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Information and Communication Technology Use Capacity Within Extension Networks: Development and Preliminary Validation of an Empirical Scale

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Abstract

Advancing information and communication technologies (ICTs) has become central to international agricultural and extension development efforts. ICTs are crucial in facilitating information transfer, ensuring stakeholder access to information, and increasing the decision-making capacity of smallholder farmers. The research presented here introduces an instrument developed to quantify perceptions of ICT use capacity within international extension networks. The aggregate scale was verified for content validity, response process validity, internal structure validity, and consequential validity informing its use. The instrument was administered to network members (n = 122) associated with the Global Forum for Rural Advisory Services. An exploratory factor analysis (EFA) was conducted with measures of correlation and reliability analysed. Six factors were extracted and analysed further. The resulting Perceptions of ICT Use scale and factors can be used as reliable instruments for quantifying perceptions of ICT use capacity, enhancing international extension network needs assessments, and informing policies and practices which maximize ICT capacity.

*Keywords***:** information communication technology (ICT); scale development; rural advisory services; international extension; capacity assessment

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Introduction

Access to information is a critical factor in socio-economic transformation (Asenso-Okyere & Mekonnen 2012). However, failure to link innovative agricultural research to farming communities significantly affects global agricultural development (Davis & Sulaiman, 2014; Lamm et al., 2019; Maningas, 2006). Agricultural sectors in the global South consist primarily of smallholder farmers with limited access to infrastructure and information. Lack of access affects decision-making capacity (Levine et al., 2019b; Taragola & van Lierde, 2010) and creates barriers to production associated with high transaction costs, limited production, and decreased marketing choices (Aker et al., 2016; Nakasone et al., 2014).

The advancement of agricultural information and communication technologies (ICTs) has emerged as a field of inquiry focused on enhancing rural agricultural development (Mahant et al., 2012). In this study, ICTs refer to "technology used for creation, acquisition, processing, storage, and dissemination of vocal, pictorial, textual, and numerical information by micro-electronics-based combination of computing and telecommunications" (Nair & Devi, 2011, p. 4). Modern ICTs facilitate efficient information transfer and increase decision-making capacity (Ekbia & Evans, 2009; Narine et al., 2019a) by reducing the cost of communicating information on a large scale, not always possible through traditional interpersonal communication channels (Aker et al., 2016). Effective ICT use provides critical connections between farming communities in the global South and emerging research (Aarts et al., 2014; Lamm et al., 2019; Swanson & Rajalahti, 2010). For international extension networks, there is a demonstrated need to evaluate network capacities for ICT development and implementation (Lamm et al., 2019).

Traditional forms of ICTs (e.g., radio and television) have a history of use in international extension (Aker, 2011). With the growth of mobile phone coverage, traditional ICTs have evolved rapidly to include voice, SMS, apps, and internet-based services (Aker, 2011; Aker et al., 2016; Nakasone et al., 2014). Expansion of technology has increased interest in understanding effective facilitation of ICTs in rural agricultural areas (Nakasone et al., 2014). Extension networks face information dissemination challenges related to scale, sustainability, relevance, and responsiveness; therefore, ICT-based services are positioned to fundamentally change the diffusion of information in the global South (Aker, 2011). It is imperative the effectiveness of extension efforts striving to provide information to rural farmers globally be assessed to ensure best practices are followed (Aker, 2011). Conducting a needs assessment for ICT information and interventions in global agriculture may offer insights to effective extension-based information dissemination (Aker et al., 2016).

Responding to this gap in the literature, Lamm et al. (2019) conducted a Delphi study of international extension experts to determine the needed capacities for effective ICT use in international extension networks. Their findings were consistent with previous literature (see Dhaka & Chayal, 2010; ITU, 2011; Patra et al., 2016; Richardson, 2003; Warren, 2002) in demonstrating how a variety in ICT modalities can address the agricultural information and telecommunication needs in rural areas in the global South. A key finding from Lamm et al. (2019) was that international extension networks have a unique set of needs and criteria, precipitating a need for the development of ICT systems and processes most appropriate for the clientele of the specific network.

A logical next step for ICT capacity building within international extension would be to develop a scale for capacity assessment. A framework and methodological recommendations directly addressing identified needs for international agricultural development would benefit practitioners and researchers in international extension networks (Lamm et al., 2018). Building on previous findings, this article introduces a scale to promote reliable data collection for ICT capacity evaluation in international extension networks.

Conceptual Framework

Although ICTs can be leveraged to ensure information sharing, many barriers to adoption exist, including lack of effective communication-intermediation tasks required for ICT use, underestimation of network member roles and capacity for innovation, and lack of network support and communication for implementing knowledge obtained from ICTs (Sulaiman et al., 2012). To provide a framework for scale development, several ICT network capacities were examined: (1) ICT access, (2) ICT use, and (3) context in relation to Roger's (2003) diffusion of innovation theory.

ICT access for international extension networks includes network ability to support use and respond to access issues (Lamm et al., 2019). ICTs increase access to information and financial services, link buyers and sellers, and facilitate agricultural data collection (Aker et al., 2016). However, ICT initiatives vary in the institutional support, information, and services provided. Extension personnel are aware of the potential to engage with farmers via ICTs but lack the necessary policy support and network administration to increase adoption and use (Narine et al., 2019b). ICT capacity development needs include financial, technological, and administrative support (Narine et al., 2019b; Taylor, 2015). Historically, ICTs have not been accessible to all (Aker & Mbiti, 2010). Challenges to widespread access include issues of trust, information quality, resource and geographical limitations, gender, social class, and ethnicity, (Aker et al., 2016; Taylor, 2015). While ICT-based services may increase market efficiency and productivity, the disparities between those with access may exacerbate resource distribution issues (Blumenstock & Eagle, 2012). ICTs should be accessible to all network members (Lamm et al., 2019); however, different regions have unique contexts, which must be considered to ensure ICT diffusion and adoption does not accelerate inequality among network members.

ICT use refers to an extension network's perception of ICTs, promotion of ICT use, and active use of ICTs (Lamm et al., 2019). Extension network members should understand the advantages associated with ICTs and receive proper training for ICT use (Narine et al., 2019b; Taylor, 2015). Therefore, network support of ICTs is critical in facilitating social acceptance of new technologies (Lamm et al., 2019; Narine et al., 2019b). Several studies have demonstrated how limited perceptions of peer and administrative support impedes use of ICTs by extension personnel (see Ganpat & de Frietas, 2010; Narine et al., 2019b; Strong et al., 2014). Network support can occur directly or indirectly through policies and managerial support (Narine et al., 2019b; Rogers, 2003). Member training and network support can impact member attitudes toward ICT tools and influence the success of ICT adoption (Lamm et al., 2019).

Context refers to network support of multiple channels for information exchange, idea sharing, and communication (Lamm et al. 2019). A shift from the traditional view of farmers as passive recipients of knowledge toward interactive, two-way communication between extension officers and farmers allows for the incorporation of farmers' opinions, experiences, and knowledge into these messages. This collaboration is necessary for the current global landscape (Masambuka-Kanchewa et al., 2020) and requires network members to transition from technology promoters to dialogue facilitators (Abdu-Raheem & Worth, 2016; Masambuka-Kanchewa et al., 2020; Masangano et al., 2017). Many ICT initiatives fail to increase knowledge share among farmers, which affects an extension networks' ability to receive feedback and local knowledge (Hudson et al., 2017; Masambuka-Kanchewa et al., 2020). Emerging user-driven

ICTs (e.g., blogs, Twitter, and Facebook) may be leveraged to overcome existing challenges (Sulaiman et al., 2012). Increased investment in ICTs may also enhance dissemination of agricultural information (Ajani, 2014; Masambuka-Kanchewa et al., 2020; Okediran et al., 2018). Governments and business networks represent two entities that can support ICT adoption and develop policies favorable to ICT use and adoption (Narine et al., 2019b; Taylor, 2015).

Diffusion of Innovations

Extension networks are critical in information and innovation dissemination (Gido et al., 2015; Kibet, 2011). Rogers' (2003) diffusion of innovations (DOI) theory notes how innovations are "communicated through certain channels over time among the members of a social system" (p. 5). The five characteristics of an innovation include relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). Additionally, individuals follow stages of the innovation-decision process before deciding whether to adopt an innovation (Rogers, 2003). These stages, along with innovation characteristics, individual adopter characteristics, organizational structure, and external factors, influence network innovativeness and technological adoption (Rogers, 2003; Taylor, 2015). Communication messages and strategies for agricultural innovations should be tailored to the needs of extension personnel and their clients (Moyo & Salawu, 2017).

Historically, DOI has been the primary model for agricultural extension and development. Therefore, the theory provides a viable framework for studying ICTs within international extension networks through innovations, adoption-decision processes, and interpersonal contexts (Taylor, 2015). However, the theory is not amenable to examining the complex social and relational dimensions that affect ICT adoption (Taylor, 2015). The traditional one-way method of information diffusion may not improve agricultural productivity, due to the exclusion of local farmer knowledge, skills, and resources (Masambuka-Kanchewa et al., 2020). The diffusion of local and indigenous innovations and knowledge, along with traditionally scientific technologies, is critical to ICT development appropriate for local needs. Considering the environmental and social contexts in ICT capacity, conducting a capacity assessment may increase the success of extension efforts (Taylor, 2015).

Scale Development

Considering the framework of DOI theory, developing a scale for ICT capacity assessment within international extension networks allows stakeholders to determine the local needs and directions of ICT development situated within the characteristics of an innovation, the innovation-decision process, and the environmental and social contexts of the surrounding area. These considerations are critical due to the gap between theory and practice for ICT development (Sulaiman et al., 2012). Multi-strategy approaches and stakeholder analysis may increase the adoption and productivity of agricultural-related ICT use (Sulaiman et al., 2012). Through a Delphi approach (Lamm et al. 2019) and the development of a standardized instrument for capacity assessment within multiple international extension network settings (Girard & Girard, 2015; Lamm et al., 2020), the current framework provides a robust foundation for assessing the content validity for an ICT capacity instrument.

Purpose and Objective

The purpose of this study was to develop and validate an empirical instrument which could be used to measure perceived ICT capacity of international extension networks. The objective of the study was to establish content validity, response process validity, internal structure validity, and consequential validity of the proposed instrument.

Methods

The data included for this research were collected as part of a global extension network capacity assessment project completed on behalf of Global Forum for Rural Advisory Services. The project included the measurement of network capacities across a range of focus areas, ICT use being one of them. The current study focuses on ICT use with the purpose of developing and validating an instrument that quantifies ICT use capacity in extension networks. Data were also collected from the same set of respondents regarding a variety of other network characteristics. This disclosure is made to provide clarity regarding multiple publications from a common dataset (Kirkman & Chen, 2011).

The data were collected from a purposive convenience sample from representatives from diverse extension networks around the globe. Specifically, the population examined in this study consisted of the extension network leaders (e.g. Secretariat members and staff) and board members of nine extension networks including: regional (4), sub-regional (1), and country-level (4) networks. Participating networks included the African Forum for Agricultural Advisory Services, the Caribbean Agricultural Extension Providers Network, the Pacific Islands Rural Advisory Services, the Latin American Network for Rural Extension Services, the West and Central Africa Network for Agricultural and Rural Advisory Services, the Kenya Forum for Agricultural Advisory Services, the Malawi Forum for Agricultural Advisory Services, the Nigerian Forum for Agricultural Advisory Services, and the Uganda Forum for Agricultural Advisory Services.

Instrument Development

A series of researcher-developed ICT items were included in the scale to measure the hypothesized factors of ICT use within extension networks. Items were primarily based on the results of the previous Delphi analysis conducted by Lamm et al. (2019). Additionally, the items were informed by an extensive review of the relevant literature. The results of the previous Delphi research and literature review resulted in 25 total items with hypothesized loadings on seven ICT factors. The hypothesized factors were generally framed within Rogers' (2003) proposed factors influencing the adoption of an innovation, specifically: 1) how the network addresses ICT access issues (complexity), 2) whether the network has a positive perception of ICT use (relative advantage), 3) network member usage of ICT tools (trialability), 4) network support for ICT use (compatibility), 5) ICT use promotion by the network (observability), 6) network support for multiple channels of information exchange, idea sharing, and communication (compatibility), and 7) performance for ICT use (relative advantage). Item responses were rated on a four-point, Likert-type scale with possible responses (*1 = little to no capacity, 2 = some capacity, but very limited, 3 = good capacity, but could still be improved, 4 = exceptional capacity, no need for improvement*). Respondents could also rate an item as *N/A = not applicable or no knowledge* if they had no knowledge of the item.

Data Collection

The data were collected in two phases between June 2016 and December 2016 using a combination of surveys administered in person and online. The in-person data collection served as a pilot for instrument. Using a paper-based instrument, 12 were obtained from African Forum for Agricultural Advisory Services secretariat members, 16 from Kenya Forum for Agricultural Advisory Services members, and five from Latin American Network for Rural Extension Services members.

After the pilot test confirmed face validity of the instrument, data were collected online using the using Qualtrics following the Tailored Design Method (Dillman et al., 2014). Prior to the beginning of the process, a pre-notice message was sent to those invited to participate by their respective regional or country contact person or champion. Approximately two days later, an invitation to complete the survey was sent to all potential respondents. Additionally, invited respondents received a series of at least three reminder messages which were sent every three to five days until the closing of the survey.

Between the pilot, and primary online data collection, 128 individuals were invited to participate in the survey. Completed survey were received from 122 individuals resulting in a 95% response rate. Due to incomplete responses, individual items or indices may have lower response rates.

Instrument Validity

Several methods were implemented to establish scale validity (Crocker & Algina, 1986; Messick, 1995; Lamm et al., 2020). Specifically, 1) content validity, 2) response process validity, 3) internal structure validity, and 4) consequential validity were examined.

Content Validity

To establish content validity, a thorough review of the literature was conducted prior to and during the development of the individual scales. Additionally, the majority of the proposed items were directly associated with previous research specifically identifying the capacities necessary for extension networks to effectively use ICTs. Once a final list of proposed items was developed, a panel of experts reviewed the instrument to establish content validity. The experts represented expertise in international extension, evaluation, and scale development and had role titles such as Professor, Executive Secretary, and Program Manager. Experts were located in either the United States or Europe; however, all experts had direct experience working with extension networks around the globe.

Response Process Validity

Response process validity was established during in person data collection as a part of the pilot phase. Following completion of the survey, a series of focus group debriefs were held with each set of participants to gauge insights and obtain feedback concerning the survey. There was consensus among focus group participants across the three locations that the pilot survey was too long. In addition to assessing the ICT capacity within extension networks, the pilot survey also assessed additional extension capacity foci. Nevertheless, the overall feedback regarding the ICT survey confirmed the content and items within the instrument were appropriate and understandable amongst intended respondents. Minor wording updates were made to individual items following the focus group feedback, additionally a *N/A-Not applicable or no knowledge* option was added, which allowed respondents to appropriately rate an item for which they had no knowledge. Overall, the intent of the items remained consistent from the pilot version to the final version of the survey. Therefore, to increase the statistical power available for analysis, the data obtained during the pilot administration was included in the overall dataset.

Internal Structure Validity

To establish internal structure validity a series of analyses were undertaken as recommended in the literature (e.g. Lamm et al., 2020). First, descriptive statistics, including response frequency counts, skewness, and kurtosis, were calculated for each proposed item in the scale. The individual item analysis was completed to evaluate item normality and to screen for potential outliers. All 25 items were observed to have acceptable response distributions with observed skewness values ranging from -.620 to +1.142 and observed kurtosis values ranging from -.654 to +3.236. These values were deemed to be acceptable given existing thresholds (see Fabrigar et al., 1999; West et al., 1995).

Next, an exploratory factor analysis (EFA) was performed to examine the nature of the observed data within the factors and determine the factor structure of the aggregate scale and individual factors. The EFA was conducted to first determine the factor structure of the instrument relative to the hypothesized structure. Several criteria were used to determine the appropriateness of factor analysis for the proposed ICT use scale. First, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was examined. Values greater than or equal to 0.500 were deemed acceptable according to established thresholds and indicated suitability for factor analysis (Kaiser, 1974). Second, Bartlett's test of sphericity was performed to examine whether the items within the instrument were related and warranted factor analysis. A chi-squared value was determined to be statistically significant if the associated *p*-value was less than .01, indicating further analysis was warranted (Dziuban & Shirkely, 1974). The Kaiser criterion, which recommends an eigenvalue threshold of 1.0, was employed to determine the number of factors retained after factor analysis (Kaiser, 1974). Additionally, Cattell's (1966) scree test was conducted to identify potential factors. Both unrotated and rotated models were analyzed. Specifically, a varimax rotation was completed to aid in the identification of extracted factors as "[Varimax] Factor scores generated for each individual are also more interpretable because the explained variances among the factors do not overlap and are therefore independent of each other" (Pett et al., 2003, p. 143).

Factor loadings with an absolute value greater than 0.500 were retained. Based on the Furthermore, any items which loaded onto multiple factors were removed to avoid issues with cross-loading across factors, and improve parsimoniousness of the proposed scale. Although there were seven hypothesized factors, the results of the EFA extracted six latent variables. Therefore, the subsequent validation and analysis was conducted on the six extracted latent variables, not the hypothesized seven.

Following the EFA, the extracted factors were analyzed using descriptive statistics including: means, standard deviations, skewness, and kurtosis. Additionally, the Cronbach's alpha coefficient was calculated for each factor to measure internal consistency and further establish internal structure validity. All data were analysed using SPSS v26.

Consequential Validity

In April 2017, a follow-up survey was distributed to extension network leadership who participated in the study to evaluate the proposed ICT instrument and establish consequential validity. Respondents were asked to provide their input regarding the overall ICT data, not factor level details. Of the 15 potential respondents, 14 elected to complete the survey resulting in a 93% response rate. Consequential validity was established through two main areas: the usefulness of the ICT information, and whether respondents intended to use ICT information to modify their networks. Respondents were asked to indicate their agreement with the two questions using a five-point Likert-type scale (*1 – strongly disagree*, *2 – disagree*, *3 – neither agree nor disagree*, *4 – agree*, and *5 – strongly agree*).

Results

Overall Instrument Exploratory Factor Analysis

Following the EFA, six factors were extracted accounting for 70.558% of the total variance. As recommended in the literature (see Pett et al., 2003) a table of extracted factors of the unrotated and rotated models are presented in Table 1. All subsequent results are presented based on the rotated analysis.

Table 1
Total Variance Explained by the Six Extracted Factors of the ICT Scale

Factor	Initial Eigenvalues			Extracted Rotated Sums of Squared Loadings		
	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	9.807	39.228	39.228	3.646	14.583	14.583
2	2.285	9.142	48.370	3.504	14.017	28.600
3	1.816	7.264	55.634	3.471	13.884	42.484
4	1.421	5.683	61.317	2.887	11.549	54.033
5	1.263	5.051	66.368	2.100	8.401	62.434
6	1.048	4.191	70.558	2.031	8.124	70.558

An EFA was conducted on the aggregate ICT scale consisting of 25 items. The resulting factor structure of the scale is displayed in Table 2. The KMO value associated with the aggregate ICT scale was 0.790 and the Bartlett's test statistic was significant (χ^2 = 1264.984, $p <$ .00), which indicated factor analysis was justified. Following the EFA of the aggregate scale, the underlying structure of the aggregate ICT scale was found to be different than the hypothesized structure that seven latent variables would emerge. The items in the aggregate scale loaded onto only six factors. There were two items which were dropped based on cross-loadings, and one item which did not meet the minimum loading threshold of 0.500. Based on the structure of the aggregate scale, six new ICT factors were proposed and additional analysis on each conducted. New factor names were created based on the nature of the items associated with the extracted factors, including: Factor 1 - network integration of ICTs, Factor 2 - ICT accessibility, Factor 3 - network use and support of ICTs, Factor 4 – ICT logistics, Factor 5 - network promotion of ICTs, and Factor 6 - network perception of ICTs.

Table 2
Exploratory Factor Analysis of Aggregate ICT Scale

Scale Items	Factors 1	2	3	4	5	6
Information and communication technologies are used as a way to leverage partnerships (ICT16)	0.825					
Information and communication technologies are used to enhance networking (ICT17)	0.761					
Systems are in place to help select appropriate information and	0.736					

communication technology tools (ICT14)					
The network integrates information and communication technology into reaching the larger objectives of the network (ICT13)	0.656				
Network members have the communication skills needed to use information and communication technology tools (ICT09)		0.728			
Network officers are able to source information (ICT11)		0.725			
Evidence of information and communication technology literacy amongst RAS professionals is available (ICT08)		0.626			
Information and communication technology tools are used to disseminate information (ICT15)		0.591			
Information and communication technologies are accessible by clientele (ICT02)		0.556			
The network provides an effective platform for asynchronous online opportunities (ICT20)			0.794		
The network provides an effective platform for synchronous online opportunities (ICT19)			0.775		
The network establishes and uses virtual networks (ICT21)			0.707		
The network communicates via distance (ICT01)			0.652		
Processes are in place to reach individuals without internet access (ICT03)				0.637	
The network uses information communication technology tools effectively (ICT24)				0.637	
Sufficient funding to support information communication technologies activities is present (ICT23)				0.606	
Information communication technology tools are used to benefit clientele (ICT25)				0.592	
Success stories about using information and communication technology tools are shared within the network (ICT18)					0.769

The network provides sources of information that are adaptable for different users (ICT04)					0.656	
RAS professionals trust the information systems in use (ICT06)						0.871
Information and communication technology tools are seen as user-friendly (ICT07)						0.817
The network has a positive attitude towards information and communication technology tools (ICT05)						0.581
*Network officers have access to information and communication technology information (ICT12)		0.638		0.512		
*The network uses social media (ICT22)	0.500		0.677			
**The network uses information and communication technology tools to link stakeholders to RAS professionals (ICT10)						

Note: Principal Component Factors. Blanks represent absolute loading values < 0.500. Item identifiers in parentheses. RAS – Rural Advisory Service. * - Cross loaded item, ** - Item failed to reach minimum threshold for factor loading.

Descriptive and Internal Consistency Analysis

The descriptive statistics and measures of internal consistency for the six factors that emerged and an overall ICT index scale score are displayed in Table 3. For each factor subscale and the overall index scale, skewness values were less than two and kurtosis values were less than seven. Based on established thresholds (see Fabrigar et al., 1999; West et al., 1995; Lamm et al., 2020), the results indicated an acceptable internal structure validity. For the overall instrument and the factor subscales for factors one, two, three, four, and five, Cronbach's alpha coefficient was greater than 0.70, indicating acceptable internal consistency given established thresholds (see Cortina, 1993; Schmitt, 1996; Streiner, 2003). The network perception of ICTs subscale had an alpha coefficient less than 0.700; however, the observed value of 0.698 was deemed acceptable for further analysis following recommendations within the literature regarding exploratory analysis (DeVellis, 2017).

Table 3

ICT Scales: Descriptive Statistics and Scale Reliability

Factor	*N*	*M*	*SD*	Skewness	Kurtosis	Cronbach's α
Integration of ICTs	105	2.648	0.596	-0.012	-0.183	0.859
ICT accessibility	103	2.676	0.532	-0.08	-0.182	0.818
Use and support of ICTs	102	2.735	0.661	-0.326	-0.092	0.849
ICT logistics	91	2.324	0.602	0.156	-0.256	0.808
Promotion of ICTs	104	2.337	0.702	-0.041	0.019	0.704
Perception of ICTs	112	2.958	0.590	0.074	-0.111	0.698
Overall	76	2.574	0.449	0.082	0.136	0.915

The correlations between the ICT factors and the overall index scale are displayed in Table 4. Each of the factors and the index scale were statistically significantly correlated with one another ($p < .05$), indicating content coherence.

Table 4
Correlation Matrix of ICT Scales

Scale	1	2	3	4	5	6	7
1. Integration of ICTs	-						
2. ICT accessibility	.648**	-					
3. Use and support of ICTs	.553**	.515**	-				
4. ICT logistics	.620**	.492**	.663**	-			
5. Promotion of ICTs	.548**	.626**	.540**	.631**	-		
6. Perception of ICTs	.252*	.377**	.246*	.271*	.400**	-	
7. Overall	.773**	.798**	.756**	.833**	.770**	.464**	-

*$p < .05$, ** $p < .01$

Extracted Factor Exploratory Factor Analysis

The first extracted ICT factor was comprised of four items. Based on the nature of the items associated with the factor, the factor was named *Network Integration of ITCs*. Among the seven items there were two which cross-loaded on a second extracted factor. The EFA extracted one factor which accounted for 70.8% of the total variance and was associated with an eigenvalue of 2.833. The KMO value was 0.772 and the Bartlett's test yielded significant results (χ^2 = 202.583, $p < .010$), thereby indicating further factor analysis was warranted.

The second extracted ICT factor consisted of five items. Based on the nature of the items, the factor was named, *ICT Accessibility*. The subsequent EFA of the five items resulted in one extracted factor, which accounted for 58.5% of the total variance. The extracted factor was associated with an eigenvalue of 2.926. The KMO value was 0.793 and Bartlett's test yielded significant results (χ^2 = 172.825, $p < .010$). Both values indicated further factor analysis was warranted.

The third extracted ICT factor was comprised of five items. The factor was named, *Network Use and Support of ICTs*, based on the items retained. One factor was extracted following the EFA, which accounted for 69.1% of the total variance and was associated with an eigenvalue of 2.765. The KMO value was 0.791 and the Bartlett's test yielded significant results (χ^2 = 172.252, $p < .010$), justifying further factor analysis.

The fourth extracted factor consisted of four items and was named *ICT Logistics*. The EFA resulted in one extracted factor, which accounted for 64.2% of the total variance and was associated with an eigenvalue of 2.566. The KMO value was 0.700 and Bartlett's test yielded significant results (χ^2 = 148.473, $p < .010$), indicating further factor analysis was warranted.

The fifth extracted ICT factor consisted of two items and was named *Network Promotion of ICTs* based on the included items. The EFA resulted in one extracted factor which accounted for 77.3% of the total variance and was associated with an eigenvalue of 1.546. The KMO value was 0.500 and Bartlett's test yielded significant results (χ^2 = 35.964, $p < .010$), which both justified further factor analysis.

The sixth extracted ICT factor consisted of three items and was named *Network Perception of ICTs* based on the included items. The EFA resulted in one extracted factor which accounted for 62.4% of the total variance and was associated with an eigenvalue of 1.871. The KMO value was 0.622 and Bartlett's test yielded significant results (χ^2 = 64.799, p < .010), which both justified further factor analysis.

Consequential Validity

Of the 14 respondents, 100% indicated the overall ICT information was useful or very useful. Additionally, intent to use the overall ICT information had a high mean score (*M* = 4.42, *SD* = 0.65), indicating an intention to use the information received in the capacity assessment to modify their extension networks. These results were used to establish consequently validity of the ICT information.

Conclusions, Implications, and Recommendations

The purpose of this study was to develop and validate an empirical instrument which quantified perceptions of ICT use capacity in extension networks. The purpose was accomplished by verifying the instrument's content validity, response process validity, internal structure validity, and consequential validity. An initial hypothesis indicating the 25 items of the aggregate ICT scale would load onto seven latent variables framed with Rogers' (2003) DOI theory: 1) how the network addresses ICT access issues (complexity), 2) whether the network has a positive perception of ICT use (relative advantage), 3) network member usage of ICT tools (trialability), 4) network support for ICT use (compatibility), 5) ICT use promotion by the network (observability), 6) network support for multiple channels of information exchange, idea sharing, and communication (compatibility), and 7) performance for ICT use (relative advantage). The results of the EFA revealed the 22 retained items loaded onto six latent variables, not seven. Therefore, the underlying factor structure was different than hypothesized, prompting the proposal of six new factor subscales. These subscales measured: 1) network integration of ICTs (compatibility), 2) ICT accessibility (complexity), 3) network use and support of ICTs (observability and complexity), 4) ICT logistics (compatibility), 5) network promotion of ICTs (trialability), and 6) network perception of ICTs (relative advantage).

The disparities between the hypothesized factor structure and the resulting factor structure suggest the distinctions between the network addressing ICT access issues, network member use of ICT tools, network support of ICT use, and network promotion of ICT use are not as rigid as previously hypothesized. For example, the newly proposed subscale measuring network integration of ICTs contained items originally hypothesized to belong to the *network can support ICT use* and *network promotes ICT use* factors. Additionally, the newly proposed network promotion factor included items originally hypothesized to belong to factors measuring the network addressing of ICT access issues, network member use of ICTs, and network promotion of ICT use. The only subscale that remained the same as originally hypothesized was the one measuring network perception of ICT use. However, the name was updated from *Network has a positive perception of ICT use* to *Network perception of ICT use* to be more inclusive of potential negative perceptions.

During the instrument construction process the hypothesized factors were framed within the main characteristics affecting adoption of an innovation (Rogers, 2003). The results were somewhat unexpected when fewer factors emerged, and within the factors multiple influences for adoption (Rogers, 2003) appeared to co-exist within one of the extracted factors. Specifically, network use and support of ICTs was associated with both observability and complexity. The remaining five extracted factors generally aligned with expectations. Nevertheless, the results indicated opportunities for additional analysis. The study should be replicated with a new population to see whether similar results are observed. Additionally, a recommendation would be to examine other items which may contribute to the network promotion of ICTs factor. Although the factor was observed to have satisfactory internal structure validity characteristics, adding additional items beyond the existing two may make the factor more robust for analysis.

Although the compositions of the proposed factors are different than initially hypothesized, they underscore the importance of access to ICTs and network use, promotion, integration, and perception of ICTs. Equitable access to ICTs is imperative as disparities in access can magnify resource distribution issues (Aker et al., 2016; Blumenstock & Eagle, 2012). Having accessible ICTs was identified as an important need for ICT capacity development (Lamm et al., 2019). In addition to access, promotion of ICT use is imperative because individuals with positive perceptions of ICTs were more likely to adopt them (Narine et al., 2019b).

Based on the findings, ICT adoption should be encouraged using a top-down approach where network administrators and officers promote ICT use and integrate ICT use into daily extension operations, increasing both observability and demonstrating relative advantage (Rogers, 2003). To facilitate social acceptance, extension network members and administration must be willing to promote ICT use (Narine et al., 2019b) and demonstrate compatibility with existing approaches (Rogers, 2003). If network administrators adopt ICTs, they can model social acceptance of new technologies and encourage network officers to do the same, increasing and promoting trialability (Rogers, 2003). Similarly, extension network officers can model acceptance and user-friendliness of ICTs, while addressing and resolving logistical issues, to extension network members and clientele, minimizing perceptions of complexity (Rogers, 2003). These actions should help to promote favorable perceptions regarding ICT use (Rogers, 2003).

Since data were only collected in international extension settings located in the global South (i.e., Africa, Latin America, the Caribbean, and the Pacific Islands), there is limited generalizability of results. Therefore, future studies should be conducted with larger, diverse samples to improve scale robustness and inform additional insights to ICT use capacity assessments of international extension networks. In addition, confirmatory factor analyses (CFA) should be conducted on the aggregate ICT scale and the proposed factors to confirm the construct structure. A larger sample would provide the power necessary to complete a CFA and would be strongly recommended. A further recommendation would be to replicate the EFA analysis with a larger data set, the varimax rotation procedure is dependent on sample size, therefore a more robust sample may provide further insights and potential validation. Additionally, it must be acknowledged for the consequential validity and intended use of the scale to be upheld that the instrument measures perceptions of ICT use capacity not objective ICT use capacity. An associated recommendation would be to consider extending the scope of the proposed scale to include not only perception data, but objective ICT use capacity data as well.

Along with practical and research implications, specific policy implications can be drawn from the findings. Rogers (2003) found that relative advantage, compatibility, and complexity characteristics of an innovation had greater effects on overall adoption than trialability and observability. Therefore, international extension networks should emphasize the benefits of a technology, consistency with cultural values, and user-friendliness when focusing on adoption of ICTs (Lamm et al., 2019). For example, Narine et al. (2019b) found extension officers were more likely to adopt SMS messaging when they had favorable perceptions of complexity, relative advantage, and trialability. The emergence of factors associated with ICT accessibility and network use and support of ICTs undergird this recommendation.

Following findings outlined in Lamm et al. (2019), international extension networks should coordinate with their national and global organizations to share strategies of adoption. Extension networks should prioritize sharing strategies which emphasize the ease of use associated with ICTs as well as the benefits of using ICTs over alternative communication methods (e.g. speed and cost). Both Lamm et al. (2019) and Narine et al. (2019b) found a lack in policies encouraging ICT adoption and a need for administrative support of ICT. Therefore, the leadership of international extension networks should encourage local governments to develop policy supportive of adoption and use of ICTs.

ICTs provide a powerful entry point for the harmonization of information availability within extension networks (Asenso-Okyere & Mekonnen 2012); however, the implementation and use of ICTs should be done with a deft touch and with sufficient care and planning. As Rogers (2003) has found, implementing technological innovations without adequate preparation, can produce undesirable results. The use of a consistent, valid instrument to support such endeavors should provide a common lexicon and understanding to help facilitate the adoption and perception of ICTs within international extension networks.

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