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A review on effective and efficient communication in agricultural extension to enhance adoption of agricultural best practices at scale

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Front page photo: Plant doctor in Uganda sharing plant health advice and knowledge with a farmer (photo: Emmanuel Edupet, Media Factory Uganda for CABI, with permission of the subjects).

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Abstract

This study builds on existing conceptual frameworks and published studies on agricultural extension, to unpack the efficiency and effectiveness of different communication channels. Focusing on studies from low-and-middle income countries, to draw lessons for sub-Saharan Africa, findings show that there is a huge variability in estimates of both cost efficiency and effectiveness of different agricultural extension communication channels. This is attributed to various factors including the enabling environment, quality of the communication channel or the relevance and quality of messaging. Although value-for-money considerations are important, there is a risk that over-emphasis on cost efficiency can undermine delivery of real change. Reaching a large audience can be achieved but unless attention is paid to information quality and context, and whether mass reach channels are appropriate, positive benefits associated with the uptake of good agricultural practices will not be achieved. Given these findings, the purpose of communication should precede the choice of communication channels based on cost efficiency and cost effectiveness. A combination of communication channels allows for larger reach and increases overall effectiveness of extension campaigns as multiple types of communication channels have complementarity and are synergistic thus better able to trigger behavioural change. This justifies extension campaign strategies that combine different channels for different types of communication.

Keywords: advisory services; sub-Saharan Africa; development communication; cost effectiveness

Introduction

It is widely acknowledged that agriculture in sub-Saharan Africa (SSA) faces many challenges and agricultural productivity remains far below its potential. The promotion and uptake of best agricultural practices is considered an effective way of closing this gap (e.g. Aker, 2011; Jayne and Sanchez, 2021). Agricultural extension is central to achieving sustainable productivity increases among smallholder farmers at scale (Danso-Abbeam *et al.*, 2018; Branca *et al.*, 2022). The predominant role of agricultural extension and advisory services in SSA is to facilitate smallholder farmers' access to information to equip them to meet new challenges and seize opportunities, such as climate change, shifting market demands, population growth and urbanization, thus enhancing their resilience and stimulating sustainable agricultural development (Bourne *et al.*, 2017; David and Cofini, 2017).

In recent years, advisory service providers and development practitioners have been under increasing donor pressure to implement cost effective approaches to extension and deliver impact at scale (Jonasova and Cooke, 2012). This has further been confounded by dwindling government budget allocations for public extension programmes (Norton and Alwang, 2020). This has resulted in the transformation of agricultural extension systems from educational style government-driven technology transfer mechanisms to broader and more pluralistic systems of advisory services (Davis *et al.*, 2020). The role of the 'New Extensionist' is diverse with objectives that go well beyond farmer education and the transfer of new technologies. It now includes linking farmers to various services such as credit, input and output markets and strengthening innovation processes through building linkages between farmers and other agencies (Davis and Sulaiman, 2014). In essence, agricultural extension has shifted from education to communication that supports problem solving and decision making by farmers (Leeuwis, 2013; David and Cofini, 2017).

Traditionally, smallholder farmers in SSA predominantly obtain agricultural information through interpersonal contacts with neighbouring farmers (Okwu and Daudu, 2011; Hampson *et al.*, 2017). This is due to the relative scarcity or absence of extension services in many SSA countries (Smith *et al.*, 2008) due to high costs associated with delivery to large and growing populations (Anderson and Feder, 2004). Given this, there have been numerous innovations in extension approaches that aim to strike the optimal balance between the intensity of interaction and number of farmers reached (Kansiime *et al.*, 2018). Public extension services, non-governmental organizations (NGOs), development agencies and donors, and private sector actors often face the challenge of making decisions on choice of extension method to make most effective use of their resources. Questions such as 'which is the most effective extension or delivery approach' or 'which is the most cost-effective approach' are common. Building on existing conceptual frameworks and published studies, this study aims to unpack the efficiency and effectiveness of different communication channels for agricultural extension, with focus on approaches that aim to increase the uptake of good agricultural practices at scale in SSA.

Understanding the concept of 'communication' in agricultural extension

Leeuwis (2013) defines extension as 'a series of embedded communicative interventions that are meant, among others, to develop and/or induce innovations which supposedly help to resolve (usually multi-actor) problematic situations'. Communication is an important part of extension and is defined as the imparting or exchanging of information by speaking, writing, or using some other medium. Communication within agricultural extension depends on the communication objectives (Leeuwis, 2013). For example, the most widespread form of communicative intervention is the persuasive transfer of policy and/or technological innovations, which aims to raise awareness, and persuade farmers to adopt specific technologies or to accept certain ideas. On the other hand, advisory communication is when farmers themselves seek out and ask advisors or extension agents to share their ideas on how to deal with a particular problem. Finally, there is also communication that supports horizontal knowledge exchange between farmers to share experiences and/or conduct on-farm experimentation (Leeuwis, 2013).

Channels of communication in agricultural extension

The different communication channels used in agricultural extension can be roughly divided into three classes (Leeuwis, 2013): i) *interpersonal channels*: small audience but high level of interaction through interpersonal communication, mostly without involvement of information and communication technologies (ICTs). These include plant clinics, demonstration plots and regular face-to-face interaction between the extension agent and farmer; ii) *mass media*: communication through written, aural or visual communication channels to reach large audiences, without personal interaction, such as newspapers, radio, television and SMS; iii) *hybrid channels*: a combination of the other two classes including radio listening groups, video screenings facilitated by an extension officer or open-air rallies. It should be noted that recent innovations in ICTs and digital technology can challenge this categorization, with, for example SMS and social media being considered as mainstream/conventional mass media, but allowing two-way interaction, which was not possible with traditional mass media. In future studies these should be given consideration.

Mass media distinguishes itself from the other communication channels in that it tends to be uni-directional and predominantly disseminative rather than communicative, which requires a multi-direction flow of knowledge and information (Adolwa *et al.*, 2012). However, ICT developments increasingly allow a multi-direction flow of communication linked to mass media, thus allowing, for example, listeners to respond to polling questions aired on radio or TV (Mtega and Ngoepe, 2018). Communication channels can further be categorized by level of intensity (i.e. amount of effort and time invested per farmer reached). We characterize the 'train & visit' and farmer field school (FFS) approaches as high intensity (resource or cost intensive), interpersonal methods. Village-based intermediaries, demonstrations plots, plant health clinics and plant health rallies are medium intensity, interpersonal approaches; while radio, print, mobile-based services, film or video are characterized as low intensity, mass media methods.

Use of multiple communication channels to deliver consistent messages are thought to be more effective in promoting uptake of agricultural technologies than a single communication modality (Tambo *et al.*, 2019; 2022), as they complement and reinforce each other. In agricultural extension, the choice of communication channel can be influenced by the complexity of the technology (and thus the message) and the target audience (e.g. individual farmers with specific problems or general information for all farmers; men or women; literacy level of the farmers; access to that particular channel). Table 1 provides an overview of communication channels often used in agricultural extension to convey messages to farmers, integrating the concepts discussed above.

Table 1. Overview of common communication channels used in agricultural extension.

Communication channel	Description	Channel type	Intensity of interaction with farmer	Communication type	Objective
Train & visit	Extension agents engage contact farmers or farmer groups; supply driven extension (transfer of technology)	Interpersonal	High	Persuasive	Training
Demonstration plots	Part of on-farm research; demonstrating recommended practices in field days. Sometimes used to promote inputs	Interpersonal	Medium	Persuasive	Information sharing
Village-based intermediaries	Farmer-to-farmer extension, can use demo plots and/or smartphone apps to support interactions	Interpersonal	Medium	Persuasive / advisory	Information sharing; service provision e.g., input brokerage
Plant clinics	Regular clinics held by government extension or other intermediaries, providing advice on plant health and other topics upon demand	Interpersonal	Medium	Advisory	Advisory; pest detection for early warning of pest outbreaks
Agro-dealers	Agro-dealers provide information on farm inputs	Interpersonal	Medium	Advisory	Input sales
Farmer Field Schools	Field-based experiential group learning for complex practices; limited to 25 farmers per FFS	Interpersonal	High	Horizontal	Education
Radio	Radio programs can cover large geographic areas instantly. Different formats used e.g. jingles, call-ins, documentaries. Affordable channel for poorer households	Mass media	Low	Persuasive / advisory	Information sharing
Printed media	Includes posters, leaflets, manuals, magazines; combining pictures, words and diagrams to convey accurate information. Formats can be adapted to target user (gender, age, literacy)	Mass media	Low	Persuasive / advisory	Information sharing
Mobile technology	SMS, Interactive Voice Response (IVR) and smartphone apps for sharing information, but connectivity of poorer households can be an issue	Mass media	Low	Persuasive / advisory	Information sharing, alerts
Rallies	Short events conducted by trained extension workers to deliver customized messages at locations where farmers congregate (e.g. markets)	Hybrid	Medium	Persuasive	Information sharing
Film / video	Videos / films (documentary, instructional, etc) that can be screened in communities. Sometimes with facilitated Q&A sessions. Timing of screening influences participation	Mass media / hybrid	Medium	Persuasive	Information sharing

Source: Adapted from Leeuwis (2013)

Complexity of communication messages

The message that is communicated can have different levels of complexity. Some messages are more context-dependent than others. In line with Harris *et al.* (2013) and Kansiime *et al.* (2017), this paper categorizes extension messages as either simple (i.e. crop rotation, pest resistant varieties); intermediate (i.e. fertility management, organic pesticides, weed management); or complex (i.e. quarantine, integrated pest management, grafting or budding) (Kansiime *et al.*, 2017).

Study methodology

We conducted a narrative review of the literature (Grant and Booth, 2009), to collect evidence on the effect of different communication channels on reach and technology adoption rates in lower- and middle-income countries. Specifically, we reviewed published journal articles, technical reports and grey literature. The search strategy consisted initially of searches in Google Scholar and SCOPUS based on key words anywhere in the article or report (i.e. not just in the title).

Specific key words used were: 'effect' or 'impact evaluation' or 'technology adoption rates' plus:

- 'Agricultural extension approach'
- 'Farmer Field School'
- 'Plant clinics'
- 'Agricultural communication approach'
- 'Radio programmes'
- 'Plant health rallies'
- 'Train & Visit'
- 'Village-based intermediaries'
- 'Farmer field days'
- 'Demonstration plots'
- 'SMS extension'
- 'Mobile messaging extension'

Literature from the initial search was sifted, with studies from the global North or high-income countries excluded as well as non-English literature (for example works with an English abstract, but with a non-English main text). The latter means that non-English literature from the global South or low-and-middle income countries was excluded. Studies from the global South or from countries categorized as low-and-middle income went through a second review, where the actual study was reviewed to ascertain if it had determined an adoption rate of any agricultural technology from any extension approach. Studies that did not have a mention of an adoption rate were excluded from the review, but may have been used as literature on extension approaches. Most of the relevant publications found were published in a 10-year period from 2007 to 2017, with a total of 28 relevant publications in SCOPUS. This contrasts with only 7 relevant publications in SCOPUS recorded in the 16-year period from 1991 to 2007.

From the literature review we assessed the relative efficiency of different agricultural extension communication channels. In this study, efficiency, which means how well inputs are converted into outputs (Lonsdale, 2000), is represented by the number of farmers reached with a particular extension message, and cost efficiency is therefore the cost per farmer reached. Based on the literature review, we documented the reported cost efficiency per farmer reached of different extension approaches. We then reviewed the findings to provide insights into the cost efficiency of different extension approaches.

Finally, we assessed the effectiveness of different extension approaches, which reflects how well outputs achieve the desired results (Lonsdale, 2000). The uptake rates of recommended practices (i.e. the percentage of farmers receiving the message who changed their behaviour or who adopted the recommended practice) are often used to measure the effectiveness of agricultural extension. The underlying assumption is that the uptake / adoption of those practices will result in the intended benefits at impact level (e.g. increased productivity or increased income). By this definition, cost effectiveness is therefore the cost per farmer with changed attitudes, awareness or behaviours, such as adopting new practices. In this review we focus on the latter – cost per farmer adopting new practices. From the literature review we documented the rate in uptake of recommended technologies and practices by farmers because of exposure to that technology / practice via an extension approach. Extension approaches reviewed are classified into six effectiveness levels, from A to F, based on documented uptake rates of recommended technologies, following the approach of Posthumus *et al.* (2015) (Table 2).

Table 2. Hypothetical effect classes and uncertainty ranges.

Effect classes		Uncertainty range		Effect on adoption
Class	Average	Min	Max	
A	0%	0%	0%	None
B	2%	0%	10%	Very low
C	10%	2%	25%	Low
D	25%	10%	50%	Moderate
E	50%	25%	80%	High
F	80%	50%	100%	Very high

Based on the approach from Posthumus *et al.*, 2015

Class A comprises extension approaches that have, on average, no effect (0%) on adoption, while Class F comprises extension approaches that have led to, on average, an 80% uptake of the technology being promoted (see Table 2). From the literature review we find that there is a high variability in the measured effects of different extension methods on the uptake of recommended technologies. This is as expected as evidence exists that shows that the adoption of an extension approach is based on diverse factors (i.e. the enabling policy environment, the agent's knowledge, age and incentives, and local infrastructure, as well as farmer organization) (Ragasa *et al.*, 2016), and hence effects can differ as the local conditions, context or enabling environment changes. To overcome this, the effectiveness classes (A to F) (Table 2) are assigned an uncertainty range, and this implies that effect classes B, C, D, E and F include extension approaches that have, on average, uptake rates of 2%, 10%, 25%, 50%, and 80%, respectively; as well as those whose uptake rates might fall within the uncertainty range. The classes correspond to zero effectiveness, very low, low, moderate, high and very high effectiveness, respectively.

Findings

The role of different extension communication approaches in technology adoption

Through the literature review, we documented the type of agricultural technology being promoted and its level of complexity, how farmers are reached (i.e. individually or collectively), and the estimated effects on adoption of the communication channel used. We also document how the study under review evaluated the effect of the extension approach (i.e. panel data, cross-sectional data, sample sizes), thus providing insights on study robustness. Documented cases for the Train & Visit approach, Farmer Field Schools, village-based intermediaries, farmer field days / demonstration plots, radio campaigns and SMS campaigns are presented. The main finding from the literature reviewed is that there is high variation in effects between studies, reflecting the variety of technologies, implementation practices, contexts and study designs.

Specifically, most studies focusing on the Train & Visit extension approach (Table 3) reported low rates of increases in uptake[1] for simple technologies that require the purchase of inputs (Akpoko and Kudi, 2007; Krishnan and Patnam, 2014). Several studies report either slightly higher or much higher adoption rates for simple technologies that do not require purchases (Akpoko and Kudi, 2007); and for more complex technologies, such as those comprising a set of agricultural management practices (Dorji *et al.*, 2016; Kondylis *et al.*, 2017), respectively. The use of mixed farmer outreach methods (such as individual contact with collective engagement of groups) enhances the Train & Visit approach as it results in much higher rates of adoption (Miheretu and Yimer, 2017).

[1] These figures are increases in adoption; so perhaps uptake was 13% before, then increased to 14% (+1%) or 20% (+7%). In all relevant tables we use the + sign to indicate an increase in adoption.

Table 3. Effect of training and visit extension on technology adoption by farmers.

Reference	Extension program	Study method	Effect on adoption likelihood	Complexity of practice	Type of action	Purchased inputs required
Kaliba *et al.*, 1997	Cattle feeding program, Tanzania	Cross-sectional survey (n=234); Heckman two-stage adoption model	Seminar attendance increased adoption likelihood of bitter watermelon as feed by **+20.8%**	Simple	Individual	N/A
Krishnan and Patnam, 2014	Fertilizers and improved seeds, Ethiopia	Longitudinal household survey; descriptive statistics	Between 1999 and 2009, use of improved seeds increased from 18% to 23% (**+5%**) and use of fertilizers increased from 62% to 64% (**+2%**) among farmers	Simple	Individual	Yes
Miheretu and Yimer, 2017	Land management practices (to control erosion), Ethiopia	Cross-sectional survey (n=176); multinomial logit regression model	Marginal effect of farmer training on adoption likelihood is estimated with a logit model at **+28%** for stone bunds and **+69%** for chemical fertilizers. The marginal effect of extension contact is similar: **+29.9%** for stone bunds and **+67.5%** for chemical fertilizers	Simple	Collective / individual	Some
Akpoko and Kudi, 2007	Youth agricultural extension outreach program on best agricultural practices, Nigeria	Cross-sectional survey (n=152); descriptive statistics; treatment vs control	The extension program resulted in increased adoption rates of **+1%** (herbicides) to **+26%** (improved varieties) Other practices: grain storage chemicals (**+2%**), fertilizers (**+7%**), plant population (**+11%**), spacing (**+13%**), weeding (**+15%**), sowing dates (**+17%**)	Simple to intermediate	Individual	Some
Hussain *et al.*, 1994	Effect of T&V extension on improved wheat technology, Pakistan	Cross-sectional survey (n=295); regression models	Extension increased farmers' knowledge of modern technologies, but no significant impact of T&V system (due to ineffective implementation) on adoption rates	Intermediate	Individual	Some
Dorji *et al.*, 2016	Training on orchard management practices, Bhutan	Panel survey (n=40); descriptive statistics; ex-ante vs ex-post	Adoption of improved management practices increased from 4.5% to 16% (**+11.5%**) due to hands-on training	Complex	Individual	Some
Kondylis *et al.*, 2017	Extension model through lead farmers; promotion of conservation farming technologies, Mozambique	RCT; control: lead farmers (n=50) are supported by extension agents to demonstrate technologies; treatment (n=150): lead farmers receive additional intensive training	Control lead farmers (contact farmers) adopted 60.1% of practices; extension training added at least **+10.6%** to adoption likelihood of lead farmers. The training did not result in increased reach or adoption likelihood of secondary reach farmers	Complex	Individual	Some

For Farmer Field Schools, various studies report significant effects on technology adoption rates (Table 4) (Ricker-Gilbert *et al.*, 2011; Settle *et al.*, 2014; Kabir and Rainis, 2015; Luusa *et al.*, 2018; van den Berg *et al.*, 2020; Bakker *et al.*, 2021). However, Farmer Field Schools are implemented, measured, and reported on in different ways (van den Berg *et al.*, 2020; van den Berg *et al.*, 2021) , thus making it difficult to compare different evaluations. Combining Farmer Field Schools with other farmer outreach approaches has been found to boost technology adoption rates (Ongachi *et al.*, 2017). In general, Farmer Field Schools have been found to be more effective in increasing adoption of promoted agricultural technologies as compared to other extension approaches (Ricker-Gilbert *et al.*, 2011). This can be attributed to their broader educational approach as farmers are taught to learn, network, analyse, experiment and innovate (Braun *et al.*, 2000). However, they are more costly, and this limits large-scale public investment (Quizon *et al.*, 2001).

Table 4. Effect of Farmer Field Schools (FFS) on technology adoption by farmers.

Reference	Technology	Study method	Adoption likelihood	Complexity of practice	Type of action	Purchased inputs required
Ongachi *et al.*, 2017	Video mediated learning vs FFS for striga control, Kenya	Quasi-experimental study (n=119); no statistical test on adoption rates	Uptake of striga control technologies was 46.2% for video and FFS combined, and 35% for FFS	Intermediate	Individual	N/A
Sjakir *et al.*, 2015	Rice productivity enhancing technologies, Indonesia	Cross-sectional survey (n=168) among FFS farmers; descriptive statistics	Adoption rates among FFS farmers: land management 77%; seed selection 60%; paddy planting system 56%; fertilizer 74%; irrigation 83%; pest and disease control 62%; harvest technique 97%	Intermediate to complex	Individual	Some
Kabir and Rainis, 2015	IPM in vegetables, Bangladesh	Cross-sectional survey (n=331); logit regression model	30% overall adoption rate for IPM	Complex	Collective	Some
Settle *et al.*, 2014	IPM in cotton, Mali	Longitudinal study based on cotton company / cooperative records	Reduction in use of hazardous insecticides (**-92.5%**) between 2003 and 2010; pesticide use unchanged in non-FFS areas	Complex	Collective	No
Murage *et al.*, 2012	Push-pull technology, Kenya	Cross-sectional survey (n=491); tobit regression model	Field days (**+26.8%**), Farmer Field Schools (**+22.2%**) and farmer teachers (**+18.1%**), had the greatest impact on the probability that a farmer would adopt PPT	Complex	Individual	No
Lund *et al.*, 2010	IPM in vegetables, Benin	Semi-structured interviews, FFS and non-FFS farmers (n=54)	FFS participants show good understanding of IPM concepts and experimented with information, but uptake of recommended is limited due to contextual constraints	Complex	Collective	Some
Mancini *et al.*, 2007	IPM in cotton, India	Panel survey, year before and year after FFS training (n=137)	FFS participants showed larger reduction (**-47%**) in toxic pesticide use compared to control	Complex	Collective	Some
Ricker-Gilbert *et al.*, 2011	IPM practices (simple, intermediate, complex), Bangladesh	Cross-sectional survey (n=350)	Participation in FFS has a strong and significant impact on all levels of technology complexity. Marginal effects**: +0.73, +0.42** and **+0.47** practices adopted for simple, intermediate and complex IPM respectively	Simple to complex	Individual / collective	Some

Village-based intermediaries (Table 5) are lead farmers who are engaged to demonstrate practices to their farming peers (Kansiime *et al.*, 2017; Nakano *et al.*, 2018). There are many variations of this approach, but all capitalize on existing social networks and assume that experienced and skilled farmers are best-suited to provide hands-on training to other farmers. Several studies show that farmer-to-farmer extension had a significant multiplier effect in increasing the uptake of technologies being promoted (Amudavi *et al.*, 2009; Murage *et al.*, 2012; Van Campenhout, 2017; Kansiime *et al.*, 2017; Nakano *et al.*, 2018).

Table 5. Effect of village-based intermediaries on technology adoption by farmers.

Reference	Technology	Study method	Adoption likelihood	Complexity of practice	Type of action	Purchased inputs required
Van Campenhout, 2017	Market crops, crop spacing, manure application, Uganda	Cross-sectional survey (n=602); double-difference model	Uptake of practices: crop spacing (**+27%**) and manure application (**+31%**); farmers reporting higher maize prices (**+22%**)	Simple	Individual	No
Amudavi *et al.*, 2009	Farmers as extension agents to disseminate push-pull technology, Kenya	Cross-sectional survey (n=672); ANOVA, logit regression model	On average, one farmer technician influenced 17 others to adopt; the follower farmers influenced another 2 farmers each	Complex	Individual	No
Murage *et al.*, 2012	Push-pull technology (PPT), Kenya	Cross-sectional survey (n=491); tobit regression model	Field days (**+26.8%**), Farmer Field Schools (**+22.2%**) and farmer teachers (**+18.1%**), had the greatest impact on the probability that a farmer would adopt PPT	Complex	Individual	No

With respect to plant clinics, various studies report that clinic users are more likely to adopt pest management options recommended at clinics (Bett *et al.*, 2018; Tambo *et al.*, 2020; 2021a; 2021b). This can be attributed to self-selection as farmers approach the plant clinics for advice, hence are likely more motivated to also adopt any recommended practices. The literature on farmer field days and demonstration plots shows a strong effect on adoption (Table 6) (Adekayo, 2007; Ricker-Gilbert *et al.*, 2011; Murage *et al.*, 2012; Hauser *et al.*, 2014). This is mainly for the diffusion of simple and intermediate technologies (Ricker-Gilbert *et al.*, 2011) and not complex ones (Table 6). But as with the visit to plant clinics, it is likely there exists a strong self-selection bias as farmers interested in a technology are more likely to attend field days and visit demonstration sites.

Table 6. Effect of farmer field days / demonstration plots on technology adoption by farmers.

Reference	Technology	Study method	Adoption likelihood	Complexity of practice	Type of action	Purchased inputs required
Hauser *et al.*, 2014	Boiling water treatment for plantain (sucker sanitation), Cameroon	Cross-sectional survey	39% among workshop participants adopted technique on 'on-farm demonstration plots'	Simple	Individual	No
Adekayo, 2007	Improved varieties (maize, cassava, cowpea); soybean intercropping (maize, cassava), Nigeria	Cross-sectional survey (n=140); descriptive statistics	Adoption rate of crop varieties within village: 45% to 100% Adoption rate of crop varieties in neighbouring villages: 11% to 100% Adoption rate in villages beyond 9 km: 40% for cassava only (0% for other crop varieties)	Simple to intermediate	Individual	Yes
Ricker-Gilbert *et al.*, 2011	IPM practices (simple, intermediate, complex), Bangladesh	Cross-sectional survey (n=350)	Field days have a strong and significant impact on simple and intermediate technology. Marginal effects: +0.96, and +0.86 practices adopted for simple and intermediate IPM respectively; zero effect for complex practices. Benefit-cost ratios: $75.42 and $28.89 respectively.	Simple to complex	?	Some?
Murage *et al.*, 2012	Push-pull technology, Kenya	Cross-sectional survey (n=491); tobit regression model	Field days (**+26.8%**), farmer field schools (**+22.2%**) and farmer teachers (**+18.1%**), had the greatest impact on the probability that a farmer would adopt PPT	Complex	Collective	No

Some agricultural extension approaches, which have been used extensively, have very limited robust evaluations of their effect on adoption (see Appendix Tables A1 and A2 for insights on effect of radio campaigns, and SMS campaigns on technology adoption by farmers, respectively). This also includes plant health rallies (Ndiritu *et al.*, 2016; Kibwika *et al.*, 2021) and different types of video formats. Use of emerging digital tools and social media in agricultural extension is also on the rise, but its review is outside the scope of this study but should be considered in future research. In addition, there is also emerging evidence that the use of combined farmer outreach methods enhances technology adoption (Bentley *et al.*, 2015a; Karubanga *et al.*, 2016; Kansiime *et al.*, 2017; Ongachi *et al.*, 2017; Kansiime *et al.*, 2022; Tambo *et al.*, 2022).

Cost efficiency of different extension communication approaches

We summarize the key cost elements (per farmer reached) associated with the implementation of the different communication channels, based on reported findings in publications and grey literature (Table 7). Estimates on cost efficiency vary per study as implementation as well as variable and fixed costs for different communication channels vary per case. For instance, in the context of Farmer Field Schools, the costs per farmer reached vary from USD19 in Bangladesh (Harris *et al.*, 2013) to USD84 in Cameroon (Muilerman and David, 2011). While the variation could be attributed to the length of the Farmer Field School and the country of implementation, the estimates may or may not also include costs such as trainers' fees, cost of training materials, travel expenses and food and drink. The cost efficiency of farmer field days / demonstrations also shows a large variation that is likely to reflect the different ways that field days are implemented.

In other cases, outliers appear; for example, the lower value for radio (Kansiime *et al.*, 2017) most likely occurs because only broadcasting costs and participation of an expert were accounted for, and no other costs such as production cost of the program. A 12-week radio campaign will be more costly than a single talk show or series of jingles. Reach will vary widely with high values where radio is largely state-controlled with few alternative stations available, or where a single language is widely spoken. Reach is much lower where deregulation has led to a multiplication of radio stations in local languages that can have quite niche audiences.

If we only look at the costs and reach of farmers (Table 7) as indicators of efficiency, following the approach of David and Cofini (2017), we find that three communication channels - rallies, radio and videos - emerged as the most cost efficient, while rural resource centres, facilitated video viewing, study tours and Farmer Field Schools are the least cost efficient. However, this classification does not consider the adoption likelihood and does not provide an indication of the effectiveness of the different communication channels. This is the case because some communication channels are good at disseminating information and creating awareness, but they might be weak at persuading or showing how the technology is implemented. In such cases those communication channels may need to be complemented by other extension approaches to ensure adoption, e.g. by demonstration, one-on-one visits.

Table 7. Estimated cost efficiency of extension methods.

Extension method	Country	USD per farmer reached (cost efficiency)	Source	Key cost elements
Train & Visit (1-day training)	Uganda	1.56	Kansiime *et al.*, 2017	
	Bangladesh	3.60	Ricker-Gilbert *et al.*, 2011	
	Bangladesh	2.67	Harris *et al.*, 2013	
Farmer Field School (FFS) (12 sessions)	Uganda	22.76	Kansiime *et al.*, 2017	*The cost of FFS depends on several factors, such as training of the facilitators, trainer incentives, travel allowances, materials (newsprint paper, pens, etc.), refreshments for weekly meetings and field days with associated costs of setting up and managing the field plots. Other key cost drivers are the length of the training cycle and the country where the FFS are implemented.*
	Bangladesh	35.53	Ricker-Gilbert *et al.*, 2011	
		19.54	Harris *et al.*, 2013	
		56	David and Cofini, 2017	
		84	Muilerman and David, 2011	
		49	Muilerman and David, 2011	
		75	Muilerman and David, 2011	
		75	Muilerman and David, 2011	
Village-based intermediaries		4.24	Kansiime *et al.*, 2017	*Costs may include training of farmer advisors, follow-up and monitoring their performance.*
Plant clinics		5.02	Kansiime *et al.*, 2017	*Costs include organizing consultative meetings, planning activities, plant doctor salaries and training, publicity, furniture and basic equipment for clinic sessions (photographs of symptoms, reference literature and hand lenses) and technical backstopping of 'doctors'.*
Demonstration plots and farmer field days		8.65	Kansiime *et al.*, 2017	*Costs include training of extension advisors, materials, maintenance costs as well as follow-up activities. Costs may also include travel and subsistence for staff to participate in field days, demo plot maintenance etc.*
		2.43	Ricker-Gilbert *et al.*, 2011	
		0.77	Harris *et al.*, 2013	
		1.88	Mitschke, 2017	
		5.88	Etwire *et al.*, 2014	
Plant health rallies		0.41	Kansiime *et al.*, 2017	*Costs for fairs may include rent for venue and facilities, publicity and transportation for farmers.*
Print media (e.g. newspaper)		0.30	Kansiime *et al.*, 2017	*Costs depend on the type of printing material used, design charges and the number of materials to be printed*
		0.35	Harris *et al.*, 2013	
Radio		0.02	Kansiime *et al.*, 2017	*Costs include staff costs, production equipment, training of staff, technical backstopping by agricultural experts, program production costs and airtime, which will vary by the type of station.*
		0.42	Bentley *et al.*, 2007	
		0.36	Mitschke, 2017	
		0.24	Etwire *et al.*, 2014	
Mobile (SMS)		0.36	Kansiime *et al.*, 2017	*Costs include setting up and developing the infrastructure**, developing / customizing the content of the information product, operationalizing the system, staff training, publicity, training clients and maintaining the infrastructure. As the number of users increases, the total cost per person will fall. *More recently there is opportunities to superimpose new interventions / messages on existing infrastructure and tools.*
		9	Farm Africa, 2015	
		9.3	Cole and Fernando, 2016	
		2.4	Mibei *et al.*, 2017	
Video		0.21	Etwire *et al.*, 2014	*Costs vary, depending on whether videos have to be produced, who is involved (e.g. film professionals, farmers), the type of equipment used as well as the approach used for reaching farmers (i.e. structured or unstructured, mass production of DVDs).*
		0.50	Bentley *et al.*, 2015a	
		0.22	Bentley *et al.*, 2015b	
Facilitated video viewing in groups		78	Muilerman and David, 2011	*Costs depend on scale of intervention and complexity of technology / equipment needed. Other costs can include facilitator training costs, system capital costs e.g. viewing equipment, recurring facilitation costs etc.*
		30	Muilerman and David, 2011	

Cost effectiveness of different extension communication approaches

Combining the results on cost efficiency with the expected effect class (see methodology section for description of these), estimates of cost effectiveness are presented in Table 8. The estimated cost effectiveness is calculated as the cost per farmer adopting a recommended good agricultural practice.

Table 8. Estimated cost effectiveness of different extension methods.

Extension method	USD per farmer reached (cost efficiency) [a]	Effect class on adoption [b]			Average cost effectiveness (USD per farmer adopting practice)		
		Simple	Intermediate	Complex	Simple	Intermediate	Complex
Interpersonal approaches – high intensity							
FFS (12 sessions)	56.00 [19.54, 84.00]	Very high	High	High	70.00	112.00	112.00
Extension agent visits (1day training)	2.67 [1.56, 3.60]	Moderate	Low	Low	10.68	26.70	26.70
Interpersonal approaches – medium intensity							
Plant clinics	5.02 [- , -]	Very high	High	Moderate	6.28	10.00	20.00
Village-based intermediaries	4.24 [- , -]	Moderate	Low	Low	16.96	42.40	42.40
Farmer field days (demonstration plots)	5.88 [0.77, 26.00]	Very high	High	Moderate	7.35	12.00	24.00
Facilitated video viewing (8-11 sessions)	30.00 [1.00, 7.09]	Moderate	Moderate	Low	120.00	120.00	300.00
Plant health rallies	0.41 [- , -]	Low	Very low	Very low	4.10	20.50	20.50
Mass media – low intensity							
Mobile (SMS)	9.00 [0.36, 9.00]	Low	Very low	None	90.00	450.00	-
Radio	0.36 [0.02, 0.42]	Very low	Very low	None	18.00	18.00	-
Print media	0.35 [0.30, 0.35]	Very low	Very low	None	17.50	17.50	-
Video screening	0.22 [0.21, 0.50]	Moderate	Low	Low	2.00	2.00	5.00

[a] Median value based on Appendix Table 3 above.
[b] See Table 2

Table 8 shows that video and other communication channels that have medium intensity (i.e. farmer field days, plant health rallies and plant clinics) seem to be the most cost-effective extension methods, regardless of the complexity of the message. Though mass media provides larger reach (i.e. better cost efficiency), the effect on uptake is generally far lower, reducing the cost effectiveness. Using the uncertainty range of each effect class allows for a hypothetical sensitivity analysis. The error bars in Figure 1 indicate the uncertainty range in the cost effectiveness of each extension campaign method. Several extension campaign methods have overlapping uncertainty ranges.

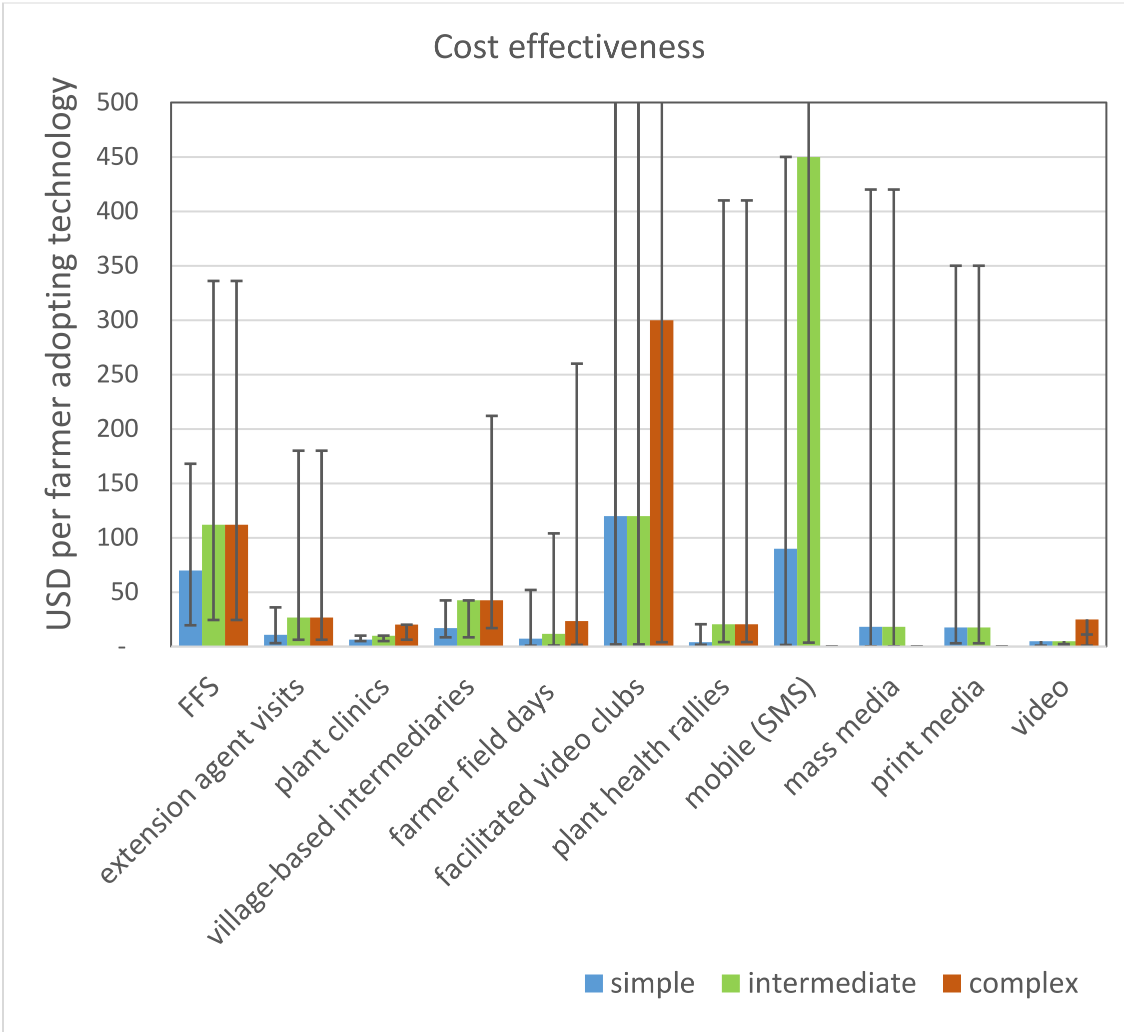

Figure 1. Sensitivity analysis for cost effectiveness of extension communication channels.

Discussion

This paper set out to answer two key questions in the context of use of communication channels in extension services: i) which is the most cost-efficient communication channel for agricultural extension, and what the determinants of cost efficiency are; and ii) which is the most cost-effective communication channel for agricultural extension, and what are its determinants? For this paper, cost efficiency means cost per farmer reached. Cost effectiveness means cost per farmer adopting good agricultural practices.

Cost efficiency

Estimates of cost efficiency vary according to the cost elements considered and the way in which costs are calculated. Some studies consider fixed costs as well as variable costs of the communication channel. In some cases, the costs towards monitoring and follow-up with farmers has also been considered (Kansiime *et al.*, 2017). Although it has been traditionally recognized that the opportunity costs of farmer participation in extension activities can be high (Wale, 2008), most of the literature reviewed does not consider farmers' time / opportunity cost of participating in an extension event. This is an area for future research. Cost efficiency is directly linked to the intensity of interaction required to deliver a message to the intended audience. Consequently, there is a trade-off between cost efficiency and complexity of the message delivered. For example, the Farmer Field School approach has been shown to be a high intensity, interpersonal communication channel typically used to educate a targeted group of farmers with specific problems, with an intent to foster a deeper understanding of agricultural practices and principles, which is thought to result in higher rates of adoption of practices with varying degrees of complexity. As an extension method, it has medium reach with relatively high costs per farmer reached and is therefore considered low on the cost efficiency scale, as compared to persuasive mass media channels such as radio or unstructured video screenings (without facilitation) that are found to be more cost efficient in reaching large numbers of farmers with simple messages.

Cost efficient extension methods tend to use more persuasive communication that can be appropriate to get clear and simple messages to a large audience, but less suitable for learning. If the objective of the communication is primarily to provide information and / or raise awareness, mass media channels prove to be not only cost efficient but also cost effective, say for alerting farmers to pest outbreaks or new pests, as they have a moderate to wide reach while raising awareness about not-so-complex messages to large audiences.

Cost effectiveness

Cost effectiveness of different communication channels varies depending on the communication channel, type of communication and the intensity of interaction with the farmers, but more importantly it depends on the communication objective and purpose of the communication. Therefore, although the likelihood of farmers participating in a Farmer Field School adopting new agricultural practices is higher, the approach has not been considered cost effective owing to its high cost and limited reach. On the other hand, with lower costs per farmer, field days or video screening are seen as the most cost-effective channels for generating interest and stimulating adoption of simpler practices. For more complex messages, visits by extension agents with high intensity of interaction can be considered as cost efficient as well as cost effective (Rajendran and Islam, 2017). In short, if the message is simple and of relevance to many farmers, then radio becomes both cost efficient and cost effective. However, for the information to be translated into action, more education is needed – which will nevertheless be cost effective but with higher intensity, limited reach and lower cost efficiency which are justified by the objective of the communication. In practice, this implies that for messages to be put into use, radio messages need to be complemented by other communication channels that provide detailed information or which show or explain how to use the technology being promoted.

Besides complexity, the quality and relevance of the message, the quality of materials used, the ability of the sender to transfer the message, and the accessibility of the message to the receiver (e.g. timing of radio programs, language) also have a bearing on its likelihood of adoption. Moreover, the effectiveness of any communication channel is also influenced by several contextual factors that make it difficult to anticipate the actual change in adoption behaviour as a consequence of the communication.

Assessing the cost effectiveness of communication channels for agricultural extension is subject to many difficulties as it is hard to trace the relationship, if any, between communication costs and farm-level adoption of good agricultural practices (Anderson, 2008). The relationship is often nonlinear and subject to many influencing factors within the context as well as the implementation itself. Furthermore, dissemination of information alone does not translate into desired change; the farmers who receive the message must also decide and be able to act upon the message and adopt the recommended practice before change can be observed.

Conclusion

We find that there is a huge variability in estimates of both cost efficiency and effectiveness for different extension communication channels in low- and middle-income countries. This may be due to the enabling environment and the local context, but also the quality of the communication channel or the relevance and quality of the message. Each type of communication channel has its advantages and limitations when used to disseminate information on best practices at scale. Although value for money is an important issue, there is a risk that over-emphasis on cost efficiency can undermine delivery of real change. Reaching large numbers can be achieved but unless attention is paid to quality and context, and whether mass reach channels are appropriate, positive benefits associated with the uptake of good agricultural practices will not be achieved. Communication channels that are based on advisory and horizontal (two-way / multi-directional) communication are better suited to share complex messages, but the reach tends to remain limited compared to the communication channels for dissemination of information (one-directional). This is especially true in some parts of sub-Saharan Africa, where economic status and some socio-cultural norms still hinder some segments of the population (such as women) from effectively engaging in and with advisory communication and in development programming in general.

The choice of communication channel should thus be driven by the aim of the intervention, the resources available and local context. This implies that the purpose of the communication should precede the choice of communication channel based on cost efficiency and cost effectiveness. A combination of communication channels allows for larger reach and increases the overall effectiveness of extension campaigns as multiple types of communication and learning processes are engaged to trigger behavioural change.

Practitioners in sub-Saharan Africa should therefore aim to use campaign strategies that combine different communication channels to increase the uptake of agricultural technologies. This should be coupled with action research to estimate the cost effectiveness and efficiency of extension campaigns that combine different communication channels, while concurrently assessing reach and uptake as well as subsequent behaviour change. Results of the action research can thus be used to make the case, to African governments and development partners alike, for financing for combined approaches. Future research should also aim to understand the gendered differences in uptake of agricultural extension information in messages received from different communication channels and / or combinations of different channels. Finally, there is also the need for research that considers the changing dynamics in communication arising from emerging digital technology. Such studies should assess not only the benefits, challenges and opportunities of digital communication channels for agricultural extension but also progress with localization - as evidenced by use of local languages in digital communication technology and applications – and how that enables or hinders farmer reach.

Statements and declarations

Competing Interests:
The authors have no competing interests.

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Appendix

Effect of different extension methods on technology adoption by farmers – literature review results.

Table A1. Effect of radio campaigns on adoption.

Reference	Technology	Study method	Adoption	Complexity of practice	Type of action	Purchased inputs required
Agwu *et al.*, 2008	Improved agricultural technologies (land husbandry, intercropping, harvesting, processing), Nigeria	Cross-sectional survey (n=135) No before-after comparison, only current uptake (%)	Radio enhanced adoption of 7 out of 19 technologies: weeding & fertilizer cassava / maize / yam (44.4%), site selection (22.2%), pest control (33.3%), yam harvesting / storage (55.5%), cocoyam processing (29.6%), planting (36.2%), early maize cultivation (40.7%). Little effect on more specialized / complex technologies	Intermediate	Individual	No
Hampson *et al.*, 2017	Forest landscape restoration activities (participatory rural radio), Uganda	Cross-sectional survey (n=413) No before-after comparison	Of those who listened to most or all of the broadcasts, 98% had carried out one of the recommended practices, whereas 84% of those who had listened to only one episode had used one of the practices	Intermediate	Collective	No?

Note: There is emerging literature that assesses the effect of radio campaigns on farmer adoption rates. This is outside the scope of this study but should be considered for future research.

Table A2. Effect of SMS campaigns on technology adoption by farmers.

Reference	Technology	Study method	Adoption	Complexity of practice	Type of action	Purchased inputs required
Cole and Fernando, 2016	A mobile phone-based technology that allows farmers to call a hotline, ask questions and receive responses from agricultural scientists and local extension workers, India	RCT (n=1200)	Treated farmers were significantly more likely to adopt agricultural practices e.g. 2.4% increase in using biocontrol: 5.7% increase in ammonium sulphate purchase	Intermediate	Individual	Yes

Note: There is emerging literature that assesses the use of SMS on farmer adoption rates. This is outside the scope of this study but should be considered for future research.

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