, and how much are they willing to pay for plant clinic services? 3) what socio-economic factors determine farmers' WTP for plant clinic services? By addressing these research questions, we contribute to the growing literature on plant clinics, as previous studies have focused mainly on access and impacts. Beyond plant clinics, we extend the extension literature's scope on WTP for extension services by providing comparative evidence from three countries (Bangladesh, Rwanda, and Zambia). Previous studies have relied on a limited sample from one country. Thus, we also contribute to the extension literature in terms of external validity.

2. Background on plant clinics

Plantwise is a global programme managed by CABI that aims to strengthen plant health systems to reduce crop losses. A major component of the Plantwise programme is the plant clinic extension model, which aims to support smallholder farmers to lose less of their crops to pests and diseases. These clinics provide face-to-face crop pest diagnosis and management advice to visiting farmers. Using a demand-driven service approach, the clinics are overseen by specially trained extension workers (called plant doctors) (Romney et al., 2013). The plant clinics are located at easily accessible locations, such as markets, village centres, and farmers' meeting sites, where they offer free services to the visiting farmers at least once every two weeks (Tambo et al., 2020). Farmers bring samples of diseased or unhealthy crops to the clinics, where the plant doctors examine the sample, diagnose the problem and suggest appropriate management actions. Their advice and recommendations to farmers are often based on a visual diagnosis of plant health problems and are in line with integrated pest management (IPM) principles. Data on the plant clinic attendees and the problem brought to the clinic, the diagnosis, and recommendations for tackling the problem, are recorded on prescription forms and then entered into the Plantwise Online Management System (POMS).

The plant clinic extension approach was first employed in Bolivia in 2003 before spreading to over 30 developing countries, including Bangladesh, Rwanda, and Zambia (Bentley et al., 2009; Danielsen & Kelly, 2011). In Bangladesh, the plant clinic approach was piloted in 2008 as part of the CABI-led Global Plant Clinic programme. In 2015, the Ministry of

Agriculture and the Economic Relations Division of the Ministry of Finance of Bangladesh collaborated with CABI to launch Plantwise (Ghosh et al., 2019). This led to a scaling up of plant clinic activities in the country. There are currently 30 plant clinics and over 200 plant doctors across ten districts in Bangladesh (CABI, 2020). So far, these clinics have attended to about 16,000 farmers' queries on pests and diseases (POMS, 2020). Most of the queries are related to rice, *Cucurbita sp*., mango, guava, and coconut.

In Zambia, the Plantwise programme, in partnership with the Zambia Ministry of Agriculture, initiated plant clinics in 2013. The 13 plant clinics established in six districts across three provinces at the inception phase have now increased to 121, operating in 39 districts across all of the country's ten provinces. About 350 trained plant doctors operate these clinics. From 2013 to the time of this study, the Zambia plant clinics have attended to about 12,300 farmers' queries on nearly 100 crops (POMS, 2020). More than half of these queries are on maize, which is the country's primary food staple.

Since the introduction of the Plantwise programme in Rwanda in 2011 by CABI in collaboration with the Rwanda Agriculture and Animal Resources Development Board (RAB), 66 plant clinics have been set up in 30 districts across the country's five provinces (Majuga et al., 2018). The plant clinics are staffed by 350 plant doctors (CABI, 2020a). As of the time of this study, the plant clinics in Rwanda have received more than 16,000 farmers' queries on roughly 90 crops. Most farmers visited the plant clinics to seek plant health advice related to maize, banana, cassava, common bean, tomato, and potato.

3. Willingness to pay for extension services

Willingness to pay (WTP) is a research approach for establishing preferences for proposed services and the amount that the respondents are ready to pay for the services (Mwaura et al., 2010). According to Le Gall-Elly (2010), WTP is defined as 'the maximum price a given consumer accepts to pay for a product or service rather than do without it'. Most WTP studies have involved contingent valuation (CV) and hedonistic methods. WTP studies are widely used in the assessment of non-market values of goods and services. In agriculture, WTP studies have been used to evaluate demand and cost curves for extension services delivery through commercial agents (Nambiro & Omiti, 2007).

The handling of agricultural extension as a public good where their services are provided for free has characterized its top-down planning, centralized management, inadequate operational funds, low motivation of staff, low farmer ownership, and weak accountability system, resulting in poor performance of the system (Ashraf et al., 2009). Therefore, privatization of agricultural extension service delivery has been considered lately as an important strategy to addressing the funding challenges (Adejo et al., 2012; Anderson & Feder, 2003). According to Saliu and Age (2009), public agricultural extension services are becoming too expensive to finance by some developing countries, and external donors are gradually withdrawing support, so alternative ways of funding public extension are now being sought. Some possible ways out of this problem include charging for agricultural extension services provided by the government, reducing public extension-expenditure, or total privatization of the services. Advocates of private extension services believe that it improves efficiency, improves public finance, and encourages competition and private sector participation.

Several studies, such as Mwaura et al. (2010); James and Smart (2001); Ozor et al. (2013); Onoh et al. (2014); Temesgen & Tola (2015); Uddin and Gao (2014), have been conducted to determine farmers' WTP for extension services. For example, Onoh et al. (2014) carried out a study on livestock farmers' willingness to pay for agricultural extension services in southeast Nigeria and found out that the farmers were not willing to pay for most extension services, such as improved techniques associated with production. Their unwillingness to pay is attributed to their inability to handle the recommended technologies easily or that the traditional free government extension service provided them with enough information to address their needs or problems. Contrastingly, Ozor et al.'s (2013) study on farmers' willingness to pay for agricultural extension services showed that 95.1% of farmers in Nigeria were willing to pay for improved agricultural extension services if the services remained relevant to their needs. Similarly, Matthew and Samson (2018) found that, out of 46% of farmers in Ondo state in Nigeria who showed WTP, 84% were willing to pay for technical advice on the handling and application of herbicides while 69% were willing to pay for information on how to treat pest and disease infestations. Furthermore, Mwaura et al. (2010) reported that 35% of farmers were willing to pay an average of 1.8 USD per extension visit for crop husbandry services in Uganda.

The sustainability of agricultural extension services depends on resource availability, whereas provision by the private sector is very much a function of farmers' WTP (Ulimwengu & Sanyal, 2011). This implies that farmers must be in a position to contribute to the provision of extension services, and for assessing this, WTP research must be conducted. However, there is no known empirical evidence on farmers' WTP for plant clinic extension services. Failure to examine the willingness to pay for the extension services could lead to the end of the plant clinics gains, poor strategies in targeting extension services, resulting in ineffective extension services, and low technology adoption. Consequently, we assess the willingness of farmers to pay for the sustainability of plant clinic extension services.

4. Methodology

4.1. Data

The study is based on Plantwise-related socio-economic household survey datasets collected between 2018 and 2019 in Bangladesh, Rwanda, and Zambia. In each country, the sample consists of farmers who had visited plant clinics to seek advice related to a particular crop pest (hereafter, clinic users), and a comparable sample of farmers who experienced the same pest problem but had not used the services of plant clinics (hereafter, non-clinic users). The focal pests were fruit fly on *Cucurbita sp.* in Bangladesh, and fall armyworm on maize in Rwanda and Zambia. These pests were the most important plant health problems recorded at the plant clinics in the respective countries. In each country, the clinic users were selected from the POMS database. With the support of local agricultural extension officers, the non-clinic users were randomly selected from communities that do not have plant clinics but share similar characteristics (in terms of agro-ecological zones, crops grown and incidence of crop pests) with plant clinic communities. Moreover, the first section of the survey questionnaires included filter questions to ensure that the selected non-clinic users cultivated similar crops and had experienced similar pest attacks like the plant clinic users but had never used plant clinic services.

The data were collected by trained enumerators using pre-tested questionnaires. The questions captured information on household demographic characteristics, household assets, crop production, social capital, risk attitude, access, and proximity to institutional support services. The questionnaires included a bidding game to elicit willingness to pay to sustain plant clinic services. Overall, the sample consists of 602 farmers in Bangladesh (226 clinic users and 376 non-users), 637 farmers in Rwanda (263 clinic users and 374 non-users), and 873 farmers in Zambia (444 clinic users and 393 non-users). Using a sample of clinic users and non-users enables us to test whether farmers who have already benefited from plant clinic services would be more willing to contribute towards their sustainability, and by extension, gauge farmers' level of satisfaction with plant clinic services.

4.2. Measurement of WTP

The methods for eliciting WTP through CV include open-ended, dichotomous (binary, discrete choice, close-ended, take-it-or-leave-it), polychotomous, bidding game, payment card, and various variants of these methods. A detailed description of these methods can be found in Russell et al. (1995); Klose (1999); Liljas and Blumenschein (2000); Smith (2000); Mitchell (2013). In this study, the iterative bidding game approach was employed to determine how much respondents would be willing to pay to seek plant clinic services in the three study countries. This approach is preferred because, in many developing countries, bidding best approximates the price-taking mechanism in local markets. It most closely resembles the haggling method used in local markets to buy most goods and services (Onwujekwe & Nwagbo, 2002), and this could have accounted for the predominance of this method in the several CV studies conducted in developing country-settings, including Daniel and Teferi (2015); Horna et al. (2007); Nguyen et al. (2015); Nicholas Ozor et al. (2013); Smith (2000); Whittington et al. (1990); Whittington et al. (1992)

In the iterative bidding technique, the functions of plant clinics were explained to surveyed farmers who are non-clinic users and were given a starting bid amount for them to indicate whether or not they were willing to pay that amount for each visit to a clinic for plant health diagnostic and advisory services. Based on the response to the starting WTP amount, the bid amount was either increased or decreased. Finally, regardless of the response to the second bid question, the farmers were asked to state the maximum amount they were willing to pay for plant clinic services. The WTP questions are presented in Box 1.

Box 1. Survey questions on WTP for plant clinic services.

Preamble: Plant clinic is a meeting place (which runs regularly at a local market) where any farmer who is struggling with plant pests and diseases can send a sample of his/her 'sick' crops, and a trained 'plant doctor' will diagnose the problem and recommend an affordable, locally available solution that the farmer can use to manage it. Suppose that an institution is willing to set up a plant clinic in your area if the operational costs could be recovered through payment of a fee at each visit to the plant clinic for advice.

(A) Are you willing to pay 700 RWF/ 10 BDT/ 20 ZMK for each visit to the plant clinic for advice on plant health problems?

1=Yes 2=No (if yes go to B and if no go to C)

(B) Suppose that instead of 700 RWF/ 10 BDT/ 20 ZMK, the cost of accessing the plant clinic at each visit is 1000 RWF/15 BDT/30 ZMK, would you be willing to pay?

1=Yes 2=No (No matter the answer, go to D)

(C) Suppose that instead of 700 RWF/10 BDT/ 20 ZMK, the cost of accessing the clinic at each visit is 400 RWF/ 5 BDT/ 10 ZMK, would you be willing to pay?

1=Yes 2=No (No matter the answer, go to D)

(D) What is the maximum amount that you are willing to pay for each visit to the plant clinic for advice on plant health problems? … … … … … … … … . RWF/BDT/ZWF
Source: Plantwise survey data 2018

The starting bid amounts were 10 BDT (0.12 USD), 700 RWF (0.81 USD), and 20 ZMK (1.54 USD) in Bangladesh, Rwanda, and Zambia, respectively.[1] These amounts were determined during discussions with key country-specific plant clinic stakeholders (including plant doctors and Plantwise national coordinators) on the amount sufficient to cover the operational costs of plant clinics per session, given the average number of clinic attendees in a session in the respective countries. The operational costs include travel and subsistence allowance for plant clinic staff, the cost of printing prescription sheets, as well as publicity and mobilization costs. Thus, the number of farmers who respond 'Yes' to the starting bid question reflects those willing to pay at least the minimum amount required to run a plant clinic once established.

4.3. Data analysis

We used descriptive statistics (including percentages, mean, standard deviation, frequency) and econometric models [logit and ordinary least squares (OLS) models] for the analysis. The descriptive statistics were used to illustrate the sample characteristics, the farmers' WTP for plant clinics, and the amount they were willing to pay, while the logit and OLS models were used to analyse the factors influencing the WTP decisions. In the logit model, the dependent variable (Y) is a dummy variable that is equal to 1 if the farmer is willing to pay an amount that is sufficient to sustain the services of plant clinics (first question in Box 1) and 0 otherwise. In the OLS model, Y represents the maximum amount the farmers are WTP for plant clinic services. The regression models can be expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + \varepsilon \quad (1)$$

Where $X_{1\ldots}$ X_n denotes the covariates that may influence the probability of WTP and the maximum amount the farmers are willing to pay to sustain plant clinic services, while $\beta_{1\ldots\ldots}\beta_n$ are the associated parameters to be estimated. The covariates include the age, education level, and gender of the household head, household land, and durable asset holdings, risk attitude, farmer group membership, access to credit and off-farm income-earning opportunities, participation in plant clinics, proximity to extension service providers, and geographic location dummies. The choice of these variables was inspired by previous studies on the determinants of farmers' WTP for extension services and pest management strategies (e.g. Ajayi, 2006; Ozor et al., 2013; Muriithi et al. (2021)). β_0 and ε are the constant and error terms, respectively.

5. Results and discussion

This section is divided into three parts. First, we explore the socio-economic characteristics of the sample farmers from the three study countries. The second part concentrates on the willingness to pay for plant clinic services and how much farmers are willing to pay. Lastly, we examine the determinants of willingness to pay for plant clinic services.

5.1. Sample characteristics

Table 1 presents the descriptive statistics of household characteristics and institutional variables. The majority of farmers are middle-aged, with a mean age of 45 years (Bangladesh) and 50 years (Rwanda and Zambia). Most (81%) of the respondents are within the age range of 18–60 years. All things

Table 1. Socio-economic characteristics of the surveyed households.

Variable	Description	Bangladesh (n = 602)	Rwanda (n = 637)	Zambia (n = 837)
Age	Age of household head (years)	45.47	49.59	50.35
		(12.13)	(13.24)	(13.23)
Gender	Gender of household head (1 = male)	0.97	0.77	0.67
Education	Years of formal education of household head	5.97	4.99	7.69
		(4.10)	(3.29)	(3.44)
Household size	Number of household members	4.72	5.18	7.09
		(1.79)	(1.93)	(3.22)
Land size	Total land owned by the household (ha)	14.97	0.59	7.59
		(21.60)	(1.15)	(19.44)
Asset index	Household asset index[a]	−0.38	−1.64e-07	−0.10
		(1.20)	(−0.11)	(1.62)
Off-farm engagement	Household member engaged in off-farm activity (1/0)	0.33	0.27	0.48
Credit access	Household had access to credit (1/0)	0.36	0.57	0.23
Farmer group	Household member belongs to a farmer group (1/0)	0.81	0.32	0.87
Risk attitude	Risk attitude of household head (0-10)[b]	7.50	6.43	5.58
		(2.24)	(1.76)	(2.96)
Distance to input shop	Distance from household to the nearest input shop (km)	1.79	2.46	15.11
		(1.94)	(2.49)	(13.85)
Distance to extension	Distance from household to the nearest extension office (km)	0.79	2.54	9.81
		(2.65)	(2.37)	(10.15)
Distance to district capital	Distance from household to the district capital (km)	25.23	15.15	32.65
		(12.04)	(13.20)	(32.33)
Clinic user	The farmer has used plant clinic services (1/0)	0.38	0.41	0.57
		(0.48)	(0.49)	(0.50)

[a]The asset index is based on household ownership of 10 durable assets. Following Filmer and Pritchett (2001), we constructed the asset index using principal component analysis and with the following formula: $A_j = \frac{\sum_{i=1}^{k} [b_i(a_{ji} - m_i)]}{s_i}$
where A is the asset index for each household; b represents the weights (scores) assigned to the assets on the first principal component; a is the asset value for each household; m is the mean value of each asset; and s is the standard deviation of the assets.
[b]Following Dohmen et al. (2011), the risk attitude variable was measured from the following survey question: 'How do you see yourself: are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please choose a number on a scale between 0 and 10, where 0 means not at all willing to take risks and 10 means very willing to take risks'

being equal, these farmers should accept innovations and be willing to pay for extension services more easily than their relatively aged counterparts. Among farming households, gender plays a vital role in the access and rights to land use and ownership. Table 1 shows that most (79%) of the three countries' households are male-headed, with at least one-quarter of them engaging in off-farm income-earning activities.

The highest educational attainment is in Zambia, with an average of eight years of schooling, compared to five and six years in Rwanda and Bangladesh. It is assumed that the level of formal education is directly related to the rate at which farmers would be willing to pay for plant clinic services. Previous literature has shown that farmers' education level is positively related to their willingness to pay for extension services (Foti et al., 2007). Table 1 also shows that our sample consists of risk-neutral (Zambia) to risk-preferring households (Bangladesh).

Household size is smallest in Bangladesh (with about five members) and relatively large in Zambia (with about seven members). More than 80% of the households in Bangladesh and Zambia are members of farmer associations, compared to only 29% in Rwanda. Additionally, proportionally more households in Rwanda than in the other two countries have access to credit. The results also indicate that the farmers in Bangladesh and Rwanda live in close proximity to input suppliers, extension agencies, and district capitals relative to those in Zambia. This is unsurprising, given that Zambia is sparsely populated and covers a land area of about 5 and 30 times that of Bangladesh and Rwanda.

5.2. Willingness to pay for plant clinic extension services

The survey results indicate that nearly 64% of the respondents across the three countries are willing to pay to sustain plant clinic services when established in their communities. Specifically, about 46%, 64%, and 81% of the sample farmers in Rwanda, Zambia, and Bangladesh, respectively, are willing to pay an amount that is sufficient to cover the operational costs of plant clinics. In other words, about 1-in-5 Bangladeshi, 2-in-5 Zambian, and about 3-in-5 Rwandan respondents were unwilling to pay the proposed amount for sustaining plant clinic services. The relatively lower fee per visit to plant clinics in Bangladesh may explain why proportionally more farmers in this country than in Rwanda and Zambia are willing to pay towards the sustainability of plant clinic services. Our result is similar to the findings of Uddin and Gao (2014), which revealed that about 20% of the farmers in Bangladesh were unwilling to pay to access extension services. Similar studies by Ackah-Nyamike (2003) and Ozor et al. (2007) showed that about 1-in-5 of farmers in Ghana and Nigeria were negatively disposed to paying to access extension services.

The average maximum amount that the sample farmers are willing to pay per visit to plant clinics are roughly 23 BDT (0.27 USD), 729 RWF (0.85 USD), and 29 ZMK (2.25 USD) in Bangladesh, Rwanda, and Zambia, respectively. Results presented in Figure 1 show that a few of the farmers (ranging from about 1% in Rwanda to 16% in Zambia) are not willing to contribute financially towards the sustainability of the plant clinics. A majority of the Bangladeshi and Rwandan respondents agreed to pay between 0.1-1.0 USD to access plant clinic services, while a greater share of farmers in Zambia are more inclined than their counterparts in Bangladesh and Rwanda to pay above 2 USD per visit to a plant clinic, possibly reflecting differences in the cost of living and the costs of operating plant clinics. The data also show that about 36%, 48%, and 60% of the farmers in Rwanda, Zambia, and Bangladesh are willing to pay an amount higher than the per-user cost of operating a community-based plant clinic. This may be suggestive that farmers highly value the plant clinic extension services. As noted by Uddin and Gao (2014), the eagerness to embrace paid extension services might result from farmers' perennial dissatisfaction with the present public extension service caused by limited coverage and poor performance.

5.3. Determinants of farmers' willingness to pay for plant clinic services

The results for the logistic regression on the determinants of farmers' WTP at least the minimum amount required to sustain plant clinic extension services are shown in Table 2. The results indicate a considerable variation in the determinants of WTP for plant clinic services across the countries examined. We find that age and education level of household head, household asset wealth, credit access, membership in farmer association, risk attitude, distance to alternative sources of agricultural information, and plant clinic participation are all statistically significant in influencing the probability of WTP for plant clinic services, albeit with differences across countries.

The significant negative relationship between age and WTP in Rwanda reveals that younger farmers are more willing to pay to access plant clinic services. This is in line with Gang and Ping (2012), who found that younger farmers are more likely to be willing to pay for agricultural information. Consistent with Ozor et al. (2013), Temesgen & Tola (2015), and Uddin and Gao (2014), the results indicate that the gender variable is not significantly correlated with farmers' WTP for extension services. This implies that both female- and male-headed households have an equal probability of agreeing to pay to sustain plant clinic services in their communities. We also find that better-educated household heads are more inclined to pay to continue to use plant clinic services, probably because educated farmers are better able to decode agricultural information more efficiently (Foster & Rosenzweig, 2010) or are more enlightened about the value of agricultural extension (Mwaura et al., 2010).

Across the three countries, wealth-related variables such as asset index, land size, and credit access are positively significant, indicating that wealthier farmers (who are likely to be less financially constrained) are more willing to pay to access plant clinic services. This further explains the significant negative relationship between household size and WTP in Zambia. Larger household size places additional pressures and financial burden on family resources, thereby constraining investing in agricultural advisory services. This result also supports the finding of Temesgen & Tola (2015), who reported a significant negative effect of household size on WTP for agricultural extension services in Ethiopia.

In Rwanda, we find that households that live farther from input dealers are significantly more likely to be willing to pay for plant clinic services. This is unsurprising, given that input shops are important sources from which farmers can obtain plant health information. Thus, farmers living closer to this alternative source of plant health services are less willing to pay for plant clinic services. Conversely,

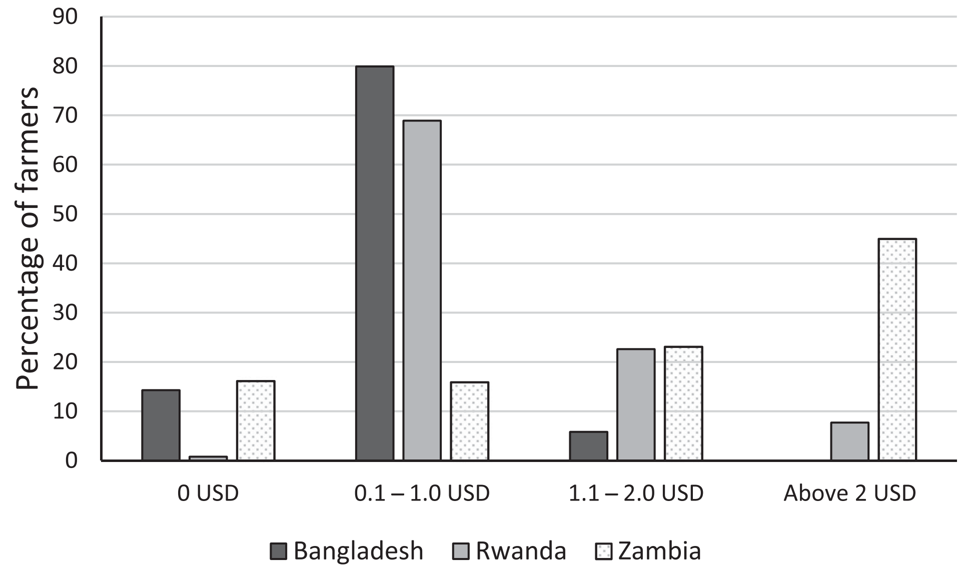

Figure 1. The amount farmers are willing to pay per visit to plant clinics.

households close to extension agencies are more willing to pay to benefit from plant clinic services. This may be due to a better awareness of the importance of plant clinics, as the plant clinic staff are mostly trained agricultural extension agents. These findings generally agree with Foti et al. (2007), who reported that farmer location significantly affects the demand for a fee-for-service extension in Zimbabwe.

In Bangladesh and Zambia, we find that risk-loving farmers are more likely to pay a fee to sustain plant clinic services. This is not surprising because plant clinic is an innovative extension approach and using its services for pest management involve some degree of risk. This also gives credence to the importance of risk in farmers' adoption of innovations in agriculture (Foster & Rosenzweig, 2010). We also find that the probability of paying for plant clinic services increases with membership in farmer groups in Bangladesh and Zambia, potentially reflecting peer effects. Additionally, the results show that households who had benefited from plant clinics before the surveys in Bangladesh and Zambia would be more

Table 2. Logit estimates of the determinants of WTP for plant clinic services.

	Bangladesh		Rwanda		Zambia	
	Marginal effect	Standard error	Marginal effect	Standard error	Marginal effect	Standard error
Age	0.001	0.012	−0.003**	0.007	−0.002	0.006
Gender	0.070	0.630	0.069	0.222	0.016	0.182
Education	0.007*	0.035	0.009	0.029	0.017***	0.026
Household size	0.001	0.084	−0.013	0.048	−0.011**	0.026
Land size	0.0001	0.003	0.074***	0.127	0.002	0.008
Asset index	0.039***	0.125	0.042**	0.074	0.029**	0.062
Off-farm engagement	0.024	0.299	0.053	0.200	−0.050	0.160
Credit access	0.073**	0.286	−0.035	0.179	0.112***	0.204
Farmer group	0.068*	0.362	0.001	0.191	0.079*	0.230
Risk attitude	0.013**	0.056	0.0004	0.051	0.026***	0.028
Distance to input shop	−0.011	0.065	0.018*	0.042	5.0E-5	0.007
Distance to extension office	0.030*	0.164	−0.022**	0.048	8.7E-5	0.009
Distance to district capital	−0.0005	0.013	−0.003*	0.007	2.6E-4	0.003
Clinic user	0.103***	0.299	−0.070	0.172	0.072**	0.159
Rajshah/Western/AEZ IIa[a]	0.608***	0.617	−0.028	0.291	0.052	0.232
Dhaka/Southern/AEZ III[a]	0.567***	0.424	0.078	0.195	0.118**	0.240
No. of observations	602		637		837	

[a]The base category is Khulna/Northern/AEZ I for Bangladesh/Rwanda/Zambia, respectively.
Significance level: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

willing to pay than those who had never used plant clinic services in these two countries. In particular, participation in plant clinics significantly increases farmers' WTP to pay at least the minimum amount required to cover the operational costs of an established plant clinic by 7% (Zambia) and 10% (Bangladesh). In the case of Rwanda, the clinic user variable is statistically insignificant. A plausible explanation is that Rwanda is a geographically small country compared to the other two counties; hence, the non-clinic users in this country may be more likely to be familiar with plant clinic activities and their benefits just like their clinic user counterparts. Finally, the location variables are statistically significant in the Bangladesh and Zambia models, suggesting within-country variation in farmers' WTP towards the sustainability of plant clinics. This, coupled with the between-country variation, point to location-specific heterogeneity in the determining factors of WTP for plant clinic services.

Table 3 presents the OLS regression results on the determinants of the maximum amount the farmers are willing to pay per visit to plant clinics. We find that several of the variables that exert statistically significant effects on farmers' WTP for plant clinics are also significantly associated with the maximum amount the farmers are willing to pay. These variables include the education level of the household head, participation in plant clinics, household asset wealth, and risk attitude. In all three countries, asset-rich and more risk-tolerant households are willing to pay a higher amount to sustain the provision of plant clinic services. The results also suggest that previous beneficiaries of plant clinic services are more willing to pay a higher amount compared to non-clinic users in Bangladesh and Zambia. Given the growing body of evidence on the contribution of plant clinics to sustainable pest management, increased productivity, and improved food security (e.g. Silvestri et al., 2019; Tambo et al., 2020; Tambo et al. (2021)), it is not surprising that the plant clinic users are inclined to pay a higher amount to keep them in operation.

We also observe some heterogeneity in the factors that influence the probability of WTP and the maximum WTP amount. In Rwanda, for instance, while households with younger heads and greater land holdings are significantly more likely to pay an amount sufficient to offset the operational costs of plant clinics, these factors are not significant when it comes to the maximum amount the households are willing to pay. Similarly, farmer group membership is important in the probability of WTP for plant clinic services in Bangladesh and Zambia, but it is not critical to stimulate the payment of higher fees to sustain plant clinic services.

6. Conclusion

Through the global Plantwise programme, about 5000 plant clinics have been established to provide free pest diagnostic and advisory services to smallholder farmers in 34 countries worldwide. In the past decade, the plant clinic extension services have been largely dependent on external donor funding. In this article, we analysed farmers' willingness to pay (WTP) towards the sustainability of the plant clinics. The findings may provide important insights into the likelihood of the sustainability of this extension model without donor support. Moreover, our paper contributes to the literature on farmers' WTP for fee-based extension services, which has attracted a lot of interest in recent years due to the dwindling financial support to public extension systems. Unlike previous studies, we focused on a unique extension model that provides demand-driven plant health services. We used survey data from over 2000 farm households across Bangladesh, Rwanda, and Zambia.

Using an iterative bidding technique to elicit farmers' WTP, we found that nearly two-thirds of the sampled households were willing to pay an amount sufficient to cover the operational costs of an established plant clinic. Specifically, about 46%, 64%, and 81% of the farmers in Rwanda, Zambia, and Bangladesh, respectively, were willing to pay the per-user cost of operating a community-based plant clinic. On average, the farmers in Bangladesh, Rwanda, and Zambia were, respectively, willing to pay a maximum amount of 0.27, 0.85, and 2.25 USD per visit to plant clinics. Only 11% of the farmers were unwilling to contribute any amount of money to sustain plant clinic operations.

Regression results suggested that previous beneficiaries of plant clinic services were more willing to pay and pay a higher amount to sustain the services. For instance, participation in plant clinics was significantly associated with a 7% and a 10% higher probability of farmers' WTP to pay at least the minimum amount required to cover the operational costs of a plant clinic in Zambia and Bangladesh respectively. This finding, coupled with previous research showing positive impacts of plant clinics on improved pest

Table 3. OLS estimates of the determinants of WTP amount.

	Bangladesh		Rwanda		Zambia	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Age	0.001	0.001	−0.003	0.003	−0.027***	0.007
Gender	0.075	0.071	0.064	0.090	0.224	0.198
Education	0.004	0.003	0.000	0.011	0.062**	0.028
Household size	−0.003	0.007	−0.037*	0.019	−0.016	0.031
Land size	0.000	0.000	0.030	0.031	0.114	0.065
Asset index	0.026**	0.010	0.089***	0.027	0.081*	0.072
Off-farm engagement	0.005	0.027	0.129	0.080	−0.548***	0.171
Credit access	0.047	0.024	0.001	0.071	0.403*	0.210
Farmer group	0.042	0.034	−0.050	0.076	0.376	0.254
Risk attitude	0.017***	0.006	0.065***	0.020	0.069**	0.030
Distance to input shop	- 0.016***	0.006	0.030*	0.017	−0.006	0.007
Distance to extension office	0.000	0.004	−0.039**	0.019	−0.000	0.009
Distance to district capital	−0.004***	0.001	−0.003**	0.003	0.006**	0.003
Clinic user	0.049**	0.024	−0.072	0.068	0.292*	0.173
Rajshah/Western/AEZ IIa[a]	−0.030	0.051	−0.128	0.115	0.374	0.254
Dhaka/Southern /AEZ III[a]	0.086**	0.042	0.146*	0.078	0.116	0.257
Constant	−0.057	0.131	0.711**	0.237	1.828***	0.587
No. of observations	602		637		837	

[a]The base category is Khulna/Northern/AEZ I for Bangladesh/Rwanda/Zambia, respectively.
Significance level: ***$p < 0.01$; ** $p < 0.05$; *$p < 0.1$.

management, agricultural productivity, and household welfare (Ghosh et al., 2019; Tambo et al., 2020; Tambo et al., 2021), highlights the important role of plant clinics in smallholder agriculture. The results also showed that factors such as age and education of household head, risk attitude, household wealth, and access to alternative sources of extension were critical to whether and how much farmers will be willing to spend to access plant clinic services, albeit with considerable heterogeneity across the three study countries.

Taken together, these findings imply that farmers value the services provided by plant clinics and are inclined to contribute financially towards their sustainability. Thus, it would be helpful to pilot fee-paying plant clinic services to gauge farmers' actual WTP. Our findings also suggest that, in some contexts, more educated and wealthier farmers, as well as members of farmer associations, could be targeted to pay the actual per-user cost of maintaining plant clinic services. At the same time, the poor and older households could be permitted to pay subsidized fees in order not to be excluded from fee-based plant clinic services. Future research would be worthwhile to explore the farmers' most preferred payment methods, thereby encouraging more farmers to participate in the payment system. For example, Cartmell (2021) has reported that in Latin America, the sustainability of plant clinics is achievable through payment of levies to farmer associations that offer plant clinic services.

It should be recognized that our WTP estimates cover only the costs of running plant clinics when already established. Hence, funding commitments from national or local implementing organizations would be needed to cover the expenses associated with establishing the plant clinics, including plant clinic staff training, data management, and purchasing of clinic equipment, such as portable microscopes or hand lens tablets, and tents. One approach to cover the initial set-up costs and contribute towards the sustainability of plant clinics would be to integrate this extension model into national or local government agricultural policies or extension strategies.

Note

1. At the time of this study, 1 USD = 860.8 RWF = 83 BDT = 13 ZMK.

Disclosure statement

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Adewale M. Ogunmodede and Justice A. Tambo are employed at CABI, the institution that manages the Plantwise programme. Other authors declare no conflict of interest.

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