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# IDIA2020

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# Message from the Conference Chairs

Dear colleagues and friends,

Welcome to proceedings of the 11th International Development Informatics Association (IDIA2020) conference which took place from the 25 - 27 March 2020. It was organized by the United Nations University institute in Macau SAR – China.

IDIA2020 was organized under the theme "The more things change ..." As the adage goes, "The more things change, the more they stay the same." Could the same be said of Information and Communication Technologies for Development (ICT4D)? To what extent has ICT4D over the years changed and/or not changed the global landscape of poverty and sustainable development? Have outcomes been positive, negative or mixed? Do strategies and interventions build in lessons from the past? What is the net contribution of ICT4D to the global development agenda?

Some would argue that technology has not altered the fundamental poverties and inequalities around the world – that despite the millions of dollars invested, social and economic inequalities remain too high. Furthermore, each new technology ascribed with "new promise" for the poor and marginalized of the world ends up unleashing new types and levels of disempowerment and unfreedoms: from increased invasion of privacy to the concentration of power and privilege in the hands of the few.

On the other hand, advocates point out that technology is having a substantial positive impact on the lives of many: FinTech has improved access to finance systems; social networking platforms are connecting people better; the data revolution is improving and enhancing monitoring and evaluation of the sustainable development goals; gig economy platforms are leveling the field and improving access to the labor market.

A third perspective contends that the answers are not so clear cut, arguing that ICT4D presents a reductionist view of the world, resulting in a tendency to oversimplify the pathways to impact of technology on the wicked and messy problems of human development. What are the underlying rationales for these differing viewpoints? How has ICT4D as a field and discipline changed over the years? And what changes are necessary for the field to meet the current and future demands presented by this evolving technology and society confluence?

Since its inception in 2006, IDIA has sought to create a space and a forum for researchers and practitioners to connect and exchange knowledge on issues of information and communication technologies for development (ICT4D) not only in, but also for and by the Global South.

The conference occurred over a period of three days consisting of workshops on the first day, and full paper presentations on the second and third days. We had the pleasure of having Prof. Payal Arora deliver the keynote presentation, titled "Privacy by design for the next Billion", at IDIA2020. Prof. Arora is a digital anthropologist and author, consultant, founder, editor, and professor at Erasmus University Rotterdam. She holds the Chair in Technology, Values, and Global Media Cultures.

IDIA2020 occurs at a challenging time globally with the COVID-19 coronavirus epidemic. While this affected the organization of the conference, we believe it also provided an opportunity to leverage the tools of our trade for a successful conference and to expand the reach of IDIA2020 to further participants.

We are grateful to the organizing committee, the technical program committee, the authors, participants, the host institution, and sponsors for supporting IDIA2020.

Sincerely,

Hannah and Mamello Thinyane  
IDIA2020 Chairs

# Message from the Proceedings Chairs

The IDIA conference has established itself as one of the premiere conferences focusing on research in the use of ICT for developing economies and societies (ICTD/ ICT4D). It distinguishes itself by being “of the South, by the South, and for the South” representing voices from scholars and practitioners from the Global South. This year’s edition of IDIA follows this strong tradition of showcasing scholarship that are relevant to issues in the Global South. The papers selected in the conference highlight the latest discourse on ICTD/ ICT4D through the lens of different scholars and practitioners and we invite you to critically engage in their scholarship in this proceedings volume.

IDIA2020 follows the precedent set in IDIA2018 of having a dual system of issuing both a Springer Proceedings (to be published under the Communication in Computer and Information Science (CCIS) volume) and a more inclusive Conference Proceedings in keeping with IDIA’s developmental spirit. CCIS is indexed in DBLP, Google Scholar, EI-Compendex, Mathematical Reviews, SCImago, Scopus. CCIS volumes are also submitted for the inclusion in ISI Proceedings. The Conference Proceedings will be published by the United Nations University and will have the benefit of being accessed by both academics and policy makers.

IDIA2020 received 43 paper submissions from more than 10 countries across five continents. These papers underwent a double-blind peer review by at least three members of our technical program committee- which consists of international ICTD/ ICT4D experts. Members of the technical program committee provided comprehensive reviews and authors had to submit updated versions of their submission before final decisions were made about the paper’s acceptance. Meta reviewers or senior reviewers were also assigned to consolidate reviews on specific papers in cases where there were notable discrepancies between the reports of the different reviewers. After this rigorous review process, there were 19 full papers for presentation in the conference and inclusion in the conference proceedings. Of the 19 full papers, 14 were included in the Springer CCIS Proceedings and an additional 5 papers for the IDIA Conference Proceedings representing an overall acceptance rate of 44% and an acceptance rate of 33% for the Springer volume. This volume contains the 5 papers accepted for the UNU Conference Proceedings as well as the titles and abstracts of the papers selected for the Springer volume.

We would like to thank our reviewers, authors, and other conference participants who made IDIA2020 a success.

Don Rodney Junio and Cecile Koopman  
IDIA2020 Proceedings Chairs

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Papers Accepted for the  
UNU Conference  
Proceedings

# Capability Approach-Based Research Models for Empirical ICT4D Research: Review and Use Guidance

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**Abstract:** ICT4D researchers believe ICTs to be a potential path to social and economic development. One of their key concerns is a human-centred approach for measuring the impact of ICT4D. Amartya Sen's Capability Approach is a popular approach because it moves beyond the dominant economic growth perspective by focusing on individuals, namely: what they value, and what they are able to choose. This study, through a systematic literature review, examines how researchers have applied and operationalized the capability approach in ICT4D studies through derivative conceptual approaches. Fifteen different theories or frameworks were uncovered and are discussed. The aim of this paper is to give guidance to prospective and current researchers or practitioners, looking for proven ways to guide ICT4D engagement using the capability approach.

**Keywords:** ICT4D; capability approach; systematic literature review; human development.

## 1. Introduction

Information and communication technology for development (ICT4D) is built on the premise that information and communication technologies (ICTs) potentially offer socioeconomic improvements to developing communities [1]. Some ICT4D scholars challenge the traditional development discourse, which measures development only in terms of economics [2]. Amartya Sen's capability approach is one such alternative of measuring development; it places the human at the centre and considers development in a holistic manner, not just in terms of economic growth [1].

International agencies, national governments, and other global institutions such as the World Bank make large investments into development initiatives, including ICT4D projects [3]. Annually, significant amounts of money are invested in ICT4D projects with the belief that ICTs will improve the quality of life of poor people [4]. Yet, the impact of these initiatives is not clear. Impact assessment in ICT4D has been highlighted as important in the ICT4D value chain [1], and it is important to assess whether the investments are yielding the intended developmental outcomes. To this

end, the capability approach is a powerful approach that could be used for assessing the impact of ICT4D [5]. This approach places the human (instead of the ICT) at the centre of the assessment, and moves away from the mainstream economic growth perspective of development by foregrounding an individual's well-being and agency. However, the capability approach does not have set of measurable variables, which makes it methodologically vague [6] and difficult to understand and use practically [3].

Attempts have been made by numerous scholars to operationalise the capability approach to make it more accessible to those who value its concepts and wish to use it in their studies [5]. However, the capability approach is not used in a consistent way in the field of ICT4D. Newcomers to the ICT4D field that are required to make use of the capability approach may find this approach difficult and confusing. Further, seasoned researchers in the field may still need guidance on how to use the capability approach, especially when choosing one of the capability-inspired derivative frameworks. Thus, a need exists to investigate how the capability approach has been used in previous research studies, and which theories/frameworks adopt a capabilities approach, to guide its use by ICT4D researchers without experience in the usage of the capability approach.

Through a systematic literature review this paper seeks to answer the following questions:

- To what extent is the capability approach being used in published ICT4D research?
- Which theories and frameworks have been inspired by, or are based on, the capability approach, in order to operationalise it for empirical research?
- What was the context for these theories i.e. in which fields or topic areas where these theories developed and applied?
- Based on these application areas, which capability theories should a prospective ICT4D researcher investigate for potential adoption in their own research project?

This paper is targeted towards stakeholders in the ICT4D research community who are concerned with impact that goes beyond economic development. The paper would also be of interest to emerging researchers looking for a suitable research framework for the capability-based approach. Furthermore, senior researchers and supervisors seeking to guide their post-graduate students when adopting or selecting an appropriate framework can also benefit from this paper. Finally, any researcher involved in conceptual research and with an interest in the capability approach would find this paper useful for further development or customizing one of the existing capability-based frameworks, to develop a more contextualized or indigenous theory.

In seeking to address the above-mentioned research questions, this paper is structured as follows: Firstly, the capability approach is reiterated briefly. This is followed by an outline of the research methodology that was adopted for this systematic literature review, and an analysis of the articles that presented new research frameworks and theories based on the capabilities approach is then provided. The paper concludes

with a presentation of a topic area-based guideline for shortlisting suitable capability approach-based frameworks in ICT4D.

## 2. Sen's Capability Approach

The capability approach has become increasingly popular in practice and policy making [7]. It is said to be one of the most influential development theories [8]. Amartya Sen is an economist and philosopher who pioneered the capability approach as it is known today; however, some aspects of this approach were influenced by Aristotle, Adam Smith, and Karl Marx [9]. The capability approach has been utilised in various fields, predominantly in studies concerned with development, social policy, welfare economics, and political philosophy [10]. Its evaluation of wellbeing not only focuses on individuals, but also on the wellbeing of a group.

Unlike other approaches in philosophy that are concerned with consumption, income, or the happiness of individuals and their desire-fulfilment, the capability approach focuses on what an individual is able to do and be, which are referred to as capabilities [10]. This approach also offers a way of conceptualising development not as economic growth, but as individual freedom [8]. "Freedom", as Sen [9] broadly describes it, refers to the opportunities that one has to live the life he/she values. This is the main concern of the capability approach [11].

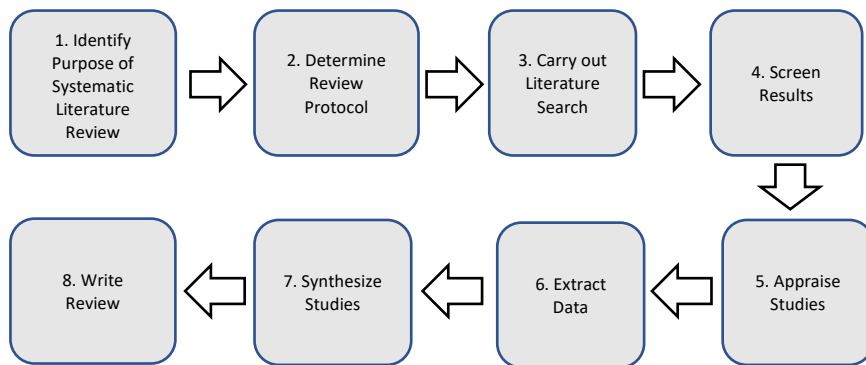
The capability approach considers poverty as the deprivation of freedom to make choices rather than as low income. The focus of the capability approach is on ends rather than means, and the local context as well as the process for development are highlighted as important variables [12, 13].

The capability approach consists of two main concepts, namely "functionings" and "capabilities". Functionings are the "beings and doings" of a person, while "a person's capabilities entail the various functionings available for them to achieve" [11]. Sen [14] differentiates between functionings and capabilities by saying: "*A functioning is an achievement, whereas a capability is the ability to achieve. Functionings are, in a sense, more directly related to living conditions, since they are different aspects of living conditions. Capabilities, in contrast, are notions of freedom, in the positive sense: what real opportunities you have regarding the life you may lead*" [14:36].

Thus, a functioning is what a person is and what he can do; it refers to realised achievements. On the other hand, capabilities refer to what is possible for a person to be and do. The fulfilment of these capabilities may require financial resources, but others will require institutions to be in place, the political climate to be conducive, and for cultural and social structures and practices to allow for the fulfilment of these capabilities. Thus, while a person may have certain functionings, the person may not be able to achieve certain capabilities if the structural conditions and other social and environmental factors are limiting.

### 3. Research Methodology

This research adopted a systematic literature review (SLR) approach to uncover the various ways in which the capabilities approach was theorised, adapted and operationalized in ICT4D research. As shown in **Fig. 1**, the methodology used in this research is based on the approach advocated by Okoli and Schabram [15], which bears a resemblance to the framework suggested in [16].

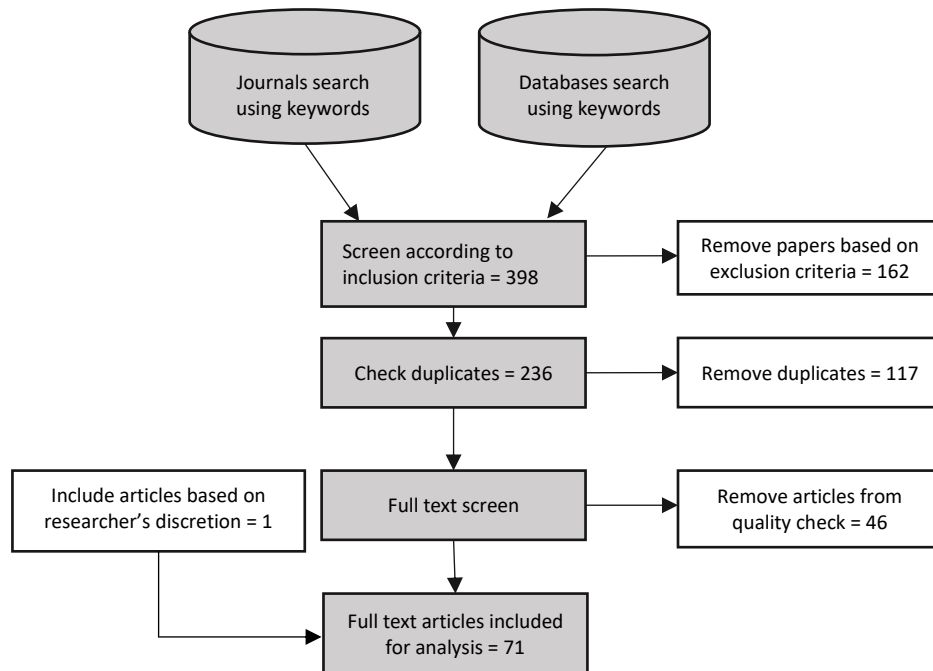


**Fig. 1.** SRL approach followed (based on [15])

The keywords used to find the relevant articles for this study were: “capability approach” and “information and communication technology”. This was done so that the retrieved papers would have both concepts included. The search terms (“capability approach” AND “ICT4D” or “ICT”) were used when searching through the databases. The following documents were excluded from this review: studies with incidental mention of the capability approach; studies with references to the dynamic capability approach; studies that are too general; and books.

The following journals were included in the literature search: Electronic Journal of Information Systems in Developing Countries (EJISDC); Information Technologies and International Development (IDIT); Information Technology and People (ITP); Information Technology for Development (ITD), Journal of Community Informatics (JCI); and The African Journal of Information Systems (AJIS). In addition, the following databases were consulted: ScienceDirect, Web of Science, Scopus, and Harzing’s Publish or Perish based on Google Scholar.

**Fig. 2** shows the search process, based on the keywords mentioned. It summarises the process [15] of how literature was found, screened, and quality appraised until a final list of 71 articles to be studied was arrived at.



**Fig. 2.** Research process followed for article selection.

## 4. Data Analysis

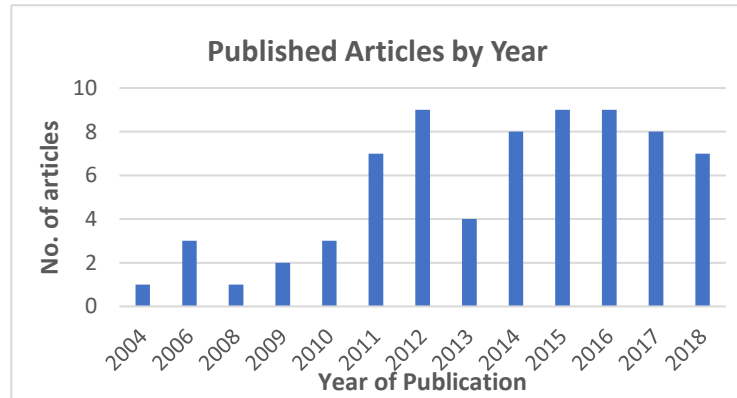
This section describes briefly the demographics of the publications that were found. It then focuses on those articles that proposed or used conceptual frameworks or theories based on the Capabilities Approach. Lastly, a decision tree to assist researchers with the narrowing down of the options available for selecting a particular approach based on their own field of interest is presented.

### 4.1 Descriptive review

This section presents the high-level overview of results, specifically the sources where the articles were retrieved, the proliferation of articles over the years, the types of articles, the geographic location where the empirical studies were conducted, and the distribution of articles across the different fields.

Most of the papers that met the inclusion criteria for this study are from the Electronic Journal of Information Systems in Developing Countries (19 articles). Further categorisation of the articles according to the type of source is as follows: We Journal of Information Technology for Development (10 articles); Conference Proceedings (8 articles) Journal of Community Informatics (4 articles); and other

sources (3 or less articles). As shown in **Fig. 3**, the majority of the articles were obtained for the period 2014-2018.



**Figure 3: Distribution of articles over years**

The articles that met the inclusion criteria could be grouped into three broad categories, namely:

1. The most important category for this research was those papers that used the capability approach in a new framework to operationalise it. This was mostly done in conjunction with other frameworks or theories. We found 26 such articles.
2. The second category contains articles that are empirical in nature; using either an existing framework that operationalises the capability approach, created one for the study, or used the capability approach as a theoretical framework to frame the concept of development. This category constituted the largest subset with 37 papers.
3. Finally, 8 papers used the capability approach within the context of ICT4D in a literature review or a conceptual undertaking.

Due to space limitations, this paper focusses on the first category, namely articles that developed/adopted a new theory or framework to operationalise the capabilities approach. We also propose a guideline for researchers to select one of these based on their intended field of research

#### **4.2 Frameworks and Theories that Operationalise the Capability Approach**

Of the empirical articles, the majority (17) did not use any approach to operationalise the capability approach; these are articles that used the capability approach concepts in framing development, and articulated findings in terms of the capability approach. Whereas both Kleine’s Choice Framework [8] [17] and Robyens’ Stylised Non-Dynamic Representation of the Concepts of the Capability Approach Framework [10] were used in 5 papers, only 3 and 2 studies employed the Hatakka & De’s [18] and Alampay’s [19, 20] frameworks, respectively. The discussed frameworks as well as the research purpose for which they were used as well as the fields or domain in which they were applied are summarized in **Table 1**.

**Table 1: Capability-based framework applications and citations**

<b>Framework Name (sorted by key source)</b>	<b>Purpose</b>	<b>Also used in</b>	<b>Fields applied</b>	<b>GS-C</b>	<b>PP- C</b>
The capability approach applied to access to ICTs [19] [20]	To analyse ICT access and use	[33]	Communities	68	66
Empowerment Framework [21]	To understand and measure empowerment	[34]	Financial services	635	600
Capability approach reference model [22]	To evaluate the impact of electronic government services		E-governance	8	6
Institutional theory and the capability approach [23]	To assess how capabilities strengthen institutions		Education	35	34
Socio-technical analysis of ICT investments [4]	To assess relations in ICT4D		E-governance	14	12
Affordances and the capability approach [24]	To assess the impact of cell phones		Communities	4	1
Alternative Evaluative Framework [25]	To evaluate ICT4D projects		ICT projects	41	35
Operationalisation of the capability approach [18]	To evaluate students' use of internet resources	[35, 36]	Education Health	50	45
Capable and convivial design [26]	To design ICTs for human development		Education	49	46
Choice Framework [8] [17]	To evaluate impact of ICT4D projects; co-design technologies with users; apply CA to action research	[37-39]	Telecentres Consumer studies Mobile phones	314	296
E-government impact evaluation framework [27]	To evaluate ICT4D e-governance projects	[40]	E-governance	291	279
Revised TAM for developing countries [28]	To assess technology adoption		Communities	87	79
Diffusion of Innovation and the capability approach [29]	To assess people's motivation to use ICT and development outcomes		Communities	0	0
Central Human Capabilities [30]	To assess quality of life and assist in political planning		Social Justice	9638	917 3
Psychology and development [31]	To evaluate the impact of ICT on social and psychological well-being		Education	1	0



Critical theory and development [32]	To analyse ICT4D project and structural power		Education ICT sector (Film)	17	13
Stylised Non-Dynamic Representation of the Concepts of the Capability Approach Framework (adapted from [10])	To evaluate participation, use of the public healthcare system, impact of educational programs	[41-44]	E-governance health education	2605	NA
Sen's five Freedoms [9]	To evaluate ICT4D e-governance projects	[45, 46]	E-governance	118	434

The last two columns indicate the number of citations. GS-C (Google Scholar Citations) gives those citations reported by Google Scholar of the first publication by the author(s) as of 26 July 2019. The numbers correlated very strongly with those as reported by the desktop application, Hartzing's Publish or Perish [47], as per column PP-C (Publish or Perish Citations).

### 4.3 A researcher decision guide for using a capability-derived framework or theory in ICT4D research

A guide to assist researchers in choosing an appropriate capability approach operationalisation framework for different enquiries in ICT4D is presented in **Fig. 4**. Several frameworks are available, each with its own specific focus, which are appropriate for specific applications. The initial framework design purpose (or focus) and the field of application (column 4 in **Table 1**) were synthesized into 10 fields/focus areas.

Which field or focus area?	Which operationalisation framework?	
E-governance		Araujo and Reinhard (2014) Sen (2001) Madon (2004) Nussbaum (2000)
ICT Access and Use		Alampay (2006) Olatokun (2009)
Choice		Alsop and Heinsohn (2005) Kleine (2010)
Choice and children		Zelezny-Green (2010)
Structural power and agency		Poveda and Roberts (2018) Dasuki and Abbott (2015)
ICT4D project Implementation/ Assessment		Gigler (2015)
ICT4D Design		Johri and Pal (2012)
ICT4D Adoption		Musa (2006) Namatovu and Saebo (2015)
Maintenance Affordances		Faith (2018)
Other		Hatakka and De (2011) Robeyns (2005)

**Fig. 4. Guideline for selecting a suitable capability framework or theory in ICT4D projects**

It should however be noted that frameworks previously used in one particular area, can often be adapted to work in different research areas or contexts. Also, it is useful to take into account the citations-based ‘popularity’ of the various frameworks (last two columns of **Table 1**).

### ***E-governance***

For projects related to e-governance, four suitable frameworks or means of application are presented. The first framework, which is a simplified version of Robeyns’ framework [7], was applied by Araujo and Reinhard [22] in an e-governance project. The framework worked well in the e-governance context and for its intended purpose; it was able to uncover the uses of e-governance by citizens, given their conditions of acquisition and their freedom and ability to choose. This framework can be used to assess the root causes for use or lack of use of e-governance services, as well as to determine what citizens mostly used e-governance services for.

The second means of application is Sen’s five freedoms [9, 48], which are also appropriate for e-governance studies since they are concerned with citizen’s economic freedoms, the opportunities that they have in society, their political freedoms, their protective security, and their transparency guarantees. Studies that applied this framework [45, 46] analysed how ICTs affected each one of these freedoms. This framework is ideal for studies with an interest in all these freedoms and how ICTs enable or restrict these freedoms for citizens.

The third means of applying the capability approach in e-governance is Madon's framework for evaluating the impact of e-governance [27]. The framework asks questions related to ICT intervention, namely: what the ICT applications can do; what the functionings are that have been enabled; how people utilise the opportunities presented by the system; and what the barriers are to achieving functionings. Studies that applied this framework [27, 40] have undertaken a comprehensive analysis of what was enabled for the citizens by the particular ICT applications, and whether or not they were able to utilise these in their contexts. This framework differentiates itself from the rest of the frameworks in that it asks for an analysis or a list of what ICT can actually do; thereafter, the framework seeks to uncover what citizens have done with those services.

The final relevant framework is Nussbaum's Central Human Capabilities list [30]. This list is premised on the notion that every human being has a right to dignity. Nussbaum [49] posits that for a society to be just, it must afford each one of its citizens all the capabilities on the Central Human Capabilities list, namely: life, bodily health, bodily integrity, senses, imagination and thought, emotions, practical reason, affiliation, engagement with other species, play, and control over an individual's environment. In ICT4D, this framework is ideal for usage in e-governance projects and any government-initiated project since it provides a checklist for governments to ensure that these capabilities, as well as social justice, is sought for its citizens.

### ***ICT access and use***

If the focus of an ICT4D enquiry is on ICT access and use, the ideal framework to apply is that of Alampay [20]. This framework specifically makes access and use of ICTs the subject of its analysis. It starts off by determining individual differences of people, and thereafter examines whether they have a choice to access and use ICTs. Scholars who used this framework [19] [33] were able to discover the reasons behind the lack of use of ICTs by people with access to ICTs. This framework is ideal for enquiries interested in how ICTs are accessed and appropriated.

### ***Choice***

Choice is another area of interest for scholars. In this study, two frameworks that operationalise the capability approach that have choice as one of the main focus areas – the Empowerment Framework [21] and the Choice Framework – were found [8]. Along with structure and agency, the Empowerment Framework is concerned with individual's degrees of choice, which are: whether choice exists, whether a choice is made, and whether the choice made meets the individual's expectation. These degrees of choice provide a useful breakdown of choice, which allows choice to be examined more effectively. Domain (where empowerment takes place) is what makes this framework different from Kleine's Choice framework. Thus, if a scholarly inquiry is based on choice as well as domain, the Empowerment Framework is an ideal framework. Bisht and Mishra [34] used the Empowerment Framework to operationalise

the capability approach. They examined empowerment in the following domains: personal, social, economic, and political.

Furthermore, the Choice Framework [8, 17] was derived from the Empowerment Framework [21]. Although both frameworks have similarities – in terms of components (i.e., structure and agency) – the differentiating factor of the Choice Framework is its focus on outcomes (as opposed to domains). Although the Choice Framework considers the same degrees of choice (from the Empowerment Framework), it examines these in relation to their ability to achieve individuals' desired outcomes. Thus, if a study seeks to focus on choice and primary and secondary outcomes, the Choice Framework is ideal for such use. In addition, the Choice Framework elaborates further on agency by providing a list of resources that affect people's agency. Scholars who used this framework [37-39] found it a useful framework for operationalisation of the capability approach. Lastly, if an enquiry is concerned with choice and children, the Child-Centred Choice Framework (CCCCF) by Zelenzy-Green [50], which adds to the Choice Framework by incorporating children, is ideally suited.

### ***Structural power and agency***

A framework that augments the capability approach with critical theory and agency is also available to researchers that are interested in how structural issues of power and agency relate to the achievement of capabilities. This framework, which was developed by Poveda and Roberts [32], found a gap in the conceptually rich capability approach in that it omitted to account for power interests that pose constraints to the ability of humans to develop, and it is inadequate on practical guidance for individuals to break through structural unfreedoms. Scholars using this framework were able to determine the factors that were causing discrimination and disadvantage to a particular gender in the ICT sector of a certain country. Therefore, this framework is ideal for researching issues of structural power and how individuals get themselves out of identified unfreedoms. Dasuki and Abbott [4] have presented an alternative framework for dealing with power. The framework is concerned with powers in society that enable or restrict people from fully exploiting resources that can further their lives.

### ***ICTD4 project implementation and assessment***

The Alternative Evaluation Framework [25] has a differentiating factor, which is its incorporation of the Sustainable Livelihoods framework. This differentiating factor considers different resources or capitals, such as human capital, informational capital, natural capital, and social capital. This framework also emphasises the need to contextualise ICTs and the information they provide to communities. It is not enough to provide poor people with ICTs, but ICTs need to be fit-for-purpose for the realities that people face in order for communities to enjoy benefits that are sustained in the long term. The framework also describes five stages of ICT projects, which would be helpful in project implementation to make stakeholders aware of factors that would yield the best ICT4D project outcomes for recipients. Thus, this framework is ideal for going the distance with locals of a community when providing ICT4D solutions.

### ***ICT4D design***

Johri and Pal [26] noticed a gap in the literature; that is, a dearth of research to guide ICT4D design. This led to the development of Capable and Convivial Design (CCD). It draws concepts from the capability approach to create ways for people to freely exercise opportunities, and for empowering them from their existing capabilities to their aspirations. This framework is ideal for assisting in the creation of ICT4D artefacts; furthermore, it ensures that the intended users are part of the design process.

### ***ICT4D adoption***

A framework exists that is suitable to the assessment of technology adoption in developing countries. This framework is a revision of TAM, and was created by Musa [28]. This revision of TAM incorporates aspects of the capability approach. The aspects that were added are accessibility and exposure, as it recognises that people in poorer areas have insufficient access to ICTs. Using the framework in an empirical study, Musa [28] was able to determine that access to ICTs does necessarily lead to sustainable use.

An alternative framework in this area is one that combines the diffusion of innovation theory with the capability approach [29]. This framework is ideal for assessing what motivates people to adopt ICTs, and it is focussed on explaining ICT use. While the diffusion of innovation is concerned with reasons for use, the capability approach is added to understand the impact of that use. Namatovu and Saebo [29] have found the framework to be useful in their empirical study, since they were able to establish factors that motivated people to use mobile phones. These factors include better health; it was found that people are able to use mobile phones to search for health information, and this contributed towards the enhancement of their health capabilities. The study found that those in business could run their business affairs efficiently. A social development element was also established because students were found to be able to search for educational material.

### ***Maintenance affordances***

Faith has proposed a framework that focuses on the fact that technology has to be maintained [24]. The framework, which combines the maintenance affordance theory with the capability approach, is ideal for researchers or practitioners intending to identify aspects about a technology that may hinder its use. Although it should be borne in mind that technology has its own sets of needs, and it is up to the user to ensure that these needs are taken care of. These needs include repairs and making sure that the technology is charged adequately. These maintenance affordances are seen as directly impacting the capability of an individual to use resources in order to live the lives they value. This framework assists in drawing the attention of the researcher to the fact that technology has to be maintained.

### ***Other ICT4D uses***

Robeyns' framework is a representation of the basic concepts that constitute the capability approach [7]. The framework considers social context, means to achieve (goods and services), individual conversion factors, capability sets (i.e. are opportunity sets of achievable functionings), choice, and achieved functionings. Due to its genericity, it has been found to be useful in any research undertaking that seeks to evaluate the impact of ICT4D [41-44]. Similarly, the Kleine's Choice Framework [8, 17] has also found more generic use and applicability.

Another framework that operationalises the capability approach concepts, and that can be applied in any ICT4D impact evaluation endeavour, was reported by Hatakka and De [18]. This framework differs from that of Robeyns [7] in that while Robeyns' framework uses good and services, it has the intervention construct comprising of the actual technology artefact and its support (e.g., training). Thus, attention is given to the artefact for evaluation by providing complete picture of functionings enabled by the intervention, given individuals' enabling or restricting conversion factors. Some scholars were able to use this framework to operationalise the capability approach by applying it in healthcare and education [7, 35-36].

## **5. Conclusion**

This paper explored how ICT4D research has been using the capability approach to impact ICTD4 beyond the economic development level. A systematic literature review resulted in the screening of 328 papers, 71 of which met the inclusion criteria of referring to both capabilities and ICT4D. Of these, 34 papers were analyzed comprehensively since capabilities-derived frameworks were explicitly applied in the papers. In total, 18 different frameworks and theories were found to apply the capabilities approach in an ICT4D context. The main contribution made by this paper is the identification of these CA-derivative frameworks and theories by ICT4D scholars that operationalise the capability approach. Ten (10) fields in which these frameworks are applied are also highlighted before suggesting a practical guideline for using the capability approach in ICT4D research by novices and seasoned researchers, depending on the field or the subject area.

The limitations associated with this research study include the fact that it focussed on the *historical* use of various capability frameworks. Nevertheless, aspiring ICT4D researchers are encouraged to explore the potential application of selected theories in *new* domains. Also, it may be fruitful to complement the capabilities approach with other theories to achieve a more holistic understanding of the ICT4D phenomena [51].

Future research can increase the number and value of existing frameworks by including additional decision criteria for selecting an appropriate research framework or approach. A study incorporating the contribution and application of the other empirical articles uncovered in our systematic search is currently underway. This will give further guidance to ICT4D researchers considering the capabilities approach for their research projects.

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# Proposed Theory of e-Government for South Africa

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**Abstract.** e-Government is used to provide improved government services, greater public service efficiencies and cost containment, utilising the ever-changing possibilities offered by ICTs. Little research is evident. There is very little evidence in the literature of e-Government theories and architectural artefacts that can facilitate the alignment between e-Government objectives and the information systems used to support them.

Using Design Science Research (DSR) methodology in the context of the researcher's experience as a former government chief information officer responsible for e-Government leadership in South Africa, a theoretical view is proposed of e-Government. The DSR methodology is in the form of a composite framework of design theory artefacts that is consistent with current IT policy and based on academic research, as well as architectural artefacts that may enable the practical attainment of these policy objectives. The twelve component artefacts composing this framework were evaluated within the limitations of this research work, using two semi-structured interview processes with subject matter experts, over a two-year period. Subsequent qualitative data analysis methodology was applied using a thematic approach. The proposed theory was further evaluated against the accepted criteria of a good design theory, a good e-Government theory as well as some guiding propositions in the field of enterprise architecture. The work addresses a recognized and urgent gap in knowledge of e-Government theory and reference architecture. The work makes both a scientific and technological contribution in the form of a composite e-Government framework artefact thereby offering improved support for e-Government implementations in South Africa and possibly internationally.

**Keywords:** e-Government, Enterprise Architecture, DSR, TOGAF, e-Government Theory, e-Government Reference Architecture, Digital Government.

## 1. Introduction

The use of enterprise architecture for e-Government implementation is increasing around the world [1-3]. This parallels the use of e-Commerce systems in the private sector where studies have shown a positive correlation between the use of enterprise architecture practice and successful alignment of information systems with business goals [4]. The research community holds the view that e-Government and enterprise architecture are young and formative fields of theory and practice requiring more research [4-5]. It has been observed that not having an enterprise architecture framework in place and a theory for e-Government can produce detrimental effects of poor system implementation and bring into question the viability of e-Government as a discrete field of research [1, 3, 6-7]. For purpose of presentation clarity, this paper is organized according to the Design Science Research (DSR) publication schema recommended by Gregor & Hevner [8].

The key concepts covered in this paper are e-Government and enterprise architecture as they pertain to the South African government. The South African government is structured in the three tiers of national, provincial and local, each with its areas of competence [9]. For practical reasons, the scope of this research covers e-Government as practiced by the South African national government, Gauteng Provincial Government, which is one of nine provincial governments of South Africa, and local government.

e-Government refers to the use of Information and Communication Technologies (ICTs) to reengineer the government organisation using the possibilities offered by advancing information and communications technologies. This will enable government to become more efficient and cost effective as a complex organisation, and it will also enable citizens and businesses to obtain services and transact with government so it appears that government can be accessed more easily through a single entry point for service delivery using multiple convenient channels including the Internet, and mobile and physical access. Government will then have a single view of a citizen or business covering events from cradle to grave, more easily providing citizens and businesses with all services they are entitled to [10].

Enterprise architecture (EA) is a widely followed business practice that uses standardised Information Technology (IT) architecture frameworks to align the strategy of a business enterprise with IT enabled capabilities. EA is focused on information systems that enable the business to take advantage of improved internal operations and more effective and rapid ways of serving its customers. Over the past twenty years, the use of EA has migrated to government organisations, and there is now a growing realisation in academia that e-Government cannot be effectively implemented without the use of EA [1-2].

In South Africa, as in most developing countries, the progress of e-Government has been slower than was initially anticipated [11]. In fact, South Africa has been observed to be regressing in its achievements [12]. There is no guiding theory to support the work of e-Government in South Africa, and the introduction of the Government Wide Enter-

prise Architecture (GWEA) framework, which is based on The Open Group Architecture Framework (TOGAF) architecture standard has been found to be largely unsuccessful. Although GWEA makes provision for inclusion of a reference architecture, such a reference architecture is currently not part of GWEA; it can therefore be deduced that this objective of designing effective e-Government solutions may then not be achieved [2-3]. It is the purpose of this work to usefully address these knowledge gaps within the scope of South African government. However, the scope of the work is restricted in terms of study participation to representation from national government, Gauteng provincial government and local government due to practical research constraints.

The relevance of this work is that it offers a tentative solution to two knowledge gaps by providing a proposed e-Government theory, inclusive of the applicable GWEA reference architecture in the form of a framework of twelve artefacts. These artefacts were initially conceived in the cultural environment of South African e-Government practice and were then evaluated empirically and analytically with the suggested results that they will provide a useful theoretical and practical orientation to e-Government practitioners in South Africa and possibly further afield. The relevance of this work is that it will effectively resolve the detrimental effects of undertaking e-Government implementation without underpinning architectures and without the understanding and direction provided to the stakeholders by the proposed e-Government theory [13-15].

## **2. Related Work**

The South African government is structured in the three tiers of national, provincial and local, each with its areas of competence [9]. For practical reasons, the scope of this research is limited to e-Government as practiced by the South African national government, Gauteng Provincial Government, which is one of nine provincial government of South Africa, and local government.

Over the past twenty years, the use of enterprise architecture (EA) has migrated to government organisations, and there is now a growing realisation in academic and government circles that e-Government cannot be effectively implemented without the use of EA [1-2, 10].

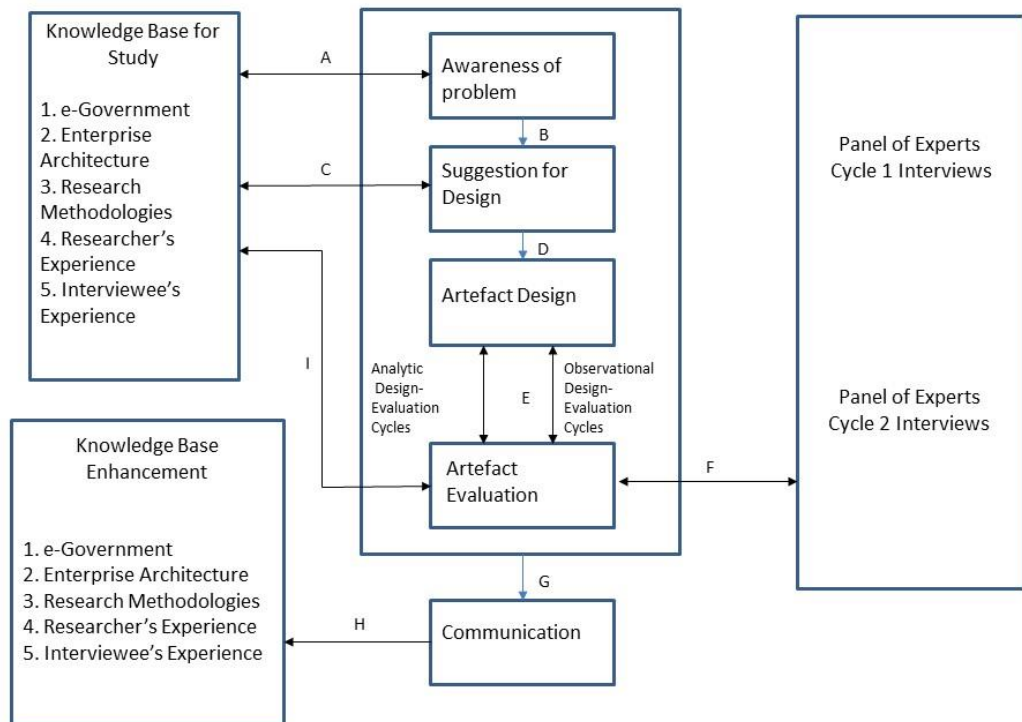
As is the case internationally, there is no guiding theory to support the work of e-Government in South Africa. Therefore, the introduction of the GWEA framework, which is based on the architecture standard of TOGAF, has not been successful thus making a scientific contribution in this regard desirable [3, 6, 12].

Since the beginning of this study in 2014, research articles have been accumulated through automated alert facility of the Scopus database, using the broadest search terms; e-Government and Enterprise Architecture. This literature review contributed to the essential knowledge base for this study as depicted in Figure 1. Scholars have questioned the viability of e-Government as a separate discipline without a suitable theory [6-7]. The relevance of this work is that it offers a rigorous research approach to filling

two knowledge gaps in the field of e-Government theory as well as illustrating the application of the approach in the form of a study in the South African context. The study offers a tentative solution to two knowledge gaps, by providing an e-Government theory, inclusive of the applicable GWEA reference architecture in the form of a framework of twelve artefacts. The artefacts were evaluated empirically and analytically suggesting that they provide a useful theoretical and practical orientation to e-Government practitioners in South Africa and possibly further afield [13, 16].

### **3. Methodology**

Due to the nature of the field of study involving man-made artefacts in e-Government and enterprise architecture, this study is qualitative in nature, using DSR as a methodology to design and evaluate the artefacts composing the e-Government theory framework [17]. The empirical component of the research involves two semi-structured interview cycles with selected experts in e-Government architecture and implementation as illustrated in Table 2 in Section 5. The collected, transcribed data is then analysed using an interpretivist approach and qualitative, thematic data analysis [18]. The empirical evaluation is followed by an analytical evaluation in the context of accepted theory attributes relevant to this research, which emerged in the research literature during the course of this work and add rigour to the research and the validity to the artefact evaluations as discussed in Section 5. To provide the reader with a summarised view of the design of this research work, Figure 1 and Table 1 are shown to illustrate how the researcher elected to apply the selected DSR framework in this study owing to its clear exposition and wide acceptance in doctoral information systems research [16, 19]. The selected DSR framework was developed by Vaishnavi & Kuechler [20].



**Fig. 1.** Researcher's DSR process followed in this study

The labels A to I in Figure 1 show the interactions that take place between the various components of the process model. Table 1 references the Figure 1 and provides the reader with a brief synopsis of the applied DSR research methodology.

**Table 1.** Researcher's DSR process steps

DSR Step for this Work	Step Description
Awareness of the Problem	The researcher identifies the general area of this study and identifies the required knowledge base as being e-Government, Enterprise Architecture, Research Methodologies and researcher's experience, as shown by the interaction labelled as A.
Suggestion for Design	Having identified the problem to be researched the next step of Suggestion for Design is entered, shown as label B, requiring contemplation of the type of solutions that might be required to solve the problem with reference to the knowledge base. Drawing on the

DSR Step for this Work	Step Description
	researcher's prior experience as South African government CIO the conception of a set of artefacts eventually allows entry into the next step of Artefact Design, which is shown as D.
Artefact Design	Having obtained design ideas from the previous step, a series of design artefacts is refined until it appears to the researcher that a feasible solution to the problem has been designed as shown by the labels C and D.
Artefact Evaluation	<p>Since the designed artefacts are for use by enterprise architects working to implement e-Government applications in South Africa, the evaluation of design artefacts using the observational method is to take place based on semi-structured interviews with a panel of experienced and qualified experts in e-Government and enterprise architecture. Based on the thematic qualitative data analysis of the results, cycles of observational evaluation method continue until the artefact validity and utility has been evaluated within the limits of this research.</p> <p>Following the conclusion of the design-evaluation cycles using observational evaluation three more cycles are to be performed using the analytical method to evaluate whether or not the proposed e-Government theory artefacts meet the published criteria for theory artefact in the DSR framework as well as in e-Government information systems and in the context of enterprise architecture theory. The design-evaluation cycles are shown as labels E, F and I.</p>
Communication	The conclusion of the design-evaluation cycles permits the researcher to enter into the final Communication step of the process, labelled as G. The scientific knowledge added by this work will be deposited in the knowledge base and further communicated to the research community and may contribute to other researchers work in e-Government, enterprise architecture and use of the DSR research methodology. This is shown by the label H.

#### 4. Artefact Description

During the course of the research, the point was reached of discovering a gap in the current knowledge related to the absence of e-Government theory including reference architecture. Therefore, the researcher engaged in a process of reflection whereby the observation of the deficit in the state of e-Government theory was surprising and brought about the recollection of the researcher's experience as Government CIO (GCIO) for almost three years with responsibility for e-Government leadership in South Africa. This eventually led to the inference that some or all of the artefacts conceived during that period of practice and extensive consultation in government under the researcher's leadership might have some theoretical validity [10], [21]. This process of thought is reflected in the process of abduction conceptualised by Peirce [22], and quoted in Timmermans & Tavory [23]. As noted by Peirce [22], insights should be viewed as fallible and the contribution of DSR methodology in social sciences is to

provide the context wherein the artefacts that result from such insights can be evaluated as having some potential of solving the identified research problem.

Gregor & Hevner [8] allude to the necessity of using kernel theories in the design of artefacts. In this context, and as discussed by Krauss [15], there is acknowledgement amongst researchers in social sciences, drawing on the Theory of Practice of Bourdieu [14], which dictates that any theory that seeks to influence a cultural environment should be influenced by the immersion of the researcher in such a cultural environment and that theory and practice should inform each other. Bourdieu [14] shows in his work how human nature requires the effective interplay of knowledge and the practical use of that knowledge. The researcher was immersed as a practitioner in the cultural work of e-Government in South Africa for nearly three years. It was in the course of learning and socialising with fellow e-Government practitioners that the researcher conceived the initial eleven artefacts that would enable the exercise of practical leadership and implementation support for an e-Government program in the future. These artefacts were socialized and appeared useful and valid during an extensive period of consultation in government involving hundreds of senior managers from government departments and agencies closely related to e-Government. During that period of consultation formal endorsements were obtained from State IT Agency (SITA) and the Government IT Officers Council (GITOC), but evidently the artefacts were never practically implemented possibly because of frequent change of leadership in the public service and consequent loss of knowledge [10, 21]. The proposed novel artefacts therefore have a provable grounding in the practical experience of e-Government in South Africa and possibly internationally as official visits by the researcher to India and Brazil during showed many similarities with South Africa [8].

As recommended by Vaishnavi & Kuechler [20], ideas arose in the mind of the researcher in the DSR process step of suggestion were logically evaluated. Vaishnavi & Kuechler [20] posit that “In a sense evaluation takes place continuously in a design process (research or otherwise) since a large number of “micro-evaluations” take place at every design detail decision. Each decision is followed by a “thought experiment” in which that part of the design is mentally exercised by the designer.” In the process of doing this, the researcher posed the following questions in connection with e-Government, which reflect the interests of e-Government stakeholders including programme managers, architects, implementers and managers:

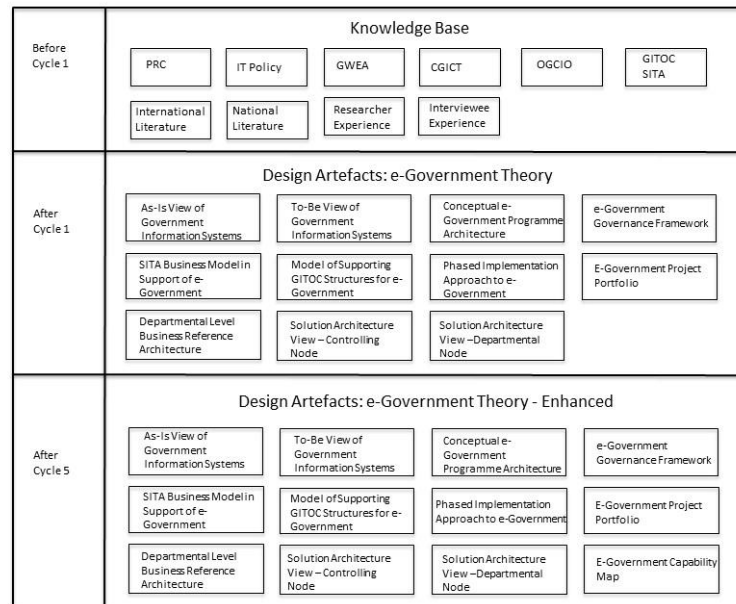
- Is it important for e-Government participants to understand the current information systems challenges in government?
- Is it important to depict the end-goal or aspirational state of the future e-Government, as espoused by the South African government [24], and how could this be done?
- Is it important to establish e-Government upon a legal foundation and informed by policy, strategy and architecture, and an appropriate public service ethic?
- Is governance, coordination, planning, accountability, authority, consultation, important to operate an e-Government programme?
- Is it important to leverage existing government structures, such as SITA and GITOC, which are already mandated to participate in e-Government from a coordinating and implementation and support perspective?



- Given that e-Government is a complex undertaking, should its implementation be attempted in one big project or in a measured evolutionary way, taking into account international experience and prior research such as that of Layne & Lee [25] and local studies of e-Government challenges [11-12]?
- Is it important to show to the various stakeholders how e-Government is progressing and contributing to their interest on an on-going basis?

This reflection resulted in the initial design of eleven design theory artefacts. A twelfth artefact was added from the result of the first cycle of evaluation. The twelve design theory artefacts, in the form of architecture models with associated descriptions, were submitted to further four design-evaluation cycles, which culminated in a composite design theory framework artefact comprised of twelve component artefacts, termed the e-Government Framework, shown in Figure 2.

The results of the evaluations show that the e-Government theory framework is considered vital to underpin the establishment and maintenance of a government-wide e-Government implementation capability from an information systems perspective as without it the present fragmented approach of departmental-level ICT modernisation may continue with a sub-optimal effect on the whole of government [11-12]. Therefore, this work addresses the two current knowledge gaps. With the suggested approach, the reference architecture should be seen as component artefacts of the proposed framework of theory for e-Government. The following theory artefacts have been designed and evaluated as part of this research and are shown in Figure 2 according to the design-evaluation cycle in which they emerged. The final e-Government theory artefact is a framework of twelve component design theory artefacts and is shown as the conclusion of the design-evaluation cycle 5 in Figure 2.



**Fig. 2.** Cycles 1 to 5 artefact contribution by the author resulting in e-Government Theory Framework.

A brief description of each of the framework component artefacts designed by the researcher is given below. A fuller exposition is provided by Vidmar [26], where each artefact is illustrated in the form of an architectural model.

**As-Is View of Government Information Systems** - This As-Is component acts as a baseline description of the current structure of information systems in government, revealing the nature of the major problems that e-Government is designed to solve. This includes multiple access channels to government and extensive system, process and data duplication and lack of system integration across government information systems, which pose challenges to the delivery of government service.

**The To-Be View of e-Government in South Africa** - This component reveals the essential features and properties of the broad e-Government information systems solution and acts as a representation of the goals to be achieved by enterprise architects and e-Government decision makers. This includes integration and consolidation of systems, establishment and reuse of authoritative sources of data throughout government, use of

shared processes to support reengineered e-Government services and a single access point to government with government having a single view of any legal entity, such as citizen, business, and others. Similarly, citizens and businesses may gain a simpler and more holistic view of government.

**Conceptual e-Government Programme Architecture** - This component shows how the proposed e-Government programme can be established on a solid foundation building up from the core ideals of a developmental state and informed by policy, strategy, architecture and the government's public service ethic.

**e-Government Governance Framework** - This component shows how the governance for the proposed government-wide e-Government programme can be achieved with assigned authority and accountability and providing for stakeholder participation in the context of South African government.

**SITA Business Model in Support of e-Government** - This component shows that as the mandated and established entity, SITA may play its designated role as an e-Government implementation agency, not in isolation, but as part of the overall e-Government programme.

**Model of Supporting GITOC Structures for e-Government** - This component shows the vital coordinating and consultative role played by GITOC in the e-Government programme to ensure government-wide endorsement and alignment with the e-Government programme amongst the ICT leaders in government.

**Phased Implementation Approach to e-Government** - This component promotes a step-wise application implementation approach for e-Government with progressive sophistication and investment in e-Government information systems solutions consistent with international practice. This artefact is based on what appears as the solely existing of e-Government theoretical concept, proposed by Layne & Lee [25] and quoted by Bannister & Connolly [6].

**e-Government Project Portfolio** - This component promotes the summary view of e-Government applications as they mature through the designated steps of development in support of the recognised e-Government stakeholder classes, including the public service itself.

**Departmental Level Business Reference Architecture** - This component is the proposed high level business reference architecture at the business level which is intended to guide e-Government enterprise architects in the design of e-Government systems in a manner that promotes the reuse of authoritative sources of data, reusable business

processes across government departments and interfaced with standardised and well managed interface channels for service delivery.

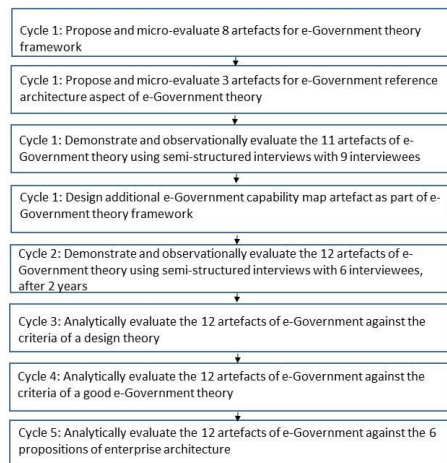
**Solution Architecture View – Controlling Node** - This component is provided as an example of how the reference architecture can be translated into a technology based solution in the case of a controlling node in the networked departments forming part of e-Government as a whole.

**Solution Architecture View – Departmental Level Node** - This component is provided as an example of how the reference architecture can be translated into a technology based solution in the case of a government department node in the network of government departments forming part of e-Government as a whole and not performing any controlling node function.

**e-Government Capability Map** - This component is included to provide a higher level perspective of the proposed e-Government capabilities than just the reference architecture artefact, thus making it more suitable for non-technical e-Government stakeholders to understand e-Government while also supporting enterprise architects in their e-Government implementation role.

## 5. Artefact Evaluation

Five design-evaluation cycles were found to be necessary to obtain a rigorous evaluation of the design artefacts in this research work, both from empirical and analytical evaluation perspectives, as illustrated in Figure 3 [16].



**Fig. 3.** Researcher’s DSR design-evaluation process followed in this study

Hevner et al. [17] describe five different methods of artefact evaluation that may be appropriate based on the nature of the design artefact. In addition to the observational method of evaluation of the artefacts, it is also appropriate to evaluate the proposed artefacts analytically against any available theoretical criteria. As explained below, use was made in this study of three sets of theoretical criteria [2, 6, 20, 16].

The interviewees selected for the observational portion of this study covered in Cycle 1 and 2 include people skilled in the practice and management of enterprise architecture and e-Government projects within the South African government and those in the private sector who support government in setting standards and adopting best practices. The demographics of the interviewees are summarised in Table 2.

**Table 2.** Cycles 1 and 2 interviewee demographics

Design-Evaluation Cycle	Number of Interview Participants	National Government	Gauteng Province	Local Government	Industry	Men	Women
Cycle 1	9	6	1	1	1	8	1
Cycle 2	6	4			2	5	1

The first design-evaluation cycle is based on the observational evaluation method using a semi-structured interview of nine expert participants and 157 822 words of transcribed interview data were collected. Results of the qualitative data analysis indicated that e-Government in South Africa had an absence of theory and GWEA was not an effective practice, thus confirming prior similar research findings reported in South Africa [12]. The general support for the theory framework demonstrated to the participants consisting of the initial eleven artefacts was evident, and it was suggested that an additional design theory artefact should be included.

After designing and adding to the theory framework a twelfth component artefact called the e-Government Capability Map, the second observational evaluation cycle was done approximately two years later based on a semi-structured interview of six experts and 23 045 words of collected transcribed data. The second cycle was focused on evaluating the validity and utility of the twelve component artefacts using the seven criteria of a design theory described by Vaishnavi & Kuechler [20]. As these theoretical artefacts are not yet in operation, other artefact criteria such as quality and efficacy could not be evaluated [13]. The subsequent qualitative data analysis result showed support for the validity and utility of the expanded framework with no further need for design changes; however, some changes were made to descriptive text to emphasise specific attributes of the artefacts mentioned by the interviewees.

In contrast to the empirical evaluation in cycle 2, the core components for an effective DSR design theory in the third cycle are evaluated logically by the researcher according to the profile of a design theory proposed by Vaishnavi & Kuechler [20] in alignment with the research design of this research work. According to Vaishnavi & Kuechler [20], the analytical review of the artefacts are in agreement with all the seven components of a design theory. This cycle required no artefact changes.

In the fourth cycle of DSR design-evaluation, the researcher used logic to evaluate the proposed e-Government theory component artefacts according to the eight features

or virtues of a good theory for information systems, including e-Government, proposed by Bannister & Connolly [16]. An agreement was found to exist between the proposed e-Government theory with all the virtues of a good theory within the limits of the research work. This cycle required no artefact changes.

The additional method of analytical evaluation of architecture analysis is performed in the fifth design-evaluation cycle as the proposed artefacts are designed for use by enterprise architects and as indicated by Hevner et al. [17] they should fit into technical IT architecture. Currently, the only theory that appears relevant as a basis for such analysis is the set of six enterprise architecture propositions of Mentz et al. [2]. This study finds that the proposed e-Government theory effectively utilises enterprise architecture as a vehicle for e-Government implementation since the set of proposed artefacts agree with the stated propositions thus necessitating the non-requirement of artefact design adaptations. This evaluation terminated the design-evaluation cycle allowing the communication of the research findings.

## **6. Discussion**

Based on the five design-evaluation cycles that have been performed, the researcher is convinced that the research objectives set for this work have been adequately met, within the limits of this research, and that, with the same qualification, valid conclusions can be drawn. The rigour of this work results from the choice of DSR as the appropriate research methodology that incorporates a rigorous approach to artefact design and followed not only by empirical but also by analytical evaluations.

With reference to the recommended knowledge contribution framework for scholarly research articulated by Ngwenyama [27], the contribution of this research work is theoretical because it proposes an evaluated theory of e-Government, which has previously not been used in the field of e-Government research in South Africa or internationally. Theory is a recognized form of knowledge contribution and the proposed framework is an example of a level 2 DSR contribution, which is referred to as nascent design theory by Gregor & Hevner [8]. Using the typology for information systems theory suggested by Gregor [28], the proposed e-Government theory may be seen as a mid-range hybrid Type IV and Type V theory because it explains, predicts and is oriented towards design and action in the field of e-Government implementation [13].

The proposed e-Government theory is also a contribution to practice in the field of e-Government since it appears to be capable of influencing the organisational, people and technical aspects of e-Government and acts as a guide to e-Government stakeholders. This is because the artefacts complement each other by addressing the interests of the different stakeholders as implied in the artefact names, ranging from architects, programme managers, implementers and executives. The methodological contribution of this study is to have applied Design Science Research methodology in a new and complex research area of information systems, spanning e-Government and enterprise architecture [13]. Measures such as perceived validity and utility by knowledge domain experts and analytical analysis against accepted theory criteria were found relevant for the e-Government theory evaluation [7, 20].

In this research work, the Theory of Practice [14] is the theoretical basis that underpins and gives credence to the initial suggestion of the e-Government design theory artefacts. This is as a direct consequence of the researcher's deep immersion in the practice of e-Government in South Africa in the context of extensive consultations with government stakeholders around the suggested artefacts [21].

## 7. Conclusion

The scientific study of e-Government is recognised as being new and important by the research community. Analysis of local and international literature by the researcher revealed a gap in the area of e-Government theory and reference architecture. Using the Design Science Research methodology the researcher conceived and designed a proposed e-Government framework of twelve component artefacts having theoretical and technical properties. The selection and use of this methodology has been covered previously by Vidmar et al [29]. The artefacts were evaluated both observationally and analytically. The result suggests that, within the limits of the research, the artefacts appear to fill the identified knowledge gaps in the theory of e-Government from an information systems perspective as well as the reference architecture for GWEA. The contribution of this work is of significance to researcher and practitioner communities in South Africa as it expands upon existing research in e-Government theory. In addition, the work also holds the promise of significantly improving the success of e-Government information systems implementations in South Africa and abroad through the use of the proposed artefacts

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# ICT for Development and the integrated nature of the Sustainable Development Goals

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**Abstract.** With the launch of Sustainable Development Goals (SDGs), the United Nations (UN) presented their self-declared ambitions for the years until 2030. These new goals therefore present a new point of reference for the UN’s work on Information and Communication Technologies for Development (ICT4D) as well, meaning the use of ICTs in support of the international development agenda. Despite a growing amount of research regarding the potential of ICTs to accelerate progress towards individual SDGs, the actual link between ICTs and the underlying principles of the SDG agenda remains rather opaque. In this paper, we focus on the SDGs’ principle of integrated development and the resulting need for policy coherence. Based on an analysis of 120 ICT-related publications by different UN entities, we explore to what extent this principle is being applied in their work on ICT4D. This allows us to identify best practices, challenges and gaps in implementing the SDGs in ICT4D, and to discuss how future research can contribute to bridging these gaps.

**Keywords:** ICT4D, Sustainable Development Goals, Policy Coherence.

## 1 Introduction

When the United Nations (UN) launched the Sustainable Development Goals (SDGs) in 2015, they framed the goals as an “[a]genda of unprecedented scope and significance” [1, p. 3]. The 17 goals and 169 targets were meant to serve as guidance for a fundamentally new approach to addressing the social, economic and environmental challenges of the planet [2]. For the field of Information and Communication Technologies for Development (ICT4D), which encompasses the use of ICTs in support of the international development agenda, these new goals presented a new point of reference. Indeed, while ICTs are only mentioned a few times within the list of SDG goals and targets, the UN General Assembly stressed their importance as key drivers towards achieving the new goals, and called upon all stakeholders to integrate ICTs into their work towards the SDGs [3]. The actual link between ICTs and the SDGs, however, remained rather opaque.

Within a short period of time, there have been contributions from the private sector [4], academia [5] and the international community [6], discussing new thematic priorities for using ICTs to achieve the SDGs. Yet, as we will demonstrate in this paper, the implications of the SDG principles for ICT4D go far beyond the pursuit of a new range of goals and targets. Rather, using ICTs in line with the SDGs requires taking into account their novel principles, such as their integrated and interconnected conceptualization of sustainable development [7].

The launch of the SDGs in 2015 was met by skepticism in the field of ICT4D, not least due to the lack of focus on ICTs. However, since the SDGs constitute the self-declared aspirations of the UN, they present a useful backdrop against which their work can be assessed. Therefore, instead of weighing in on the ongoing debate regarding the adequacy of the SDGs' novel principles<sup>1</sup>, this paper explores whether these principles are materializing in the UN's work on ICT4D. In particular, we explore how and to what extent different UN entities, which are committed to the pursuit of the SDGs, are applying the principle of integrated development in their work on ICTs. For this purpose, we analyze a sample of ICT-related publications by the UN Secretariat and UN agencies, funds, and programmes, and map their compliance with this central, new principle of the SDGs. The aim of this paper is therefore to identify patterns, best practices and potential gaps with regard to implementing the objectives of the SDGs using ICT4D, and to highlight opportunities for ICT4D research to contribute to this transition.

## **2 Background: The SDGs as an integrated network of interdependent goals**

The 2015 UN resolution *Transforming our World: The 2030 Agenda for Sustainable Development* [1] defines the SDGs as part of a *universal, global and integrated* agenda. These three notions represent three central novel principles of the SDGs: (1) their universal scope of targets; (2) their global applicability for all countries alike; and (3) their interconnected and interdependent nature [7-8]. Although these principles are intertwined, it is ultimately the third principle that will be at the core of this paper. As Le Blanc [12, p. 11] summarises, “[t]he novelty of the SDGs [...] is that they aim to cover the whole sustainable development universe, which includes basically all areas of the human enterprise on earth”. In this section, we will elaborate on the integrated and interconnected architecture of the SDGs and the need for policy coherence resulting from their universal and global nature.

First and foremost, when compared with the 8 Millennium Development Goals (MDGs) [13], the SDGs cover a much larger scope of development objectives with 17 goals and 169 associated targets [1]. In doing so, the SDGs combine the socio-economic focus of the MDGs with the environmental development efforts of Rio+20 [9], thus resulting in a rather holistic set of new and refined objectives. Secondly, this large scope

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<sup>1</sup> These questions have been meticulously discussed by authors such as Fukuda-Parr [8], Gore [9], Gupta & Vegelin [10], and Stafford-Smith et al. [11].

of goals entails a widening horizon in the geographic understanding of development [7]. As opposed to the MDGs, the SDGs acknowledge sustainable development as a global challenge, that is, “universal goals and targets which involve the entire world, developed and developing countries alike” [1]. Areas such as climate change, sustainable production, inclusive cities or reducing inequalities, for example, are as much a challenge for the Global North as they are for so-called developing countries [14]. This vast, universal and global conceptualization of sustainable development cumulates in the third novel principle of the SDGs: their integrated nature.

The scope of the SDGs has been criticized for being too large and covering too many targets [15]. It is, however, important to view the large number of goals and targets in the context of the SDGs’ integrated approach. Rather than an arbitrary enlargement, the large scope is deeply rooted in the interdependencies between the various areas of sustainable development around the globe [16]. These interdependencies are integral to the network architecture of the SDGs. To give an example, *zero hunger* cannot be achieved without combatting climate change, while climate change cannot be combatted unless countries work on issues such as sustainable transport and infrastructure, which in turn requires international cooperation and the economic means. As Le Blanc [12] analyses, the SDGs take these interlinkages into account. Rather than being a mere list of goals, they represent a network of interrelated targets, which feature numerous references between one another, highlighting interdependencies and spinning a complex web around the 17 goals.

While not all areas are equally well connected, Le Blanc argues that this approach could begin to “correct one of the drawbacks of the MDGs, in which ‘silo’ goals encouraged silo policies and did not make links and trade-offs across areas explicit” [12, p 11]. Indeed, reports show that progress towards achieving MDG7 on environmental sustainability have largely been undermined by efforts towards other targets of the MDG agenda, such as economic growth or increased agricultural productivity [17]. This shows that without internal coherence and an awareness of potential trade-offs, it will be impossible to deliver on a holistic development agenda like the SDGs. Nilsson et al. [16, p. 320-321] highlight such possible trade-offs, stating that “using coal to improve energy access (goal 7) in Asian nations [...] would accelerate climate change and acidify the oceans (undermining goals 13 and 14), as well as exacerbating other problems such as damage to health from air pollution (disrupting goal 3)”. Despite a positive *direct* outcome in the intended target area, affordable energy, the overall development impact would be detrimental.

Rather than merely suggesting possible *snowball effects*, in which the pursuit of one of the goals can simultaneously support other goals as well, the SDGs’ integrated approach is thus also a response to the risk of incoherent development efforts. SDG 17 introduces the notion of Policy Coherence for Sustainable Development (PCSD) [18], promoting coherent development policies that take into account their potential impact on the whole of the SDGs, as opposed to merely considering their desired effect within their particular area of development [19]. In other words, PCSD means ensuring that development policies in support of a certain goal do not undermine the rest of the development agenda. Given the holistic scope of the SDGs, the pursuit of PCSD is a complex yet inevitable challenge for development practitioners. In order to truly benefit

sustainable development at large, development policies must be as coherent as possible with all of the 169 targets [20], and their negative side-effects must be identified and minimised.

With regard to ICT4D, the notion of PCSD reveals a particular challenge. While we see a wide range of opportunities to use ICTs in order to accelerate SDG progress, they are also associated with numerous negative effects on matters of sustainable development, which Unwin [21] comprehensively outlines. To merely name a few, these ICT-related effects range from the environmental impact related to their production, use and disposal [22], to social aspects such as the prevalence of slave- and child labour in their value chains [23] or their contribution to increased inequalities [24], as well as political implications such as surveillance and persecution [25]. Incorporating the PCSD approach into ICT4D thus requires a holistic awareness of the potential side-effects that are associated with the use of ICTs and granting the biggest possible coherence with the whole of the SDGs. Taking these manifold side-effects into account is essential in order to assess, whether an ICT4D project does, in fact, more *good* than it does *harm* in the bigger scheme of sustainable development.

### **3 Research Corpus and Methodology**

The previous section demonstrated how the interconnected nature of the SDGs requires development actors to adopt an integrated approach and strive for policy coherence. Moreover, it has outlined the vast range of potential side-effects that are associated with ICTs, which need to be taken stock of in the interest of policy coherence. Based on this theoretical background, we want to analyze how and to what degree UN entities incorporate the principle of integrated development into their ICT4D-related work. For this purpose, we coded and analyzed a range of reports, research papers, policy briefs, books and book chapters by the UN Secretariat and 5 affiliated organizations (agencies, funds, and programmes). The result was a matrix of 120 documents by 6 entities, which were coded with regard to their topical and geographic focus and their level of integratedness, as well as the nature of relation they present between ICTs and development. The following subsections will elaborate on how the corpus of documents was compiled and how the codes for analysis were defined, before discussing our findings in Section 4.

#### **3.1 Corpus**

Given that different UN organizations have distinctive areas of work and, sometimes, particular regional target areas, we decided to compare the work of different entities in order to gain a broader overview. The first entity considered in this study is the UN Secretariat, including its associated departments and offices, such as the Department for Economic and Social Affairs (DESA), the Office for the Coordination of Humanitarian Affairs (OCHA), or the United Nations Conference on Trade and Development (UNCTAD), as well its regional offices such as the Economic and Social Commission for Asia and Pacific (ESCAP) or the Economic and Social Commission for Western Asia (ESCWA).

In addition to the UN Secretariat, we identified the five UN entities with the most ICT-related publications in 2018, which at the time of this research was the most recent full year of publications. Based on a multi-keyword search of the main United Nations online library, as well as the databases of the different UN agencies, funds, and programmes (including their respective regional offices and innovation units), the five most relevant entities were the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Children's Fund (UNICEF), the United Nations Development Programme (UNDP), the Office of the United Nations High Commissioner for Refugees (UNHCR) and the International Telecommunication Union (ITU), where we exclusively considered publications of its development sector, ITU-D. The number of relevant publications we identified per organization ranged from 56 (UNESCO) to 21 (UNICEF) in the year of 2018. Based on simple random sampling, 20 ICT-related publications were selected per organization, resulting in a dataset of 120 publications (see Table 1).

**Table 1.** Number of selected publications per organization

<b>Organization</b>	UN Secretariat	UNESCO	UNICEF	UNDP	UNHCR	ITU	<b>Total</b>
Number of documents	20	20	20	20	20	20	<b>120</b>

### 3.2 Methods

In order to structure the corpus of research, we first of all deducted theory-driven codes [26] from the literature on the SDGs' novel principles. Such *a priori* codes are useful for testing documents against theory [27], and allowed us to identify which documents feature which of the SDGs principles. Based on the literature discussed above, a first set of codes was created to analyze documents with regard to the three novel principles of the SDGs (Table 2). On the level of (1) the SDGs' topical scope, we coded links between ICTs and the 21 MDG targets [13] as well as links between ICTs and *new* SDGs with no equivalent MDG targets (see [28]). With regard to (2) the SDGs' global geographic scope, we coded the focus on ICTs in the so-called Global South (developing countries as defined by UN DESA [29]) as well as in the Global North (developed economies or economies in transition). Thirdly, and centrally for this paper, on the level of (3) policy coherence, we coded whether the documents contained explicit accounts of potential side-effects and risks of the use of ICTs for areas of sustainable development.

**Table 2.** Deductive codes used for topical, geographic and integrated aspects

Code	Definition
MDG targets	Link between ICTs and one of the 21 MDG targets
SDG targets	Link between ICTs and an SDG target that has no equivalent in the MDGs (see [28])

Global North	Considering ICTs in developed economies or economies in transition, as defined by UN DESA [29]
Global South	Considering ICTs in developing economies, as defined by UN DESA [29]
Side-effects	Explicit mention of potential side-effects of ICT use on other development areas

After an initial close reading [30] of the documents' executive summaries, introductions and conclusions, we further refined our codes. Following a hybrid approach [31], our theory-driven *a priori* codes were complemented by data-driven, inductive codes regarding the nature of the connection between ICTs and development at the core of the documents. Within our corpus of documents, the recurring kinds of connection that were presented could be categorized into 4 types. Certain documents primarily looked at ICTs as (1) a means to achieve or accelerate development, others treated them as (2) (a part of) a development goal in itself, (3) a sector or a phenomenon that has implications for development, or (4) a realm in which development efforts must be implemented (see Table 3); this will be explained in more depth.

Given the scope of the corpus and the explorative nature of this study, we manually coded the documents' executive summary (or, if not available, its introduction), conclusion, as well as its ICT-related and PCSD specific sections, which were identified through a multi-keyword search and on the basis of the document's table of content. For the purpose of this study, the combination of executive summary, conclusion, table of content and keyword searches proved sufficient in order to identify the documents' key areas and features. This was tested by the full coding of one randomly selected document per organization.

**Table 3.** Inductive codes regarding the nature of relationship between ICTs and development

Code	Definition	Example
Accelerator	ICTs as means to achieving/accelerating development	The use of drones and data analytics software in agriculture to improve food security (ITU)
Goal	ICTs as (a part of) a development goal	Strategies to improving digital literacy among displaced youth (UNHCR)
Sector	ICTs as sector/phenomenon that has implications for development	Understanding the environmental impact of e-waste (ITU)
Realm	ICTs as a realm in which development efforts must be implemented	Preventing discriminatory outcomes in machine learning (UNICEF)

## 4 Findings

The coding process resulted in a database of 120 documents, containing their respective UN organizations, the development areas they relate to, and the nature of relationship between ICTs and development they primarily discuss. These documents were coded with regard to their explicit references to potential side-effects and risks related to the use of ICTs, or lack thereof. When analyzing this database, certain patterns and potential gaps became visible. As we will demonstrate in this section, an integrated approach to the side-effects and (in)-coherences of the use of ICT use is only featured in a minority of the documents. Moreover, it varies strongly between the different types of documents we analyzed.

Before elaborating on these findings, the following section will present the predominant types of ICT-development relations that are discussed in the documents. These categories provide valuable context in order to interpret our findings.

### 4.1 Context: ICT *for, as, or and* Development

Indexing the documents according to the nature of relationship between ICTs and development showed that more than half of the 120 documents (65) primarily focused on the use of ICTs for achieving and accelerating development (see Table 4). Roughly one third (31) focused primarily on ICT-related goals, such as enhancing access to ICTs or improving digital literacy. Fourteen per cent of the documents (17) mainly covered the potential implications of ICTs on development issues; for example, the impact of e-waste on the environment. Lastly, 7 documents, published by 3 of the 6 organizations (ITU, UNESCO, UNICEF), focused primarily on development issues within the digital realm, such as cybersecurity.

**Table 4.** Publications by nature of ICT-development relation, per organization

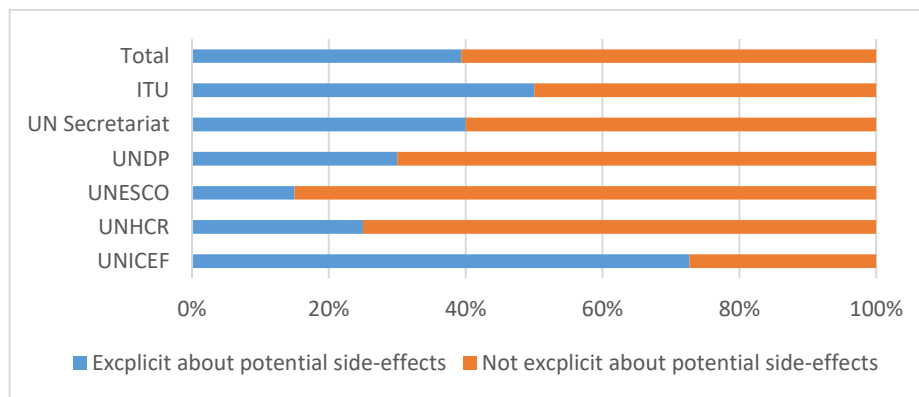
	Using ICTs to accelerate development	Achieving ICT-related goals	Understanding ICTs' implications for development	Achieving devel- opment in the realm of ICTs
ITU	9	7	2	2
UN Secretariat	11	2	7	0
UNDP	9	5	6	0
UNESCO	11	5	1	3
UNHCR	13	7	0	0
UNICEF	12	5	1	2
<b>Total</b>	<b>65</b>	<b>31</b>	<b>17</b>	<b>7</b>

This index (Table 4) provides us with further context for our findings. It allows us to identify patterns not only by organization but also by document category. As we will discuss, for the topic of policy coherence, it makes a difference whether only the documents looking at the development implications of ICTs consider their side-effects, or whether documents on using ICT *for* development take policy coherence into account as well.



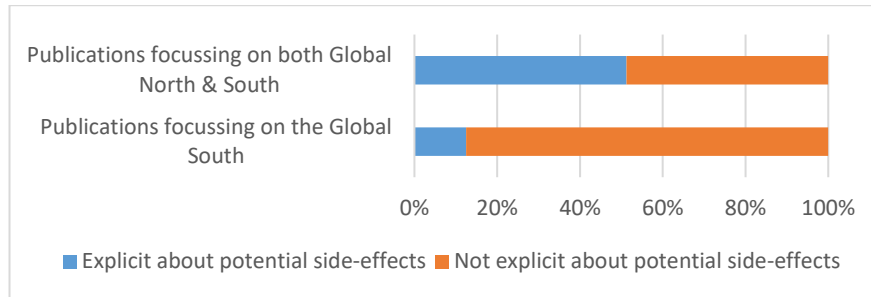
## 4.2 Policy coherence: Are potential side-effects taken into account?

Coding the explicit mentions of potential risks and side-effects on areas of sustainable development allowed us to identify the number of documents in our sample that made some sort of reference towards potential policy incoherencies associated with the use of ICTs. Our data revealed that, overall, little attention is being paid to policy coherence in the documents that we analysed. This suggests that the integrated nature of the SDGs is not yet commonly applied in the UN organizations' work on ICT4D. A majority of the 120 publications we studied (74) make no explicit mention of the potential side-effects of ICTs whatsoever. As can be seen in Figure 1, with the exception of UNICEF, this is equally true for of the organizations in our study. This indicates a significant gap with regard to the implementation of the SDGs' integrated approach into the work on ICT4D.



**Fig. 1.** Share of publications with/without explicit reference to potential side effects, per organization

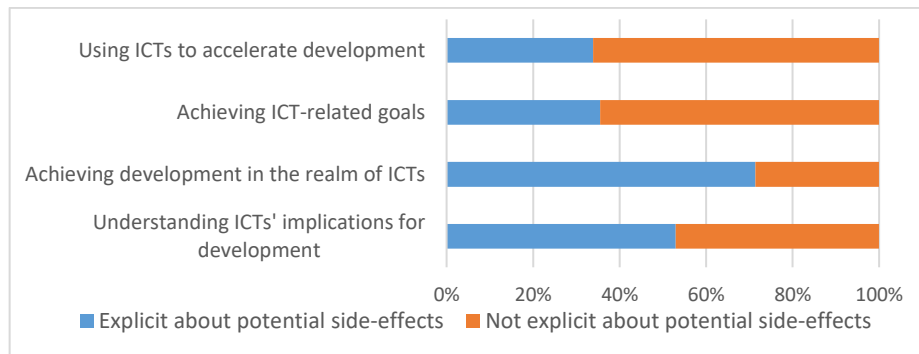
Moreover, we found significant differences between documents that exclusively focus on the Global South and those that relate to both developed and developing countries. Remarkably, the vast majority of documents that focus on ICTs in the Global South neglect their negative side-effects (87.5%). In contrast, at least half of the documents that consider both the Global North and South take a more integrated approach (see Figure 2). As we will discuss in the following section, this may suggest a problematic tendency, as it resonates with the longstanding critique of techno-optimism in ICT4D in developing countries.



**Fig. 2.** Share of publications with/without explicit reference to potential side effects, per geographic focus

In order to contextualize our data through the lens of PCSD, we had to further distinguish between those publications that look at ICTs as either tools for or goals of development efforts, as opposed to those that draw more general implications of or for the realm of ICTs. Policy coherence must be achieved by those actors who work in the pursuit of development objectives, by taking into account how the externalities related to the process and the outcome of their intervention affects other development areas [19]. Therefore, it is of particular importance that ICT's potential side-effects are taken into account when treating them as a means or end to development efforts.

Yet, as shown in Figure 3, for these two categories, we see an even lower share of publications taking into account possible side-effects. In contrast, the publications that look at the implications of ICTs on development, or ICTs as a realm in which development must take place, are much more likely to focus on their overarching impact on sustainable development.



**Fig. 3.** Share of publications with/without explicit reference to potential side effects, per publication category

## 5 Discussion: Policy coherence in ICT for Development

In Section 2, we argued that the integrated nature of the SDGs may present the most challenging new principle of the SDG agenda. Indeed, in the sample of ICT-related UN publications that were analyzed in this study, it appears to be significantly underrepresented, as only a minority take into account ICTs' potential side-effects on sustainable development. Especially within publications that look at ICTs as tools to achieve certain SDG targets, or as development objectives in themselves, matters of policy coherence are, more often than not, absent. For the nexus of ICTs and development, this appears to be particularly problematic.

First of all, scholars working on PCSD argue that a holistic approach to the impact of development projects and policies is imperative to achieving the SDGs. As discussed earlier, the lessons learned from the MDGs show that development efforts risk doing more harm than good if they neglect their effects on other development objectives. As stressed by OECD [18], it will thus be impossible to deliver on the SDGs as a whole if development policies are developed in silos. At the same time, a growing body of research shows that ICTs are linked to significant environmental, social, economic and political costs, as discussed in Section 2. The use of ICTs in pursuit of a certain development goal is therefore very likely to come at the expense of other targets. While this does not disqualify ICTs as potential accelerators for sustainable development, it shows the necessity to treat them with an integrated approach and view their potential impact with regard to PCSD.

The absence of such an integrated approach in a majority of the documents suggests various interpretations. On the one hand, it resonates with the recurring critique that ICT4D actors tend to treat ICTs as a panacea for development challenges [32]. Both the high share of publications focusing on ICTs as accelerators and the lack of focus on potentially negative side-effects and incoherencies seem to represent the tendencies of techno-optimism and techno-determinism that several researchers have been criticizing for a long time [33]. This criticism seems to be further confirmed by the fact that particularly the documents focusing on the Global South are remarkably less likely to take negative side-effects into account. Arguably, this suggests a somewhat uncritical deployment of ICTs in the Global South. Yet, a closer look at our findings paints a somewhat more nuanced picture.

If we look the types of publications that consider the implications of ICTs for development, or treat ICTs as a realm in which development efforts should be implemented, we see a high share of publications that make ICTs' potentially harmful externalities explicit. These documents focus on issues such as the environmental impact of ICTs production and disposal, or ethical concerns such as privacy and freedom of speech. This shows that, within the UN system, work on the ICT-related risks for development is certainly taking place. Yet, the publications we sampled suggest that this is seldomly explicitly integrated into the work on ICTs *for* development, as means and ends of development efforts. The issue therefore seems to lie less in the absence of work on policy coherence, but in the lack of integration thereof.

Clearly, the findings from this explorative study need to be contextualized. First of all, the scope of this study was rather limited. Secondly, a deeper qualitative analysis

would add crucial layers of context. For example, certain ICT-related publications, such as those focusing on digital skills development, may in fact not be linked to significant negative aspects of ICTs. However, our findings clearly show the need for further research on the implementation of PCSD in ICT4D in a larger context. Do we see particular ICT-related development areas that are more closely linked to the manifold potential side-effects of ICTs? And do we, in these fields, see a similar lack of attention to policy coherence, as our sample of publications indicates? This could for instance be explored through a large-scale document analysis that focuses on risk-intense ICT4D areas.

Moreover, our findings suggest the need for greater cooperation. This can be seen in the discrepancy between the strong focus on ICT-related risks within those publications discussing ICTs' implications, and the weak focus within those concerning ICTs as accelerators or targets. While research on potential incoherencies of ICTs with the development agenda exists, it does not appear to be structurally integrated within the work on ICT *for* development, or at least not communicated as such. A context-specific analysis between those gaps and the existing work on ICT-related risks could point to particular areas of potential cooperation, as well as potentially under-researched elements of policy incoherence in the use of ICTs for development. Moreover, it will be interesting to identify the role of newly created fora such as the High-level Panel on Digital Cooperation or the UN Innovation Network in enhancing cooperation with regard to policy coherence. If we are serious about using ICTs to the real benefit of sustainable development, it is vital to structurally take stock of their potential negative side-effects and to incorporate the integrated nature of the SDGs into our work on ICT4D.

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# Farmer Engagement by Means of SMS in the Kingdom of eSwatini

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**Abstract.** Access to information is one of the ways to assist farmers to improve their agricultural output, gain access to markets and generate income. The advancement of mobile phones and their high adoption levels by developing countries has made them one of the ideal means of disseminating information. Mobile phone adoption benefits not only the farmers who receive information but also the organizations supporting them by improving the means of engagement. This study looks at communication through the use of Short Message Service (SMS) and the effects it has on farmers and the organizations supporting them. The study follows the Design Science Research approach to develop a communications module for a project involving smallholder farmers. Two iterations of the design of the messaging platform are discussed along with future plans to improve the work that has already been undertaken.

**Keywords:** Short Message Service (SMS), information dissemination, smallholder farmers, SMLP Project, eSwatini.

## 1 Introduction

In most developing countries the agricultural sector contributes the most to economic and social development, and also providing food security [1]. The Agricultural sector is the largest employer in the Kingdom of eSwatini with over 70% of the population relying on agriculture for their livelihoods [2]. Subsistence farming is the most widely practiced type of agriculture in the country, a practice commonly associated with low production and low output, often leaving those engaged in it as their primary source of income in a dire state of poverty [3], [4].

Agriculture is touted as the quickest route to escape a life of poverty for rural inhabitants [3], [5]. If applied effectively through the use of new farming techniques, embracing technology, having access to information and access to markets, agriculture has the potential to assist subsistence farmers out of poverty [6]. Access to information is a major contributor to increasing agricultural production, and it affects all stages of the agricultural value chain and allows farmers to apply the proper implements at each stage [7]. Information becomes useful if it is easy and cheap to access and is from a reliable source [8]. Governments and universities are often credible sources of information but lack the structures and the resources to disseminate infor-

mation effectively and timeously to those that need it [9], [10]. Mobile phones have become a popular medium to disseminate information, transcending all other forms of ICT [11]. Mobile phones have been widely adopted and their mass adoption has been credited to their dynamism, mobility and ease of use [12].

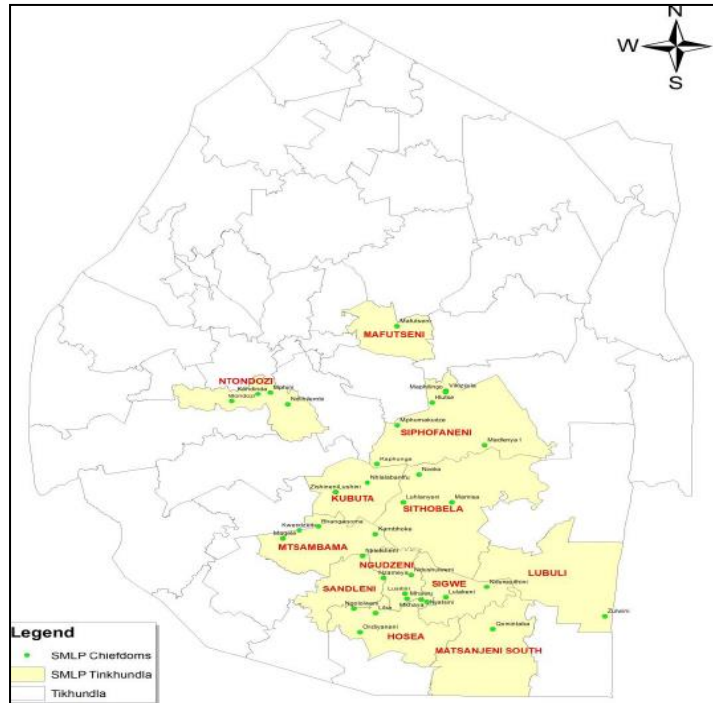
The use of mobile phones and its application in agriculture for information dissemination has been studied exhaustively. The topic is typically covered from the perspective of the farmer and the benefits they can glean from adopting the use of mobile in their agricultural pursuits. Although this paper acknowledges the importance of exploring the benefits that can be accrued by farmers from mobile phones, it also proposes a different angle, that is, the impact on the organizations that support the farmers. The objective of this study was to create an artifact for disseminating information to farmers through the use of Short Message Service (SMS).

One of the novelties of this paper is the inclusion of the aspect of the content creator, which is a perspective that is not as widely studied when discussing adoption of mobile phone in agriculture by subsistence farmers.

## **2 Context and Literature Review**

eSwatini Water and Agricultural Development Enterprise (ESWADE) is a government parastatal under the Ministry of Agriculture. The organization is tasked with implementing government goals of economic development and poverty reduction through agriculture-based projects [13]. One of the projects under the ESWADE umbrella is the Smallholder Market-Led Project (SMLP). The mandate of the SMLP is to reduce poverty and food insecurity of rural dwellers through supporting increased agricultural production and market-led commercialization of smallholder agriculture [13]. The project targets economically active poor households and food deficit households in 37 chiefdoms, spread across 12 Tinkhundla (an administrative subdivision smaller than a region but bigger than a chiefdom) in 3 regions in eSwatini (Figure 1). The covered areas reach an estimated population of 15 300 households (i.e. about 80 900 persons) [14]. The support to farmers is implemented through farmer education, demonstrations, training manuals, provision of starter packs (seeds, vaccinations), expert advice, market linkages through facilitation of market days, negotiations with vendor for farmer contracts and dissemination of other useful information. The plan is implemented by project staff, 4 sustainable agriculture officers reporting to a single sustainable agriculture coordinator and 4 livestock officers reporting to a single livestock coordinator.





**Fig. 1.** Map of eSwatini showing area covered by SMLP Project

The project is supported by the Ministry of Agriculture through the extension of offices available in the different regions. Even with the available support, reaching the target population is still a daunting task with the staff compliment available.

Quality, timely and contextually relevant information is paramount to the farmers for improving their farming practices. Farmers often prefer face-to-face communication when sourcing information and they often receive advice from their input dealers, extension officers and personal networks [11], [15], [16]. Face-to-face communication often falls short in that it is reliant on the transmitter's recollection of the facts, the timeliness of the information can be lost and this medium can only reach a limited number of people at a given time [17]. In contrast, Christensen et al [10] asserts that agricultural information can be collected for dissemination to a few lead farmers and thereafter, distributed to other farmers through word-of-mouth, posters and public announcements. This approach has proven to be effective because the community was small and in a remote location and mobile phones had not been widely adopted because of lack of electricity. Initiatives led by government, Non-governmental Organizations (NGOs) and other authorized stakeholders can be effective in providing training and knowledge to farmers that can improve their production yields [18]. Information is not the sole elixir to increased agricultural production, the farmer needs to have the resources and possess the ability to apply information for it to be effective

[19]. Training and demonstrations can be bolstered by other information that needs to be communicated to farmers from time to time.

Mobile phones are widely adopted in developing countries, reaching even the most remote rural areas [15]. Their wide spread adoption is due to factors such as their affordability, intuitiveness and relative ease of use [11], [12], [15]. Mobile phones also boast effortless usability, mobility, accessibility and some even incorporate the functions performed by other ICTs such as radio and email [11]. The dynamism, mobility and accessibility of mobile phones makes them ideal for information dissemination even in the most remote locations. Information can be disseminated through one of the many features that a mobile phone can perform such as Text, Voice, Unstructured Supplementary Service Data (USSD), Multimedia Messaging Service (MMS) and email, to name but a few functions.

The wide spread adoption and use of mobile phones is beneficial to the farmers because it allows the farmers easier access to information. NGOs, parastatals, government and other institution that educate and provide support to farmers also benefit from the adoption of mobile phones by farmers. These organizations are able to engage with farmers in other forms apart from face-to-face communication.

This study aims to develop an SMS based messaging system that can improve engagements with farmers and improve information dissemination.

### **3 Design Science Research (DSR) Approach**

Design Science has been practiced for decades in other fields such as engineering and computer science, and it has produced artifacts like algorithms, data structures, new programming languages and others [20]. Although DSR is not new to the field of information systems, the field has been more focused on research that produces descriptive research and theories [21]. DSR focuses on the activities that result in the construction and evaluation of a technology artifact that meets an organizational need as well as the development of the theories associated with development [22], [23]. This paper adopted a DSR framework proposed by Hevner et al [24] (see Figure 2) and also using a DSR process proposed by Offermann et al [25] (see Figure 3) to develop the design artifact.

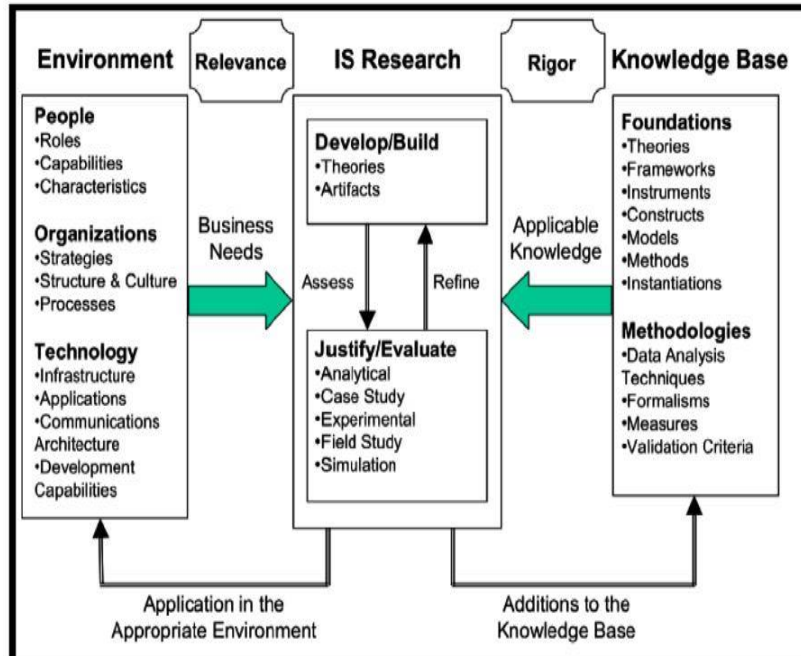


Fig. 2. DSR Research Framework Hevner et al [24]

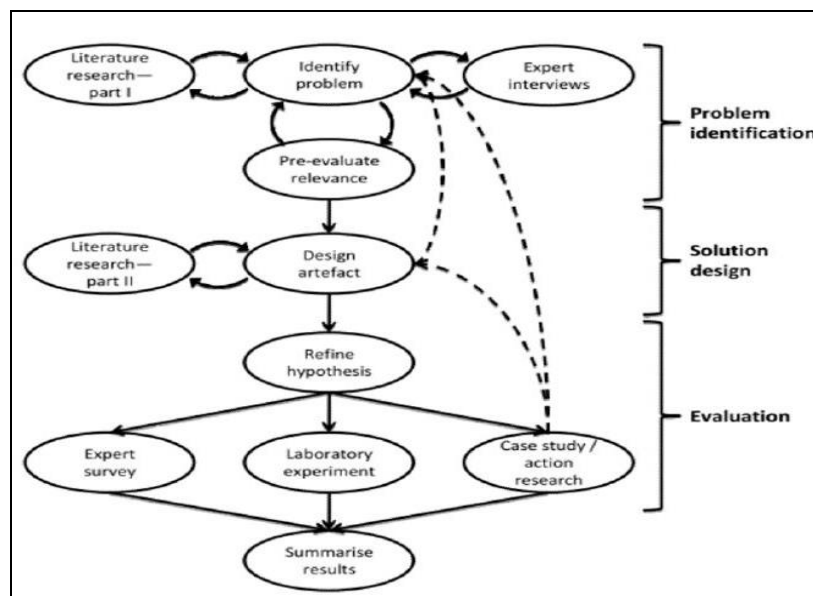


Fig. 3. Research Process Offermann et al [25]

DSR is fundamentally is a problem-solving paradigm, the primary goal of which is to develop an artifact that needs to rely on a kernel theory that is applied in the problem-solving efforts [20], [24].

In applying the DSR framework and process a problem needs to be identified before an artifact is developed. The DSR framework indicates that the problem is defined within a specific environment that consists of people, organization and technology. The DSR process states that a problem can be discovered through expert interviews and literature research. The identified problem in this study context is that the SMLP needs an effective way to engage with farmers. Applying the DSR framework, which requires that we understand the environment in which the problem occurs, we identify the technological resources, such as servers, computers, internet, available to the SMLP and the technological resources, such as mobile phones, available to the farmers. The DSR framework helps in refining the problem and finding potential solutions by studying literature and interviewing experts. Studies, such as [8], [9], [11], [14], show that mobile phones have been widely adopted in developing countries and communication through these devices has been very effective in disseminating information to farmers in rural communities. The DSR framework and process enabled this study to better understand the problem, the available resources, and solutions that are available for implementation.

## **4 UTAUT and MOPTAM**

### **4.1 Application of UTAUT to the Study**

A number of models and theories of technology adoption have been developed over the years. For a long time, the Technology Acceptance Model (TAM) has been the model of choice to explain technology adoption [26]. The TAM has been adapted and modified on numerous occasions but the most popular modification has been Unified Theory of Acceptance and Use of Technology (UTAUT) model, developed through studying the TAM and other adoption theories to create a unified model of technology acceptance [27]. The UTAUT model is effective at interpreting technology use up to 70% of the time [26], making it an effective technology use model to apply. The model is better suited at explaining technology acceptance at an organizational level, and it is for this reason this paper adopted the UTAUT model to explain the adoption of the SMS based system by SMLP staff.

Following the research process adopted and utilizing the UTAUT model the study is able to address the research problem through the developed artifact while being anchored by the UTAUT model. The identified problem is that engagement with farmers and dissemination of information is inefficient and can be better addressed through the adoption of technology.

The UTAUT model uses four constructs, namely Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions as measures that inform Behavioural Intention and ultimately Use Behaviour of a technology. The four constructs are moderated by Gender, Age, Experience and Voluntariness of Use to varying de-

grees. The UTAUT model constructs are used in this study to help guide the requirements gathering, development and analysis of the developed artifact.

**Performance Expectancy** - The developed artifact needs to help the project staff communicate certain types of information to large groups of farmers. In order to meet the criteria of improved performance expectancy the developed artifact needs to improve the status quo and also not add complexity as a proposed solution. Information about market days or availability of tractors is communicated through face-to-face engagements, making phone calls or dissemination through lead famers. The utilized means limit the number of farmers that can be reached and requires a lot of effort. Sending messages to the farmers removes the tedium from mobilizing farmers and simplifies farmer engagements.

**Effort Expectancy** – The project staff is able to select from a series of selection boxes to target a certain group of farmers and select a date and time when they want the message to be sent. The system is simplified so that the user with the appropriate rights is able to easily send a message. This minimizes the effort required to communicate with farmers through the system.

**Social Influence** – The influence to use the system comes from the project manager and line managers. Staff members engaging with staff are expected to use the SMS system as part of their working tools.

**Facilitating Conditions** – The SMS system is run off a server that the user connect to through their work devices (Laptop or Desktop). The challenge is that the system is not accessible when connecting through an external network connection, this means that the user needs to be in the office to send a message to the famers. Therefore, although the system can be implemented in the organization, it is limited by non-availability of access when working outside the office.

The study also considered a construct proposed by Benard et al [28], namely **affordability**. Affordability is critical because the proposed system needs to continue working once the project ends and the system is no longer run through donor funds. The SMLP is currently being implemented by donor funds for the Ministry of Agriculture. Once the project reaches its end date, all project resources are handed over to the Ministry of Agriculture includes all developed artifacts and data. The SMS system utilizes a bulk SMS service which cuts the cost per message to 19c (SZL 0.19 ≈ USD 0.013). If the Ministry of Agriculture does not absorb the cost of sending the messages like the SMLP does, the charge of 19c is a small fee on to pass on the farmers.

The system requirements as proposed by the DSR process are gathered through expert interviews and literature reviews. The UTAUT explains the use of the system from the perspective of the organization that disseminates information to the farmers.

## 4.2 Application of MOPTAM to the Study

The Mobile Phone Technology Adoption Model (MOPTAM) was developed from elements of two popular technology adoption and acceptance theories and models, TAM and UTUAT. MOPTAM integrates determining factors from the TAM with mediating factors from UTAUT [29]. MOPTAM uses 6 factors, namely Social Influ-

ence, Perceived Usefulness, Perceived Ease of Use, Facilitating Conditions, Behavioural Intention and Attitude as determining factors for Actual System Use. These factors are mediated by Demographic Factors, Socio-economic Factors and Personal Factors. The MOPTAM was used to study the perspective of the farmer when adopting the SMS based application. Even though the service costs are absorbed by the project for now, it is important to consider the factors determining the adoption of the service by the farmers. The constructs of the model were used to explain and determine adoption and use of the SMS system.

**Social Influence** – The farmers place the work of SMLP in high regard so advice from the project field workers to embrace the information being received through the system is welcomed. The study also showed influence from other farmers, a lot of farmers did not want to be left out of a program that others in the community are using. The influence of extension officers and lead farmers was also a factor but a lot of farmers were willing to adopt the information from the system because it was something new.

**Perceived Usefulness** – The farmers find the system useful as they receive information on their phone instead of having to travel to the extension offices to access the same information. Knowing that the information is from an organization they already trust means they have peace of mind to apply the advice they receive.

**Perceived Ease of Use** – The farmers were asked questions on how well they are able to navigate their phone and find specific information. This question was intended to gauge if the farmers would be able to determine that they have received information from the system and be able to read it. Younger farmers responded to the question by indicating that they were able to navigate their phones without any difficulty. Older farmers indicated that indicated that they often ask for assistance from their children to find something on their phone. The MOPTAM model uses demographic factors to mediate the perceived ease of use factor. Compared to younger farmers, older users are expected to experience challenges when using their device.

**Facilitating Conditions** – The farmers that were interviewed indicated that they lived in an area that has adequate network coverage. Their phones are on a prepaid package, suggesting that they can still receive messages with or without credit on their phones. When it comes to receiving information from the system the farmers do not need to do anything on the system, they are just the recipients. The farmers also need to consider the cost implications when the information is no longer provided for free and a lot of farmers indicated that they would be willing to pay for the information in the future.

**Attitude** – This factor was mostly influenced by the project field workers relaying the benefits of the SMS based communications to the farmers. The farmers also expressed interest in receiving information from the SMLP to decrease their information search costs.

The MOPTAM is used to determine use of the SMS based system from the perspective of the farmer. Since the farmers are already using mobile phones, the model is used to explain the actual use of the system and not adoption of the physical device.

Through the application of the DSR framework and process a design artifact was developed following the guidelines specified. The design artifact was intended to

solve a problem identified within the SMLP that not only affects the project but the farmers they support as well. The application of the two models was to ensure that the two perspectives being considered are adequately catered for.

## **5 Developed Artifact**

The developed artifact went through several iterations in order to address the research problem. Version 1 describes the first stage of the development which is the initial attempt at address the research problem. Version 1 was tested and evaluated to determine if it is an adequate solution to the research problem. The second version of the artifact address the results of the evaluation of version 1 and attempts to resolve the identified issues.

### **5.1 Version 1**

Figure 4 shows a screen grab of the artifact that was developed and tested on a small group of farmers. The system captures the type of information (e.g. weather, market prices, agricultural tips) that is being sent to farmers. The user can then select the group of farmers to send the message to, this can be filtered according to Region, Inkhundla, Chiefdom or Section. The four filters described are locations, so the message can be sent to farmers in specific locations. If a user selects a specific region, the system will disable all other filters and select farmers in the selected region. The same applies for all other filters. A message can also be sent to a specific group of farmers (e.g. chicken farmers, goat farmers, horticulturist or apiculturist). The message can also be sent to individual members instead of specified groups. The message content is limited to 480 characters which is equivalent to 3 text messages. The system allows the user to set a time for when the message should be sent, this feature enables users to queue messages to be sent on a future date.

**Fig. 4.** Outcome of communications module

The developed artifact enables the SMLP project staff to send bulk messages to farmers, simplifying communication with farmers that previously required face-to-face communication or phone calls. The system also filters the farmers for the user through the selection boxes making it easy to send information to the appropriate group that needs it. The filtering through the selection boxes eliminates the effort to manually enter the phones of a larger group of farmers. The information is taken from a database containing farmer demographics and other project related data already being captured by the SMLP. The network setup of the organization does not allow connection from outside the organization, this restricts access to the system when the SMLP staff are doing field work. The system partially addresses this issue by allowing messages to be queued and sent on a future date, project staff can plan the messages they want to send to farmers and create and save them on the system to be sent on a future date. The queuing of messages also ensures that messages are sent at a time when they are needed thus addressing the issue of timeous accessing of information by the farmers.

The information input before entering the message sent to farmers is for analysis purposes. The users can draw reports on the type of messages that were sent to farmers, for example weather information or market prices, the frequencies of the messages and the number of farmers that received the information. Other data, such as location of the farmers, the type farmers' businesses in the value chain (e.g. indigenous chicken, goats, horticulture and apiculture) can also be collected and be included in the analysis.



The main objective of the developed artifact was to send messages to farmers and improve communication efficiencies. The analysis does not constitute the objectives of the study but only gives an indication of a potential direction the system could take.

## 5.2 Version 2

The DSR framework and process requires that the developed artifact is tested and refined before the results of the study are communicated. Version 2 of the design artifact is a result of testing and refining of Version 1. This section describes the additions made to the design artifact after testing version 1.

The first iteration (i.e. Version 1) of the system was developed and tested with a small group of farmers. The artifact addressed most of the issues from the research problem but there was still a concern of ensuring the quality of the messages that are sent to the farmers. The first version of the artifact allowed project staff to create and send messages unrestricted.

The second iteration (Version 2) of the system included a verification step that involved a manager. The message was created and queued to be sent in the same way as described in Version 1 but an additional step was added for a manager to check the message before it could be pushed to the famers. Figure 5 illustrates the step that was added in the second iteration (Version 2) of the system.

Communication Type	Address	Message	Send Date	approved	Approved By
Market Information	2000	Flea Market to held at the Manzini Market on the 2nd of June from 8 a.m	27 May 2019 06:30	Not Set	<a href="#">Approvals</a>   <a href="#">Details</a>   <a href="#">Edit</a>   <a href="#">Delete</a>

Fig. 5. Verification step for managers

## 6 Outcomes, Discussions and Future Considerations

Through the use of DSR and the UTAUT and MOPTAM models an SMS based information dissemination system was developed. The study looked at the adoption of mobile phones in agriculture from two perspectives, the farmers and the SMLP. Accessing information through the use of a mobile phone helps farmers in a number of ways that have been widely discussed in the literature. This paper also takes a look at the perspective of the SMLP given that mobile phone adoption also affects the way that they engage with famers.

The developed artifact helps the SMLP reach a much larger audience. Given the limited number of human resources personnel expected to service a very large population, the SMS system makes it easier to communicate with farmers. The study shows that it is not only the farmers that benefits when they adopt mobile phones. The organization that supports the farmers are able to communicate with farmers with minimum effort. Phone calls and face-to-face engagements can be decreased, thus saving

time and reducing expenditure. This study did not detail the financial implications of having a messaging system versus the cost of continuing with the initial way of doing things. The study has demonstrated the impact of mobile phones in the field of agriculture, the farmer and other stakeholders that support the farmers.

This paper is limited by the fact that it looked at engagement from one direction, the SMLP sending information to the farmers. Further studies on the effect of bi-directional engagement on both the farmer and the organization sending the information are required. The study also notes the influence ESWADE has on farmers given that ESWADE is a parastatal and there is a high level of trust by the farmers given the stature of the organization.

This paper discussed the development of a DSR artifact intended to address a problem identified to affect both farmers and the SMLP. The study followed a DSR framework and process and also applied the UTAUT and MOPTAM models to develop an SMS system to address the identified problem. The study looked at the problem from the perspective of the farmer and the SMLP to see the dual effect the system has on the two parties.

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# Exploring the Digital Gender Divide: Insights from the Colombian Case

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**Abstract.** In recent decades, various authors have studied the digital divide not only between territories (countries, continents, etc.) but also between social groups (ethnicity, age, education, etc.). The purpose of this article is to review the relationship between the digital divide and gender in Colombia. The literature discusses the inequalities that women have in terms of interaction with ICT. However, this interaction (digital divide) is usually understood exclusively by material access or use. In this study, the relationship between ICT and gender are evaluated for four dimensions, according to the process of digital technology appropriation (motivation, physical and material access, digital skills and usage) as proposed by Van Dijk. Based on the analysis of over 5800 surveys conducted during 2017, where each dimension was modelled through an item response theory model, linear regression and multiple correspondence analysis were carried out to search for evidence between the gender relationship. The results indicate that for all four dimensions there is a significant relationship with gender ( $P < 0.001$ ) and women have a lower score than men. Likewise, it suggested that the dimensions with a greater difference are digital skills and usage with a delta of -0.2 concerning a normal distribution. This approach is expected to contribute to the understanding on how the gender issues are reflected in ICT access and use and the need for more in-depth national research on the social outcomes of gender inequalities on technology appropriation.

**Keywords:** Gender·Digital Divide·Colombia·Data analysis·Regional

## 1 Introduction

Although a widespread access and use of ICT has brought many opportunities for economic and social development, it has increased and reinforced some former social disadvantages to certain social groups. For instance, digital gender divide has been long studied, finding for example, that fewer women access and use ICT as a direct result of

their unfavorable conditions related to employment, education, and income [1]. This gap is persistent in developing countries where the ITU found that it grew from 15,8% in 2013 to 16,8% in 2016 [2]. Also, the Institute for Sustainable Development and International Relations (IDDRI) found that across urban poor areas in 10 cities, including Bogotá (Colombia), “women are 50% less likely than men to be online, and 30-50% less likely than men in the same communities to use the internet for economic and political empowerment” [3]. The IDDRI states that such differences have their roots on high costs, lack of digital know-how, scarcity of content that is relevant and empowering for women and barriers to women speaking freely and privately online.

In Colombia, a study conducted by Bogotá Mayor's Office found there were no major gender differences in usage between the citizens with access to the internet and computers [4]. However, some differences could be spotted between those not having access to the internet or mobile phone, most of them being women. Also, compared to men, more women stated that they did not access the internet due to lack of interest, low perceived utility, lack of digital skills and unawareness. Despite this, there is still a lot to be understood about the digital gender divide in Bogotá and other regions, its causes and evidences, particularly considering that the digital divide is increasingly understood not only as a matter of access but as an interaction of several factors affecting the relationship with ICT [5, 7].

The purpose of this paper is to understand how the gender digital divide is observed in Colombia in terms of *motivation to interact with ICTs, access to the digital devices, networks or services* and *digital skills to use and to take advantage of ICT* through a statistical approach. The Ministry for ICT in Colombia (MinTIC) has taken several actions towards bridging the digital divide in the country, including a research project aimed at understanding the digital divide between its regions. We considered one of those studies, the grand ICT survey -*Gran Encuesta TIC*-, to analyze the indicators around the digital divide. This survey provides a database with more than 5,000 observations and 80 questions collected during 2017, available on an open data platform of the Colombian government<sup>1</sup>. The first section introduces a review of the main concepts used on the digital divide and the contribution of Van Dijk to its definition, as well as how the gender issues are being discussed. The second part describes the methodology of how the survey was applied and used, including a description of the item response theory and the multiple correspondence analysis. The third section presents the main findings observed in terms of the relevance of gender, education and socio-economic level in the dimensions of the digital divide both at a national and regional approach. Finally, some conclusions about the survey data analyses results and the possible contribution to public policy decision making in Colombia were exposed.

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<sup>1</sup> This platform is based on the premise that data or information created by the Public Administration belong to society because it has been financed with public funds, therefore must be available to any citizen for any purpose (Decreto único Reglamentario del sector TIC - 1078 de 2015).

## 2 Literature Review & Theoretical Framework

Concerns about disparities in the propagation of information and inequities generated by differentiated uses of information exist a long time ago [8]. For example, since 1970 literature related to communications introduced a concept for this phenomenon, knowledge divides. This divide theory proposed that as more information was broadcasted through mass media, such as television, newspaper or radio, more disparities were generated among the different social groups who did not have access to them. As a consequence, people with higher economic incomes and social capital were more effective in processing media and information than others.[8].

Later, when the Internet was announced and developed, the concept of the digital divide was introduced for the earliest time in an official document presented by the National Telecommunications and Information Administration of the United States Department of Commerce (NTIA) [9, 10]. At that time, the digital divide referred to differences between people who had access to computers or the Internet and those who did not [11]. Therefore, literature associated with the digital divide towards the end of the 1990s and the beginning of the new millennium focused on the differences that existed and were produced by not having physical access to new technologies [12]. The digital divide of this period could be named as the first level.

Years later, after the implementation of initiatives aimed at bridging the first-level digital divide, researchers found that providing physical access to computers and the Internet may not be enough to solve it. In other words, it was useless to have access to new technologies if people did not use them or had the skills to exploit them[11]. Therefore, in mid-2005, the second-level digital divide emerged, related to that goes beyond physical access to technologies [9, 10, 13]. The second level divide has been the most researched in the last decade, but a new body of literature has begun to mention a third-level digital divide [11]. This third level is focused on the impact that ICTs generate in different areas of life [9]. Therefore, this level of the digital divide aims to study the consequences of technology use around issues such as participation in society, economy, education, employment, health, etc. [11].

One of the most important frameworks to understand the digital divide, including the different levels mentioned above, was proposed by Van Dijk [5]. This framework defines four stages to observe it: *motivational access*, *material access*, *skills access*, and *usage access*. In this case, access is understood beyond physical possession, being a process comprising psychological, social and technological factors. In this paper, we delete the term “access” to avoid misinterpretations because the term may usually be associated with physical access related to devices and networks.

- **Motivation.** It determines the will of individuals to interact with ICT. Some motivational factors are, for instance, lack of time, unfavorable social value, technophobia, low perceived utility, among others.

- **Material.** It is related to the availability of technological devices and services. It is often associated with socio-economic conditions determining the possibility of individuals to afford ICT devices or services.
- **Digital skills.** These are the hard and soft skills needed to operate and use technologies. This dimension might be defined by other authors under the name of digital literacy or digital capital and, according to Van Dijk [14], it comprises the following specific skills: operational, formal, informational, communicative, content creation and strategic.
- **Usage.** Counting with motivation, material access and digital skills do not necessarily lead to a meaningful and successful usage of ICTs, which is evidenced when individuals use technologies to reach a specific goal and gain some type of capital - social, economic, cultural, etc. [15]. Moreover, usage is usually determined by the intensity of use, the frequency of use and the diversity of uses and applications [5].

## 2.1 Digital Divide: A Gender Approach

Tension over gender divide in science and technology dates back from the industrial revolution until today [16]. Therefore, the gender digital divide has been observed and analyzed around the world. Although its manifestations may differ, the gender digital divide is evident, especially in developing countries and underserved areas. Geldof [17] shows how stereotyped roles in Africa lead to the exclusion of literacy, use of, and ownership of ICTs by women. Furthermore, Hilbert [1] demonstrated based on research conducted in Latin America and Africa, that the gender digital divide is not linked to psychological factors (such as technophobia, for example), but with disadvantages on income, education and employment.

Globally, several actions to overcome that situation have been proposed. For example, on a micro-level, alternatives to applications and devices considered gender issues and differences among countries, such as literacy or language [18]. Whilst on a macro-level, metrics to measure and overcome the gender digital divide were proposed [19]. The ITU proposed that overcoming the gender digital divide should be one of the main goals for 2020 [19], and it is considered a primary condition to reach the Sustainable Development Goals [3]. Nonetheless, some authors claim that a focus on the gender digital divide might not be enough, as it has structural grounds. For example, Gil-Juárez et al. [20] argue that one result of this is the lower registration rates by women in ICT-based undergraduate programs.

Zapata et al. conducted a documentary review that showed that research on the gender digital divide in Latin America is scarce: there is no greater awareness of this phenomenon, and it tends to be measured indirectly, through studies on female work penetration in the IT sector, or the situation of female engineering students [21]. Also, it was found that in Latin America Internet use in general, social media use, and use for political information gathering, is more likely to occur in those states with lesser gender inequality. For them, this difference in the usage may exacerbate traditional gender divides in political participation and hinder activism. Colombia, with a Gender Inequality Index of 0.383 in 2017 (87th in the world), is not exempt from this reality; there is still



no gender digital divide index and few studies have been carried out at the national level using this approach. This hampers the generation of adequate public policies, as there is a lack of understanding of the problem.

### 3 Methodology

In this section, an overall description of the methodology is presented. Since one of the added values of the work is focused on the use of Item Response Theory (IRT) to assess the surveyed results, a summary of its application is provided. A model of IRT was constructed for each dimension from the data contained in the grand ICT survey 2017 [22] carried out by the MinTIC. The universe of the survey was composed of the population residing in urban and rural households in 8 regions of Colombia (according to the regional divisions of the National Development Plan (NDP) for 2014-2018), and the target population were individuals between 16 and 70 years. The final sample was composed of those individuals residing in the municipalities randomly selected by region and by population size in 5 strata, where "large cities" with a population of over 500 thousand inhabitants where of forced inclusion.

In addition to items related to ICT access and use conditions and behavior shown in the **Appendix**, three main socio-economic variables were taken: *gender*, *socio-economic level* -based on the socio-economic stratum, and *declared education level*. **Table 1** presents a summary of the frequencies in each survey variable.

**Table 1.** Survey Summary

Variable	Categories	Frequency	%
Gender	Male	2666	45,2
	Female	3226	54,8
Education level	1- Pre-school	22	0,4
	2- Primary	682	11,6
	3- Secondary	2823	47,9
	4- Technical or technological	1165	19,8
	5- Undergraduate (incomplete)	463	7,9
	6- Undergraduate	557	9,5
	7- Specialization	114	1,9
	8- Master	40	0,7
	9- Doctorate	12	0,2
	97- None	14	0,2

Variable	Categories	Frequency	%
SEL	1	1396	23,7
	2	2252	38,2
	3	1673	28,4
	4	372	6,3
	5	168	2,9
	6	31	0,5

IRT models are used in the modelling of latent traits, that is, variables that cannot be measured nor observed directly. Under these models, the dimensions of the digital divide are considered random variables not directly observable in the regions of Colombia. However, it is possible to formulate items (questions) related to the latent trait for later mathematical modelling. **Table 2** presents the number of items assigned to each dimension, which were modelled employing a 3-PL item response theory model (1) by Birnbaum [23]:

$$P(u_{ij} = 1 | \theta_j, a_i, b_i, c_i) = c_i + (1 - c_i) \frac{e^{a_i(\theta_j - b_i)}}{1 + e^{a_i(\theta_j - b_i)}} \quad (1)$$

where  $\theta_j$  is the parameter that describes the latent trait of the  $j$ -th person;  $b_i$  describes the Item Characteristic Curve (ICC), or also called difficulty parameter, which refers to a point in the latent trait with a probability  $p=0.5$  of a correct answer;  $a_i$  is a parameter that indicates the slope of the ICC for each the items; and  $c_i$  is a parameter that indicates the probability of a correct answer by guessing.

**Table 2.** Items per Dimension of the Digital Divide

Dimension	Items
Digital skills	10
Material	10
Usage	41

For this analysis, the parameters of the 3-PL IRT model for each dimension of the digital divide are interpreted as follows:

- $\theta_j$  indicates the latent trait for the  $j$ -th person.
- $a_i$  indicates the relevance of the item  $i$  to describe the dimension.
- $b_i$  indicates the easiness-difficulty of the item  $i$ .
- and  $c_i$  indicates the minimum estimate for the item  $i$ .

It is important to note that for performing the modelling, each item of the survey was loaded to a single dimension of the digital divide, taking as a reference its relationship with the theoretical constructs per dimension presented in Section 2. Furthermore, the final selection of the items used to model each dimension was set after two iterations of the model, in order to review the mathematical relationship of the item with its construct through a sequence of principal component analysis [24] and the construction of Cronbach-Mesbah curves [25]. The final set of items for each dimension is presented in the **Appendix**.

By using this approach, it is possible to estimate for each person in the survey a numeric measure for each dimension. This numeric value follows a normal distribution with mean=0 and standard deviation=1. For the estimation, the MIRT R-package was used, adjusting a classic 3-parameter model without restrictions and using an EM estimation method [26]. **Table 3** shows the observed aggregated mean and standard deviation for each dimension, observing a slight greater homogeneity in the material dimension among the population.

**Table 3.** Aggregated Estimates per Dimension

Sub-indexes	Mean	SD
Digital skills	0	0.917
Material	0	0.866
Usage	0	0.916

After this modelling, an estimate per person per dimension (sub-indexes) is related to the social groups variables as shown in the findings section.

A first step consisted of performing a multiple regression analysis with the sub-indexes as active variables for the three socio-economic variables. In order to find additional relations between the mentioned variables, a Multiple Correspondence Analysis (MCA) was carried out. The MCA allows researchers to find proximities between categories, identifying groups that typically might appear and, on the other hand, variables that cannot be associated. In some cases, when the frequency of observations per category in the same variable has significant differences, categories could be regrouped to reduce the inertia of the analysis and have a more detailed result, as long as the categories had common characteristics. In this case, categories 1, 2 and 97, and categories 8 and 9 in education level were regrouped. Besides this, the same action was applied for categories 5 and 6 at the socio-economic level. The results of the scores on each dimension were divided into quartiles, given that the MCA allows finding better relationships in a more delimited group of categories.

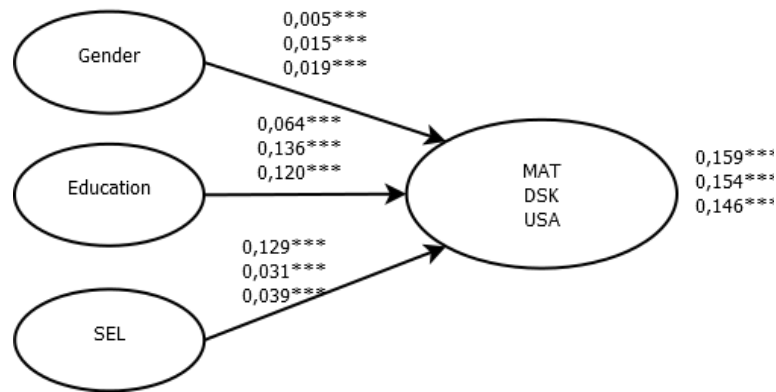
## 4 Findings

A total of 5892 observations were processed after dismissing the observations that did not present responses in the questions of interest. Multiple correlations and MCA were conducted to assess the influence on gender, socio-economic level and education level in the Material, Digital Skills and Usage dimensions indexes.

### 4.1 Multiple Regressions

Once the sub-indexes dimensions factors were obtained per observation, several multiple-regression analyses were conducted to validate the hypotheses of the existence of statistical relevance of gender, socio-economic and educational level in the results of material access, digital skills and usage dimensions.

Firstly, each variable was individually analyzed in the three dimensions. **Fig. 1** shows the individual values of linear regressions for gender, education and socio-economic level with each dimension. Moreover, the effect of all three variables on each dimension was calculated. In sum, all three factors were statistically significant to predict the dimensions of Material Access, Digital Skills and Usage. However, the R-square factor is, at its best, 0,159 in the case of material access. In that case, the socio-economic level is the most predominant variable, whereas the education level is the most important for the digital skills and usage dimensions.



**Fig. 1.** Coefficients of multiple regressions between gender, education level and SEL, and digital divide dimensions. \*\*\*p<0,001

As gender is concerned, although its statistical weight is not the most relevant, it is a sure predictor of a lower score in all dimensions in the case of females. The least relevance is observed in material access. Nonetheless, in the cases of digital skills and usage, gender is a more relevant predictor than socio-economic level. Tests of multicollinearity, mediation and moderation were applied, but those confirmed the independence of the variables.

**Table 4.** Coefficients for Material Access

		Coefficients		Dependent Variable: MAT		
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.951	.052		-18,236	.000
	Education	.122	.009	.170	13,694	.000
	Gender	-.084	.022	-.045	-3,757	.000
	SEL	.284	.011	.313	25,243	.000

**Table 5.** Coefficients for Digital Skills

		Coefficients		Dependent Variable: DSK		
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.745	.052		-14,391	.000
	Education	.245	.009	.344	27,701	.000
	Gender	-.199	.022	-.108	-9,023	.000
	SEL	.072	.011	.080	6,444	.000

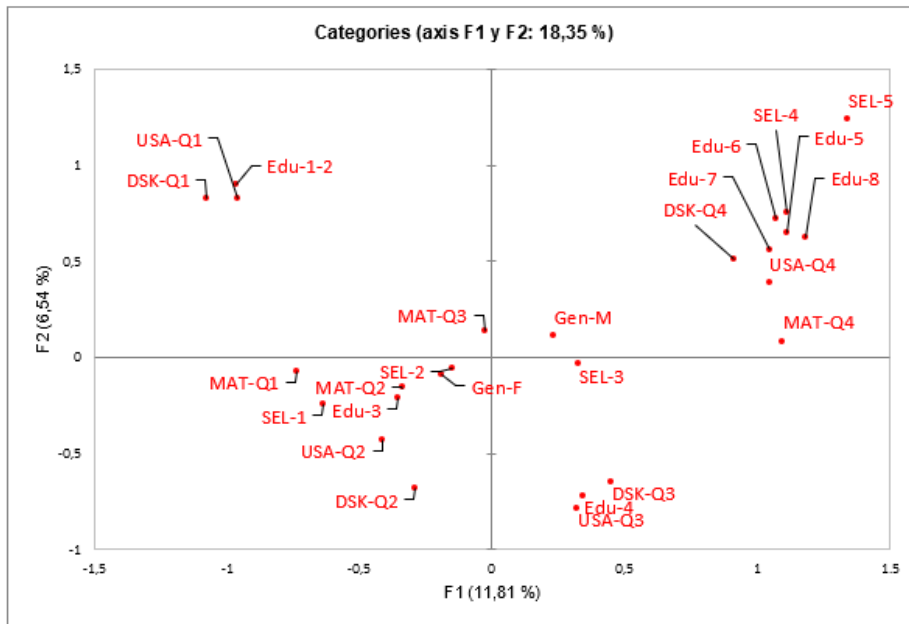
**Table 6.** Coefficients for Usage

		Coefficients		Dependent Variable: USA		
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.698	.052		-13,380	.000
	Education	.224	.009	.314	25,166	.000
	Gender	-.221	.022	-.120	-9,907	.000
	SEL	.099	.011	.109	8,759	.000

## 4.2 Multiple Correspondences

In this case, four groups could be observed (**Fig. 2**). In the first one, a strong relationship between low digital skills, low usage and the lowest education level was evidenced. The second one showed a less evident relationship between mid-low usage and digital skills, low and mid-low material access, socio-economic levels 1 and 2 and female gender. The third group relied on proximity between education level 4, and mid-high digital skills and usage. Finally, a fourth group was composed of high levels of digital skills and usage, the highest education levels, the highest socio-economic level and, to a lesser extent, men.

The MCA shows that although there are no close relations between female gender and lower results in each category, and male gender with highest results, there are subtle trends that, when gender is added to socio-economic and education level, more accurate assumptions about the results on digital skills and usage might be depicted. Furthermore, a weaker relationship between material access and the other dimensions is confirmed, leading to consider the hypothesis that material access by itself would not be enough to understand the digital divide.



**Fig. 2.** MCA for three socio-economic variables and three dimensions of digital divide

## 4.3 Regional Differences

Given that the survey was designed at a regional basis, similar correlations were carried out for each region in order to identify how the same variables provide different results. Accordingly, the results of the coefficients found are presented in the **Table 7**.

**Table 7.** Coefficients for Regional Variables

Dimen- sion	MAT			DSK			USA		
	Gender	Educa- tion	SEL	Gender	Educa- tion	SEL	Gender	Educa- tion	SEL
Amazonas	-0,094	0,066	0,188*	-0,139*	0,46***	-0,049	-0,144*	0,422***	-0,048
Antioquia	-0,130***	0,123**	0,261***	-0,090**	0,263***	0,122**	-0,138***	0,198***	0,124**
Atlántico	-0,004	0,237***	0,376***	-0,099**	0,31***	0,131***	-0,039	0,334***	0,162***
Bogotá	-0,026	0,172***	0,188***	-0,075*	0,315***	0,007	-0,141***	0,28***	0,071*
Central	-0,049	0,15***	0,348***	-0,181***	0,421***	-0,005	-0,164***	0,313***	0,218***
Oriental	-0,052	0,239***	0,199***	-0,113***	0,375***	0,048	-0,105***	0,36***	0,043
Pacífico	-0,1*	0,288***	0,22***	-0,119*	0,269***	0,145**	-0,211***	0,236***	0,099*
Valle	0,009	0,121**	0,215***	-0,125**	0,347***	0,001	-0,079*	0,266***	0,048

\*p<0,05    \*\*p<0,01    \*\*\*p<0,001

There are several partial findings which were highlighted. Firstly, although gender is still relevant at a national level, it was only statistically significant for material access in two regions: Antioquia and Pacifico, both next to each other and located in the west of the country. Despite that, the economic, geographic and demographic conditions are substantially different. While Antioquia is the second most developed region (at least in terms of GDP), Pacifico has a limited urban and economic infrastructure, as well as meaningful differences on cultural and ethnic terms. Secondly, these two regions, in addition to Atlantico, were the only areas in which the socio-economic level had statistical significance to predict the results on the digital skills dimension. Finally, the influence of the education level for all dimensions in all regions was confirmed with a unique exception for material access in Amazonas. In conclusion, it is possible to observe how some variables could be regarded as significant at a national level, even if they are only statistically significant for two or three regions.

## 5 Conclusions and Discussion

Statistical data analysis models like linear regression and MCA to test the relation of gender and the digital divide in Colombia were presented, finding that gender is a statistically significant variable in the digital divide from a multidimensional approach. Notably, women seem to score lower on digital skills and usage, and this appears to be related to the educational level. The results are coherent with previous findings on researches in other countries, reflecting that the gender digital divide might be the result of former structural inequalities. Initiatives aimed at strengthening the digital literacy of women, supporting the digitalization of their business activities or the actions to include more women in STEM higher education programs make more sense since the educational level is observed as one of the most relevant variables in the effective digital inclusion of women.

In order to gather evidence of the existence of a gender digital divide and discuss its impact, it is necessary to build measures that understand the phenomena based on a theoretical framework and a practical stake. For that purpose, the use of IRT models provides a replicable methodology that results in numeric values which can be related to other primary and secondary information available, and consequently, get a more comprehensive understanding of the divide and its characteristics. Furthermore, other data analysis techniques, such as MCA, could give other perspectives of the problematic characteristics and lead to a broader and more systemic approach of the context.

Statistics, especially at a national or regional level, might not fairly reflect the contribution of several initiatives aiming to tackle the gender inequalities on the digital divide. Furthermore, it is difficult to understand how the gender digital divide takes place in every context based on data from surveys. Nonetheless, having more accurate data about gender issues might lead decision-makers on all levels, especially in government agencies, to have a more in-depth view of the actual situation. Hence, it would be important that government agencies explore more specific data about gender issues on ICT access and use in everyday life.

Based on a critical review of both the survey instrument and results, there are some necessary reflections. Firstly, although it is evident that the aim of the application was having a richer picture of the context of the country at a regional level, the opportunity to explore the differences and how the gender digital inequalities take place was missed. On the other hand, the indicators used should be continuously reviewed for future applications in terms of its validity. Given the dynamic character of the digital divide, some items could be outdated or irrelevant in some specific contexts, and there are implications that some indicators may have when used to measure the digital divide. For instance, stating that visiting adult entertainment or sports websites are indicators for the usage dimension could lead to prevail male-dominant activities in some situations, regardless of their actual contribution for “high” usage scores. In the case of the mentioned items, for example, the proportion of women was 30% and 32% respectively, in contrast to the percentage of 54% in the overall sample. Hence, as Hafkin and Huyer argued, activities that young-adult men do online are more valued, instead of furthering media and content which might be meaningful for girls and women [27].

Whereas progress in the reduction of the gender divide is observed from the material access perspective, the categories of digital skills and usage still present signs of a gender divide. This reasserts the need for a broader definition and measurement of it, given that despite the relevance of material access, it does not represent a reliable prediction of the actual conditions of use of ICT and its implications, where men seem to keep an advantage in practice. Moreover, because of the close relationship of digital skills and usage with other socio-economic variables, the problem of individual digital divide does not respond to gender only, but by other social structural divides such as income, education level and others which were not considered in the survey and might explain better the differentiated use of ICT. Notwithstanding, regional analyses evidence that socio-economic conditions are not always the most relevant characteristics to understand the digital divide. As shown in the regional results, areas with utterly different



economic, infrastructure, cultural and ethnic characteristics can share similar results, and in turn, have different results from others “standard regions”

## Acknowledgements

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## Appendix

Set of items considered for latent trait estimation per dimension of digital divide.

Dimension	Item - Indicator
Digital skills	% of people who know how to copy or move a file or folder
Digital skills	% of people who know how to use the copy and paste function to duplicate or move information within a document
Digital skills	% of people who know how to send emails with attachments
Digital skills	% of people who know how to use elementary arithmetic formulas in a spreadsheet
Digital skills	% of people who know how to connect and install new devices
Digital skills	% of people who know how to find, download, install and configure software
Digital skills	% of people who know how to create electronic presentations with presentation software
Digital skills	% of people who know how to write a computer program in a specialized programming language (programming)
Digital skills	% of people who know how to find and download apps
Digital skills	% of people who consider having a good level of knowledge and ability to use Internet
Material	% of people who regularly access the Internet from their home
Material	% of people who regularly access the Internet from internet cafe or cabin
Material	% of people who rate the quality of Internet service in their home as good
Material	% of people who rate the quality of Internet service from the educational establishment as good
Material	% of people who rate the quality of Internet service from their workplace as good
Material	% of people who rate the quality of Internet service from an internet cafe or cabin as good
Material	% of people who have fixed telephony in the home
Material	% of people who have public open television
Material	% of people who have subscription television
Material	% of people who have Internet connection in their home
Usage	% of people who have used the internet recently to send and receive emails (e-mails) with attachments
Usage	% of people who have used the internet recently to communicate with acquaintances through call, video or chat
Usage	% of people who have used the internet recently to access social networks
Usage	% of people who have used the internet recently to create and share documents collaboratively
Usage	% of people who have used the internet recently to access alternative media (blogs, youtubers, forums)
Usage	% of people who have used the internet recently to read and / or listen to books and stories
Usage	% of people who have used the internet recently to read news from newspapers or magazines
Usage	% of people who have used the internet recently to search for entertainment information
Usage	% of people who have used the internet recently to listen to music and / or watch music videos
Usage	% of people who have used the internet recently to download music
Usage	% of people who have used the internet recently to play video games
Usage	% of people who have used the internet recently to watch / download movies, series or videos
Usage	% of people who have used the internet recently to watch online television (streaming)
Usage	% of people who have used the internet recently to share photos, videos, profiles, comments
Usage	% of people who have used the internet recently to meet new people on social networks
Usage	% of people who have used the internet recently to bet
Usage	% of people who have used the internet recently to visit adult entertainment pages
Usage	% of people who have used the internet recently to visit sports content pages

Usage	% of people who have used the internet recently to search for information to do academic tasks
Usage	% of people who have used the internet recently to carry out bank transactions
Usage	% of people who have used the internet recently to buy or offer items or services
Usage	% of people who have used the internet recently to do paperwork before a private entity (college, university, eps)
Usage	% of people who have used the internet recently to compare prices / search for offers / make reservations
Usage	% of people who have used the internet recently to find information for work
Usage	% of people who have used the internet recently to find employment
Usage	% of people who have used the internet recently to offer employment
Usage	% of people who have recently used the internet for online work meetings (skype, webex, google hangout, etc.)
Usage	% of people who use a laptop for more than 1 hour each time they use it
Usage	% of people who used social networks in the last year to access content published by others and comment
Usage	% of people who used social networks in the last year to produce their own content
Usage	% of people who used social networks in the last year to be a member of social media groups and causes
Usage	% of people who used social networks in the last year to promote and convene events or meetings
Usage	% of people who used social networks in the last year to create groups and promote social or environmental causes
Usage	% of people who used social networks in the last year to promote their business or professional activity
Usage	% of people who used social networks in the last year to express their ideas on facts or topics of public interest
Usage	% of people who used social networks in the last year to interact with public / official / state entities
Usage	% of people who used social networks in the last year to complain about the attention or service of any public entity
Usage	% of people who used social networks in the last year to support any initiative of a public entity
Usage	% of people who used social networks in the last year to report the status of roads / routes
Usage	% of people who used social networks in the last year to report accidents
Usage	% of people who used social networks in the last year to report crimes or other events that affect citizen security

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# Technology Stewardship Training for Agricultural Communities of Practice: Establishing a Participatory Action Research Program in Sri Lanka

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**Abstract.** This paper reports on a technology stewardship training program to promote ICT leadership development with agricultural extension practitioners in Sri Lanka. Technology stewardship is an approach adapted from the communities of practice literature that recognizes the importance, practically and ethically, of guiding change from within a community. The technology steward's role in development is not to impose ICT solutions on a community of practice but instead to empower members as part of a "change through choice" strategy, with the end goal of improving the informational capabilities of the community. Researchers assessed the training program using a multimethod approach with a single embedded case study. Data were collected using a pre-course survey, formal course evaluation, classroom observation, and semi-structured interviews with participants. Findings from this study show a positive response to technology stewardship training among agricultural extension practitioners in the course, that learning objectives of the course are achievable when offered as an in-service training program, that self-confidence with ICT is improved, and that some participants applied their learning in a post-course activity. This study contributes to a better understanding of the role of social learning to foster change in ICT practices among communities of practice in agricultural extension services, and in contributing to effective use of ICT for development more broadly.

**Keywords:** ICT4D, Leadership Education, Technology Stewardship, Communities of practice, Information Communication Technologies, Informational Capabilities, Choice Framework, Capabilities Approach, Agricultural Extension, Sri Lanka.

# After the Smartphone has arrived in the Village. How Practices and Proto practices emerged in an ICT4D Project

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**Abstract.** This paper presents a case study of an Information and Communications Technologies for Development (ICT4D) project in rural Bangladesh and examines the emergence of new practices connected through a theoretical lens. Social Practice Theory and different concepts of place provide a middle-range theory frame for interpretation. Two groups of 100 women living in different remote villages took part in the project and received smartphones and training. The project also established a call center and delivered timely agricultural information by voice, apps and short message service (SMS). A mixed design was used to evaluate the project progress. A baseline survey was completed in the two areas before the project started. After one year, the two groups of women involved in the project and two control groups completed a questionnaire on smartphone use practices. Episodic interviews were also conducted with a subsample of 40 participants. Project participants developed new skills and meanings associated with smartphones, which contributed to enhanced communication practices. The new practices and the emerging proto-practices at a micro-level also resulted in new perceptions of time and place and new locations for personal presence and interaction. The use of Social Practice Theory in conjunction with insights from theories of place provides a transferable framework with which to identify and emphasize what is meaningful to individuals and communities in the relationship between skills, materials and ideas with respect to different social-technical initiatives. In this regard, Social Practice and theories of place provide new insights into the integration of Information and Communications Technologies (ICTs) in development projects.

**Keywords:** Social Practice Theory, Place, Placefulness, Gender and ICTs, Bangladesh.

# Tacit Knowledge Explicitation and Sharing through Social Networks by the South African Healthcare Practitioners

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**Abstract.** Drawing from the social capital concept, this study evaluated how trust, social cognitive and social ties influence the explicitation and sharing of tacit knowledge through social networks by South African public healthcare practitioners. A model underpinned by the social capital concept was proposed and quantitatively tested with data collected from four South African public hospitals. A total of 146 healthcare practitioners responded to the survey. The results confirmed that social cognitive and trust had direct strong effects whilst social ties had moderate effect on the explicitation and sharing of tacit knowledge by South African public healthcare practitioners. The findings of this study are valuable for they elucidate factors that influence the explicitation and sharing of tacit knowledge at public hospitals through social networks. The explicitation and sharing of tacit knowledge through social networks is valuable at South African public hospitals because it provides an interface for archiving organizational experiences.

**Keywords:** Knowledge Sharing, Social Capital, South African Public Health sector, Tacit Knowledge Explicitation.



# Towards a Human Rights-Based Approach to AI: Case Study of Apprise

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**Abstract.** Frontier technologies such as Big Data and Artificial Intelligence (AI) are hailed to improve decision-making by reducing and even mitigating human biases. The emergence and rapid adoption of these technologies, particularly in optimization of services and provision of key analytics and insights was justified by the widespread benefits of AI to democratize intelligent software for all. Yet, recent studies have brought to light cases where AI has perpetuated existing biases and deepened inequalities, contributing to the further marginalization of specific groups in society. Despite the opportunities that AI offers, it also poses new threats to human freedom, fairness, non-discrimination, privacy, and security; leaving questions regarding the human rights implications of AI unaddressed. This paper proposes the use of international legal frameworks such as the International Bill of International Human Rights (including the Universal Declaration of Human Rights) to assess the human rights impacts of AI system. To ground the discussion, we present a case study to assess the human rights implications of Apprise, a multi-lingual expert system for screening potential victims of human trafficking and forced labor, piloted in Thailand. Drawing on amplification theory, we highlight that AI systems are not deployed in neutral systems, and that pre-existing inequalities and “unfreedoms” can be aggravated if not addressed. We argue for a balanced view of the potential of AI systems, cognizant of both the positive and negative intentions of users of such technologies.

**Keywords:** Amplification Theory, Artificial Intelligence, Expert Systems, Human Trafficking, Forced Labor, Human Rights.

# **Cultivating Online Virtual Community of Purpose to Mitigate Knowledge Asymmetry and Market Separation of Rural Artisans in India**

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**Abstract.** One of the key deficiencies in many marginalized rural communities is lack of linkage to local and larger metropolitan area opportunity structure, financial, technical, social and political resources. The primary reason behind this is the knowledge asymmetry between these resources and the urban marketplace and associated agencies, which often disallows rural artisans to sustain profitable entrepreneurial ventures. Knowledge asymmetry occurs when one party (the artisans) in an economic transaction possesses lesser market knowledge (or, lesser understanding about the market context in which a business operates) than the other party (urban marketplace and associated agencies). The resultant market separation derivative of knowledge asymmetry necessitates dependence on middlemen and resultant lack of autonomy for the rural artisans, which often impedes a rural community in achieving workable levels of self-sufficiency. This paper proposes building an online virtual community of purpose to mitigate knowledge asymmetry and market separation of Indian rural artisans. The community of purpose is defined as a community of people, who are going through the same process or are trying to achieve a similar objective. The paper concludes by providing an architectural framework of a Community Information System (CIS), through which we have attempted in building a virtual community of purpose for rural Indian artisans by connecting them digitally with other relevant actors in the craft production system.

**Keywords:** Information, Asymmetry, Knowledge, Asymmetry, Rural Artisans, Market Separation, Community of Purpose, Community Information System.

# Mapping the Factors Influencing the Sustainability of Public Access Computing in Africa to the ACE Framework: A Systematic Literature Review

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**Abstract.** Information and communication technology (ICT) has been widely used in attempts to address the diverse range of socio-economic challenges in Africa. Included in these initiatives is the establishment of public access computing (PAC) venues. PAC venues are spaces where the general public has access to computers and/or the Internet and are established to address ICT access in underserved and marginalized communities. Despite the good intentions of such interventions, the success and sustainability of PAC initiatives remain a challenge. A systematic literature review (SLR) was performed to determine the common challenges faced by PAC initiatives in Africa as well as the recommendations based on PAC success stories. These challenges and recommendations are subsequently evaluated against the Access, Capacity, and Environment (ACE) framework for PAC developed by Gomez. It is shown that the recommendations for PAC in Africa do not necessarily correspond to the identified challenges. In addition, a number of challenges and recommendations are identified that are not represented in the ACE framework. It is suggested that the ACE framework is extended to incorporate these factors in order to make it more relevant for PAC in Africa.

**Keywords:** Public Access Computing (PAC), Telecentres, Public Libraries, Cybercafés, ACE Framework, Information and Communication Technology for Development (ICT4D).

# The Effect of Digital Community-Based Tourism Platform to Hosts' Livelihood

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**Abstract.** In this paper, we present results of a contextual inquiry study in a Community-Based Tourism (CBT) village. We investigate the influence of an enabling digital service platform for tourism that rural Tanzanians utilise to attract and host guests. Our interviews and observations show that hosting tourists delivers positive short-term livelihood outcomes (income, visitors), but the long-term impact (social, infrastructure) to the communities requires deeper consideration. We recommend that sustainable digital service platforms for CBT should be developed and assessed including their features in addressing long-term impacts on livelihood. We propose the following topics for consideration in future development of digital CBT platforms: the role of surrounding communities, rewards to platform contributors, enabling of indirect economic activities, understanding conflict-of-interest between communities and platform, empowerment all of the users, and monitoring the local performance of the platform for its users.

**Keywords:** Digital Platforms, Emerging Economies, Sustainable Livelihood Approach.

# Development Tendency of Double-Layer Digital Divide in Mainland China: A Longitudinal Study Based on Perspective of Group Segmentation

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**Abstract.** This research makes a longitudinal analysis of a development tendency of a double-layer digital divide (access and usage) in mainland China by using data from CGSS (Chinese General Social Survey) over the period of 2005 to 2015. Results indicate that the double-layer digital divide is narrowed in mainland China from 2005 to 2015 overall, while varies among different groups. Firstly, the access gap between the western region and others in China is further widened. Secondly, although there is still a significant double-layer digital divide between male and female, the probability gap of accessing the Internet between them is gradually declining. Thirdly, communist party members have higher probability of accessing the Internet compared with those non-communist, while there is no significant difference on the usage of the Internet between communist members and non-communist. Finally, the double-layer digital divide between the young and the elderly shows the opposite tendency. As time goes by, digital divide among the young with different characteristics tends to be narrowed, while that among the elderly tends to be widened. Theoretical and practical implications are discussed.

**Keywords:** Digital Divide, Group Segmentation, Age, Education.

# ICT and Interactivity in the Classroom: A Case Study of an ICT Intervention in Indian Rural Public Schools

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**Abstract.** Amongst educators, there is a consensus that constructivist forms of learning where teachers and students actively interact to co-create knowledge is valued over instructional forms, which prioritize the transmission of information from teacher to learner. Across the world, ICTs have been applied toward enhancing learning outcomes for school children. This paper analyses an ICT intervention in rural India to assess whether ICT interventions can improve interactions in the classroom towards constructivist learning. Our study of a teacher-focused ICT intervention finds that teachers working in a resource-constrained environment use ICTs as a time and effort saving commodity resulting in little change to classroom interaction. We also find that ICTs are used passively by teachers, without unlocking their interactive potential, as they lack the ICT capacity to do so. Students continue to have minimal say in the pace and outcome of classes. Future design of ICT interventions must strike a balance between addressing teacher's constraints and providing students and teachers features that spark interaction.

**Keywords:** Classroom Interactivity, Constructivism, Information and Communication Technology.

# Towards a Resilience Framework for Integrating and Using Mobile Technologies in South African Public Rural Schools: Theoretical Considerations

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**Abstract.** South Africa has seen research and development (R&D) efforts in Information and Communication Technologies for Development (ICT4D) to provide rural schools with mobile technologies for improving the quality of teaching and learning. The challenge however is that most of the interventions fail when the project team withdraws from the beneficiary schools. The failure of the ICT initiatives in public rural schools has led to studies that aim to understand the problems related to the sustainability of these interventions, however, despite all that, ICT initiatives continue to fail in these schools. While sustainability studies have historically focused on the ICT initiatives and factors impacting on their sustainability, in contrast, this study focuses on building resilience of the education system in a way that enables the school to thrive when using ICTs. Using a Design Science Research Method, the overall study seeks to identify existing sustainability and resilience frameworks for purposes of developing a resilience framework and guidelines for South African rural schools. This conceptual paper presents the theoretical building blocks for such a resilience framework.

**Keywords:** Resilience, Sustainability, Rural Communities, ICTs, ICT4D, ICT4E.

# Appropriating Digital Citizen Engagement in Resource Constrained Local Government Service Delivery: A Case Study in South Africa

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**Abstract.** South Africa is currently plagued with destructive civic protests associated with a lack of service delivery and deteriorating local government operations. Digital Citizen Engagement (DCE) has globally been promoted as a game changer in these circumstances, as it is identified as essential in facilitating a two-way communication and evidence-based engagement between government and citizens. However, programmes in resource constrained municipalities struggle to align and integrate ICTs with existing service delivery operations. The paper proposes a framework to support the appropriation of DCE in local government in South Africa. Adaptive Structuration Theory is applied to contextualize the study, using a pragmatist qualitative approach. The findings illustrate a holistic process needed and deduce that appropriation of DCE in a local municipality is a gradual process of complex learning which depends on the strength of the civil society context, the effectiveness of the enablers of social accountability, and inevitably political change.

**Keywords:** Citizen engagement·Social accountability·e-Government·Open government·Alignment



# When the King turns Jester: A Carnavalesque Analysis of Police Outreach on Social Media in Kerala

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**Abstract.** As bureaucratic organizations enter social media spaces for public outreach, the organization of their communication assumes forms more suited to the needs, requirements and tastes of a digital society. Successfully interacting with new media users requires that the organization shed bureaucratic formality and appropriate a social media personality, with its language and viral digital artefacts. The study examines the digital approach of the Kerala Police in its use of memes based on popular Malayalam cinema, a sub-literacy that the bureaucracy shares with the public. Using a mix of interpretive examination of memes and interviews with the police, we use a carnivalesque frame to highlight ways in which the Kerala Police subverts the negative discourses related to police identity and police-public interaction through comic memes. We propose that the choice of a means of outreach that has a greater affective impact on the middle-classes, rather than the poor, offers insight into a specific moment in state-citizen relations where a bureaucratic organization's use of technology becomes the means of defining its approachability. This case also highlights the prerogative institutions have in creating solid online presences to deal with new forms of informational attacks that are enabled by viral social media.

**Keywords:** Bureaucratic Communication, Social Media Communication, Police, Humour, Cinema, Facebook, Meme, Carnavalesque.

# Perceived Factors Influencing Blockchain Adoption in the Asset and Wealth Management Industry in the Western Cape, South Africa

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**Abstract.** Blockchain is an archive of data records known as blocks with key functionalities that include validation, security and preservation. Blockchain has been applied in a wide range of industries, including the financial sector. However, little is known about its adoption and usefulness in industries operating within developing countries. Moreover, while some studies have focused on the financial sector, the Asset Wealth Management (AWM) industry remains relatively unexplored. This preliminary study has identified factors influencing the adoption of blockchain in the AWM industry in the Western Cape province of South Africa. Through a qualitative exploratory study, perceptions of AWM experts were gathered on how blockchain adoption is influenced by the technology's compatibility, complexity and relative advantage. The influence of the South African context was also explored. A preliminary framework is being proposed that will inform an in-depth, longitudinal study on blockchain adoption and use within AWM organizations in South Africa.

**Keywords:** Blockchain, Asset and Wealth Management, Adoption, Developing Countries.

# **Evolving an Efficient and Effective Off-the-Shelf Computing Infrastructure for Rural Communities of South Africa**

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**Abstract.** Information Communication Technologies (ICTs) have diffused into almost every area of life for citizens living in the Global North. Data is seen as a key element in the fourth industrial revolution and is the foundation of Information, Knowledge and Wisdom. Knowledge has become the new “make or break” asset and an inability to access the world’s data and technologies that facilitate access, synthesis and interrogation of data places one at a disadvantage. In 2013, the Department of Communications in South Africa announced a new national broadband policy to promote the reduction of a digital divide and support citizens and the economy in digital interactions. Implementation has thus far not been successful. Furthermore, the Broadband policy does not address how South Africans are to access the Internet once available. The Siyakhula Living Lab (SLL) provides an example of a computing infrastructure model for the introduction of ICTs into rural communities. Through the deployment of “broadband islands” and low-cost computing infrastructure to promote both knowledge creation and consumption, access to the proposed ubiquitous Internet connectivity can be unlocked. However, the initial computing infrastructure deployed to the SLL suffers from a single point of failure. In this paper, we discuss alternative computing infrastructure configurations that were tested and deployed within the SLL in order to determine a more appropriate computing infrastructure model for the SLL and potentially other rural South African communities; such that learners, teachers and community members can be active contributors and consumers of data, information, knowledge and wisdom.

**Keywords:** ICT4D Computing Infrastructure, Broadband Islands, Low-cost Computing Infrastructure.



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