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ABSTRACT

Prescriptive knowledge constitutes one of the important contributions of information systems design theorizing in information systems (IS) research. Existing methods for IS design theorizing apply kernel/reference theories as sources of justificatory knowledge that serve to justify and validate the knowledge produced. This has gaps in guiding how specific contexts of stakeholders and their practices can be entertained in the design process. This research attempts to address the above void, taking a socio-technically complex agricultural extension information service and the contexts that define it into account. The research builds on an existing IS design theory framework and shows how it can be improved by incorporating context into its components. It contributes to theory by adapting the existing frameworks using contextual insights from the local development practices and the stakeholders' conditions. It in turn contributes to practice by developing a context-specific knowledge that can guide practitioners engaged in rolling out information and communication technology for development interventions in such environments.

Keywords

Context, context-specific information systems, context-specific theorizing, context-specific theorizing methodology.

INTRODUCTION

The role of information and communication technology for development (ICT4D) in supporting development processes and its contribution to development proves immense (Heeks, 2002). However, ICT4D research is criticized for failing to entertain context of the development practices and stakeholders (Avgerou, 2017; Sein et al., 2019). The problem is severe in developing economies, specifically those found in Africa. For instance, the information systems targeting the value chain in agriculture domain is poorly designed, giving less attention to the low educational levels of smallholder farmers and the quality of information needed for a specific context (Muhanguzi & Ngubiri, 2022).

Moreover, scholars in developing economies, who would be more favorable as they are living, interacting, and engaging with the phenomena to produce context-specific knowledge, overlook context in their studies (Ramadani & Almaarif, 2021). Inadequate facilitating conditions to the discovery of new theories (Ramadani & Almaarif, 2021) and the universal treatment of theories in information systems where researchers ignore the context and boundary conditions of the theory in use (Urquhart, 2016) resulting in the exclusion of sensitive contexts that have an effect on theory and its wrong application (Whetten, 2009). As a result, ICT4D interventions in Africa overlook context, and lack guidelines to reflect the cultures, values, and local development realities (Krauss, 2022).

The ICT4D research is also criticized as over-simplistic (Andoh-Baidoo, 2017) showing the inadequate application of theory and context-specific theorizing (Chipidza & Leidner, 2017; Schelenz & Pawelec, 2021; Sein et al., 2019). This opens up room to produce controversial knowledge, and a lack of clarity in the knowledge contributed (Andoh-Baidoo, 2017). Moreover, Osei-Bryson et al. (2022) also reported the consideration of the value-adding, context-based potential of actors to the local beneficiary community by ICT4D research to be inadequate. As a result, projects face design/reality gaps, leading to failed interventions. As a result, there is a need for developing ICT4D-oriented design science research methodologies that reflect the above contexts (Osei-Bryson & Bailey, 2019) and tools that can offer guidelines to researchers and practitioners in the field (Gichamba & Lukandu, 2012). Such guidance on how and where context can be entertained is missing in prior research. This research attempts to build on one of the genres of design science research, namely information systems design theory, to address this gap. Contextual factors are considered important in building context-specific theories as such knowledge is key to contextualize a given phenomenon (Hong et al., 2013). These factors have been reported in Atinaf et al. (2020).

Context refers to the aspects of the environment that explain a focal phenomenon of a setting under investigation (Avgerou, 2019). Context is a methodological issue, presenting a challenge to information systems (IS) research (Avgerou, 2019; Davison & Martinsons, 2016), as well as to ICT4D theorizing (Avgerou, 2017; Sein et al., 2019). Specifically, there is a lack of methodological insight regarding how context can be included in the existing information systems design theory frameworks to guide research and practice. The fact that ICT4D research and practice is embedded in multi-faceted socio-technical factors (Atinaf et al., 2020) also recall the need for an information systems design theory (ISDT) peculiar to ICT4D. Prior works on ISDTs favor the application of kernel/reference theories (Gregor & Jones, 2007; Walls et al, 1992) giving less attention to context while theorizing ISDT. Therefore, prior research producing ISDTs that favor forms and functions are incomplete, due to their limitation to include context (Heiden & Beverunger, 2022). Hence, more research is needed on ISDT in order to guide how context can be entertained in the ICT4D research. Such understanding is required in order to show the processes of incorporating context into ISDTs and explain the link between context and ISDT components.

Different reasons are given for the lack of inclusion of contexts in the ISDTs and application of reference/kernel theories in ICT4D research. One of the arguments is that theories are limited in describing context (Zewge & Ditrich, 2017). Others argue the difficulties of reducing theoretical insights into the local development practices and stakeholder contexts (Arazy et al., 2010; Zewge & Ditrich, 2017). The lack of guiding methodologies to incorporate contexts of local development practices and the stakeholders has resulted in the deployment of poorly designed information systems (Atinaf et al., 2022; Atinaf et al., 2023). This research considers the agriculture extension information service in Ethiopia, from which context could be investigated, in order to develop the proposed methodology. The current IS applied for agriculture extension information service in Ethiopia is challenged by limited consideration

of the socio-technical factors including the structures, practices, and contexts of the information service provision; problems in the development of contextually relevant and timely content that led to weak information and communication technology (ICT) support in the agriculture extension service (Atinaf et al, 2020); and difficulty in scaling (Shilomboleni et al., 2020).

As most ICT4D research focuses on the description of context, it is suggested to shift from describing and understanding (descriptive knowledge) to context-specific theorizing that guides ICT intervention, and appropriate theories for design intervention (Sein et al., 2019) to fill the scarcity of theorizing in the ICT4D field. Further argued knowledge that both theorizes and contributes to closing the gap between linking ICT interventions and development in the context of developing economies is important and can inform both research and practice (Sien et al., 2019). To close the discussed gaps, this research addresses the following research question: How could context be included in information systems design theorizing?

LITERATURE REVIEW

Gregor (2006) identified five categories of theories: namely theory for analyzing, theory for explaining, theory for predicting, theory for explaining and predicting, and theory for design and action. ISDT is a type of design and action theory that gives "explicit prescriptions on how to design and develop an artifact, whether it is a technological product or a managerial intervention" (Gregor & Jones, 2007, p. 313). Design and action theory deals with two aspects: first, it is concerned with the methodologies and tools used in the development of IS; and second, it deals with "design principles, which are design decisions and design knowledge that are intended to be manifested or encapsulated in an artifact, method, process, or system" (Gregor, 2002, p. 17). The focus of this research is on the second aspect. Walls et al. (1992) articulate the two purposes of design theory as prescribing the properties of the artifact to be designed (deals with the product) and prescribing the method(s) to construct the artifact (deals with the process).

Information systems design theories presented in the form of design and action theories are considered more important for IS research and implementation (Gregor & Jones, 2007). This knowledge, in the form of design and action theories, is important both for providing prescriptions for the architecture of applications and guiding practitioners working with IS (Gregor & Jones, 2007). Due to its usefulness in terms of addressing rigor and relevance, ISDT research is given much attention by scholars in the field (Gregor & Jones, 2007; March & Smith, 1995; Walls et al., 1992). Design knowledge proves promising in improving our work through improving design theorizing in the industry (Gregor & Jones, 2007) as it lends support to design activities that can guide practitioners in the design of effective ISs, as well as set an agenda for future research as well (Goldkuhul, 2004). To reach the solution, Gregor (2002) and Walls et al. (1992) suggest that ISDT needs to address three interrelated elements: a set of user requirements, a set of system features or principles for selecting system features, and a set of principles for guiding the process of development.

Methodologies and Perspectives on ISDT

There are different perspectives regarding what constitutes ISDT and the process of information systems design theorizing. Gregor (2002) has argued that design theory must have well-defined constructs, definitions, and propositions and its propositions must go a step further to guide "how something should be done" (p. 18). In line with this argument, Gregor & Jones (2007) proposed an ISDT composed of eight components. The components include purpose and scope, constructs, principles of form and function, justificatory knowledge, artifact mutability, testable propositions, principles of

implementation, and instantiation. The principles instantiated in the method, tool, process, or design will be articulated in natural language, diagrams, or make up a given design theory (Gregor, 2002).

Walls et al. (1992), on the other hand, described ISDT as a prescriptive theory based on theoretical foundations to define "how" a design process can be carried out in a way that is both effective and feasible. They defined the structural components of ISDT and categorized the purpose of ISDT into two classes: one is to prescribe the properties of the artifact to be designed (deals with the product), and the other is to prescribe the method(s) to construct the artifact (deals with the process) (Walls et al., 1992). This research is related to the second purpose, i.e., the process of information systems design theorizing that takes context into account. Walls et al. further classified the ISDT aspect, dealing with the design of the product into four components: the meta-requirements, meta-design, kernel theories, and testable design product hypothesis. The first component of design theory dealing with product design is a set of meta-requirements. The meta-requirements serve to describe the class of goals to which the theory applies, and meta-design describes a class of artifacts hypothesized to meet the meta-requirements. Kernel theories, on the other hand, are theories from natural or social sciences governing design requirements and tests to check whether the meta-design satisfies the meta-requirements. Kernel theories can be academic theories, or practitioner theories in use (Ngai et al., 2009). This supports the formulation of testable predictions and relates the design theory to outcomes such as the system requirements fit (Markus et al., 2002). The design method specifies a description of the product(s) for artifact construction, the kernel theories govern the design process, and the testable design process hypotheses are used to verify whether the design method results in an artifact that is consistent with the meta-design (Walls et al., 1992).

Another methodology that introduces a new perspective on information systems design theorizing is the framework suggested by Kuechler & Vaishnavi (2012), who called it design relevant explanatory/predictive theory (DREPT). The authors claim that the DREPT "explains how and why the artifact functions as it does; specifically, it explains how novel artifact design features the effects have they do" (Kuechler & Vaishnavi, 2012, p. 397). The DREPT perspective is like that of Walls et al. (1992) and Gregor & Jones (2007), in the sense that they all apply kernel theories as main sources of justificatory knowledge to ground the design. They both promote the use of kernel/reference theories to justify the validity of the design theory being developed. However, the DREPT is different from the other two, in the way in which it incorporates informal experience-based insights into the process of justifying ISDT. Against this backdrop, there are arguments regarding the sufficiency of kernel theories to justify design theorizing. For instance, Arazy et al. (2010) have argued that kernel theories are insufficient sources to ground information systems design theorizing, due to the following four reasons. First, it is difficult to find relevant kernel theories that fit the design problem at hand. Second, all the important constructs to be designed cannot be informed from a few kernel theories, because their scope is narrow. Third, the theoretical model guiding the design doesn't provide a sufficient level of abstraction, and the constructs do not finely fit the design problem, as they are derived from the kernel theories. Fourth, kernel theories tell us only the effect, but not the magnitude of the effect. They added that there is a limitation from the ISDT frameworks in providing guidelines to link kernel theories to prescriptive statements of design.

Related to grounding ISDT, Goldkuhl (2004) has argued that ISDT needs to be justified and validated at three stages, which he calls a multi-grounding of information systems design theories. These are theoretical grounding, internal grounding, and empirical grounding, respectively. Theoretical grounding involves the use of external theories and knowledge to demonstrate grounding; prescriptive design knowledge in explanatory theories; and empirical grounding refers to grounding design theory from

explicit modifications of applications and observations or reconstruction of action rules from practice, whereas internal grounding refers to ensuring the cohesion and consistency between the design theory components. This technique incorporates the insights from kernel theories with the reflections from stakeholders and the cohesion between the components of the designed artifacts. However, the concept of context and how and where it could be entertained in the process of information systems design theorizing is not covered sufficiently.

There also exists various empirical works in the literature related to and contributing to ISDT knowledge. For instance, there exists work on ISDT for emergent knowledge processes (Markus et al., 2002); a web-based education (Jones et al., 2003); secure information systems design methods (Siponen et al., 2006); an ISDT for an RFID-based healthcare management system (Ngai et al., 2009); design of social recommender systems (Arazy et al., 2010); a design theory for supporting creative individuals (Muller-Wienbergen et al., 2011); design theory propositions for digital platforms supporting social interactions in online communities (Spagnoletti et al., 2015), etc. From the review undertaken of ISDT and design theorizing, there is a fundamental challenge that is common to all. This is related to, "how best to ground and to perform the search for a design solution that satisfies the problem constraints (i.e., requirements) while achieving the desired goals" (Rai, 2017, p. vi). In other words, the main issue is creating a link between the justificatory knowledge to the prescriptive statements about a class of systems, and the utility provided by the guidelines in an artifact (Kuechler & Vaishnavi, 2012). Therefore, grounding or justifying ISDT, the prescriptive solutions, the goals or purpose and scope of the solution, and evaluation of the solution, are among the key areas of debate, and demanding of focus.

Hence, context driven ISDT research can add new knowledge to the ISDT literature. The review of literature shows that key areas of debate in information systems design theorizing are categorized into three major types, namely: the techniques of grounding/justifying; and validating the design theorizing which kernel theories to use to inform the design; and linking the justificatory knowledge sources to designs. However, the way in which such ISDT is grounded and justified, and which kernel theories to use, remains a gap for further investigation. Though these key areas of debate are the directions for future research focus in ICT4D, this research focuses on contextualizing design theorizing.

Context and Context-Specific Theorizing in ICT4D Research

The ICT4D research domain is known for its focus on context, where lessons are drawn from it demanding to shape the methodologies, discourse, theory, and practice that better explain Global South phenomena (Khene & Masiero, 2022). Qualitative methods such as interviews, focus groups, and content analysis are among the techniques applied to analyze and figure out the context-specific factors (Truex et al., 2006). The set of such contexts fall into three main categories, namely: technology, usage, and users; with additional relevant contexts for ICT4D research, such as culture, socio-political and geo-political space to develop significant, unique, and novel theoretical contributions (Andoh-Baidoo, 2017). Whetten (2009) has also grouped contexts into two types. These are the omnibus contexts, which include occupation, location, time, and rational for collecting data; and discrete contexts that include task, social, and physical factors. From the two types of contexts, the former is useful for contextualizing research results (describing the type of data collected, etc.), whereas the latter are more directly related to the practices of contextualizing theory and using context effects as theory (Whetten, 2009). The application of the two types of contexts described above are also described in Sarker (2016).

The importance of context becomes more critical than ever before in an increasingly interconnected and globalized world (Urquhart, 2016). Context constitutes a key to researching technical and design science research, behavioral, and economic research (Fernández, 2016) in describing and explaining local truths

or realities (Sarker, 2016). Though context awareness grows over time, and it plays critical role, where empirical research suffers from a troubling lack of context sensitivity (Whetten, 2009), and where context is neglected in the implementation of ICT in developing economies (Krauss, 2021; Osei-Bryson et al., 2022; Sein et al., 2019). This has resulted in the limited inclusion of aspects of socio-technical factors in the existing ICT4D theories (Andoh-Baidoo, 2017). The attempts to consider and further conceptualize context, both in IS research (Avgerou, 2019; Davison & Martinsons, 2016; Ramadani & Almaarif, 2021), and ICT4D, are still limited (Krauss, 2022; Osei-Bryson et al., 2022; Sein et al., 2019). It is also reported that the effort to consider relevant contextual factors by researchers does not meet the expected level (Whetten, 2009). This is due to the lack of a single conceptualization of technology that will work for all usage contexts putting the technology artifact at the core of context-specific theorizing (Hong et al, 2013). As a result, the significance of context in theory development has received attention in the ICT4D research.

Context is bound up with theory (Davison, 2021), and all theories are context constrained, or context dependent (Whetten, 2009). Hence, theory needs to be *adapted* to the indigenous communities and decolonized (Khene & Masiero, 2022) where it is transposed from contexts elsewhere. Such adaptation is needed in order to appropriate theory for the context in which it is to be applied (Davison & Andrade, 2018). The responsibility for selecting theories carefully and adapting to the context at hand as well as making sure that the theorizing contributes back to the discipline in terms of theory development rests on the researcher (Truex et al., 2006).

Hong et al. (2013) have indicated three benefits of integrating context into theory development: 1) contextualization involves linking observations to a set of relevant facts, events, or points of view that make possible research and theory that form part of a larger whole; 2) theories incorporating contextual elements are often better able to explain anomalous findings; and 3) the process of deep contextualization helps to identify how context enhances or modifies understanding of a common phenomenon across contexts and also discover context-free regularities. In other words, context and theory are combined to provide explanations for the phenomenon under scrutiny (Whetten, 2009).

One of the mechanisms used to develop a context-specific theory is to take context into greater consideration to generate insights about the phenomena associated with information technologies, individuals, and organizations (Hong et al., 2013), and alienate their cultural/traditional philosophies from ICT4D spaces (Khene & Masiero, 2022). Therefore, inclusion of context in theory development can follow different mechanisms. These fall under the following six mechanisms of theory development suggested by Hong et al. (2013): 1) it can be through grounding in a general theory; 2) via contextualizing and refining a general theory; 3) thorough evaluation of the context to identify context-specific factors; 4) via modeling context-specific factors; 5) through examination of the interplay between technology artifact and other factors; and 6) by examination of alternative context-specific models. Doing these as context-specific theorizing activities leads to systematic modification of extant theory to address unique features of different contexts in ICT4D research (Andoh-Baidoo, 2017). Sarker (2016), on the other hand, has suggested three main issues to consider while context-specific theory development: a) the importance of starting with omnibus and discrete contextual elements discussed before for a given phenomenon; b) the deliberate selection of the desired level of abstraction, and the contextual elements to be incorporated (or not incorporated) in the abstraction, leading to a clear articulation of boundary conditions based on the theoretical and empirical objectives of the study; and c) recognize that the appropriate balance between contextual specificity and generality is achieved as a result of multiple iterations of induction and deduction, often across multiple studies. Contributions can be either contributions *to,* or *of* theory (Whetten, 2009). The contributions to theory include formulations

of new theory, which can be adding a new explanation to the corpus of accepted theory as an improvement in existing theory, characterized by a shift in focus from 'looking through the lens' to 'improving the lens' (Whetten, 2009); whereas contributions of theory refer to the application of theory (Whetten, 2009). The literature offers different guidelines to develop an ISDT, amongst which the work of Gregor and Jones (2007) is notable.

ISDT Guideline

This research applies the ISDT framework proposed by Gregor and Jones (2007). The framework has six core components, viz.: purpose and scope, constructs, principles of form and function, artifact mutability, testable propositions, justificatory knowledge; and two additional components, namely principles of implementation; and expository instantiation. According to Gregor and Jones (2007), the nature of the artifact can be best understood from its six core components.

Purpose and Scope

The purpose and scope of an ISDT specify "what the system is for" or the scope and boundaries of the theory and the artifact requirements in terms of its operational environment (Gregor & Jones, 2007, p. 322). A description of those classes of goals to which the theory applies also defines the meta-requirements (Walls et al., 1992). Goals that a designer does not want to see are excluded as one defines the goals of the desired artifact, and hence, the boundaries of a given theory therein reveal themselves (Gregor & Jones, 2007).

Construct (the Causa Materialis)

The constructs ISDT component defines "representations of the entities of interest in the theory" (Gregor & Jones, 2007, p. 322). Those entities can be represented in different ways, such as words, mathematical symbols, or diagrams (Gregor & Jones, 2007). One of the characteristics of design theories in IS is the possibility of representing subsystems whose design theories form part of a construct, therein providing the advantage of decomposing design problems into parts which in turn provides design parts with some degree of independence (Gregor & Jones, 2007).

Principles of Form and Function

The principles of form and function define the blueprint or architecture of the artifact, in other words, they define the "structure, organization, and functioning of the design product or design method" (Gregor & Jones, 2007, p. 325). The architecture defines different functions that the system is expected to accomplish, based on the concepts derived from justificatory knowledge, as well as kernel theories (Gregor & Jones, 2007). The principles of form and function are explained as design principles (Chandra et al, 2015; Gregor & Jones, 2007).

Artifact Mutability

The artifact mutability principle defines the changes in the state of the artifact anticipated in the theory or the extent to of the artifact is incorporated and informed by the theory (Gregor & Jones, 2007). It refers to the changing nature of artifacts due to the emergent properties and behavior from the evaluation (Gregor & Jones, 2007). Two types of changes may be introduced due to the evaluation, namely changes in system state, or changes in the basic form or shape of the artifact (Gregor & Jones, 2007). According to Gregor and Jones, artifact mutability is informed by two components, namely: the principle of form and function; and the principle of implementation.

Testable Propositions

One of the requirements of an ISDT is to provide testable propositions or hypotheses about the system or tool to be constructed (Gregor & Jones, 2007). These propositions are used to test whether the meta-design satisfies the meta-requirements, resulting in an artifact that is consistent with the design (Walls et al., 1992). The testable propositions component deals with the truth statements about the ISDT, exemplifying scientific propositions (Mandviwalla, 2015). These statements are more precise statements than the artifacts and are appropriately situated to be evaluated and compared to previous and future knowledge (Mandviwalla, 2015). Accordingly, a range of propositions open to empirical testing for future research are proposed and applied in the research.

Justificatory Knowledge

Developing an ISDT requires a definition of kernel theories and a specification of meta-requirements (Gregor & Jones, 2007; Walls et al., 1992). Kernel theory refers to the theories in the natural and behavioral sciences governing design requirements and the design process (Walls et al., 1992). It also refers to a design theory, or heuristics from practice, which can provide relevant constructs and measures from the outer environment (Mandviwalla, 2015). Kernel theories are used to: define the set of meta-requirements or goals that specify the type of system to which the theory applies and the scope or boundaries of the theory (Gregor & Jones, 2007; Ngai et al., 2009); define the scientific validation process that makes design theory valid; "provide insights into how to build something or how their object will be perceived"; or provide explanations for the design (Mandviwalla, 2015, p. 321). They constitute the linking mechanism for goals, shapes, processes, and materials and "explains why an artifact is constructed as it is and why it works" (Gregor & Jones, 2007, p. 328). It is an accepted principle that the meta-requirements will be derived from useful kernel theories once these are identified. Meta-requirements define a class of goals to which the theory applies (Walls et al., 1992). Developing an ISDT requires the definition of kernel theories and a specification of meta-requirements (Gregor & Jones, 2007; Walls et al., 1992). Kernel theories govern design requirements and the design process (Walls et al., 1992). Kernel theories are important for: defining the set of meta-requirements or goals that specify the type of system to which the theory applies, and the scope or boundaries of the theory (Gregor & Jones, 2007; Ngai et al., 2009); the scientific validation process that makes design theory valid; "provid[ing] insight[…] into how to build something or how their object will be perceived"; or providing explanations for the design (Mandviwalla, 2015, p. 321). It should be noted that the design in this research benefits from insights drawn from empirical observations. According to Mandviwalla, goals, existing kernel theories, and existing artifacts also serve to constrain the process and provide tools to move it forward.

However, there are different arguments regarding the need for and application of kernel theories. Kernel theories are suggested as sources of justificatory knowledge by Gregor and Jones (2007), but there are also arguments relevant to difficulties to reduce theories into design guidelines (Arazy et al., 2010; Zewge & Dittrich, 2017) and gaps between socio-psychological theories and design interests (Hooker, 2004); difficulty in finding relevant kernel theories for a particular problem; the narrow scope of kernel theories to cover design issues alone to guide the design; and often there is a mismatch between theoretical constructs and design requirements (Arazy et al., 2010). Recent research also argues that most ICT4D interventions inspired by western theories are acontextual (Krauss, 2021).

Principles of Implementation

This information systems design component, which is considered additional, describes how the design is realized or materialized (Gregor & Jones, 2007). It refers to the description of the processes to reach the product or method in the context of the research. It can also refer to the principles that are important to implementing a design theory in a specific context.

Expository Instantiation

Expository instantiation is used as a proof of concept of the ISDT by physically implementing it for testing or as a proof of concept (Gregor & Jones, 2007). Expository instantiation of an artifact refers to things in the physical world (Gregor & Jones, 2007). Others suggest different techniques of proof of concept, such as different types of evaluation (Möller et al., 2020; Ploesser, 2012; Yassaee et al., 2019). A conceptual artifact is also sufficient for complex designs of ISs involving multiple concepts, due to the substantial time required to develop the conceptual artifacts (Gregor & Hevner, 2013; Yassaee et al., 2019).

RESEARCH METHODOLOGY

The research was undertaken in four different but interrelated phases. Phase One identified relevant justificatory knowledge. The set of justificatory knowledge applied in this research is composed of a set of kernel/reference theories and empirical observations that reflect the context. Phase Two developed the design theory for agriculture extension information system (DT4AEIS) based on the justificatory knowledge identified for this research, i.e., insights drawn from the kernel theories and the empirical observations. The DT4AEIS serves as an abstract representation of and prescription for designing and implementing information systems that enable access to basic public agriculture extension information services through mobilizing stakeholders' resources. Phase Three is devoted to evaluating the DT4AEIS, serving as a proof of concept. Finally, Phase Four presents the refined DT4AEIS.

The purpose of this research is not to propose a new methodology for information systems design theorizing, rather it builds on an existing ISDT focusing on the interplay between context and the components of the existing ISDT. Hence, the research adopts the Gregor & Jones (2007) ISDT framework to embed context into it. Improvements have been made to some of the components concerning how context can be included in the process.

Phase One: Identifying Relevant Justificatory Knowledge

Given the initial understanding of the problem situation in the introductory section, the next process was identifying initial kernel theories guided by a holistic understanding of the problem context. Coming up with a final designed artifact at once is not possible, as not every problem can be identified at once, and not every design issue may be decoded to embrace all the potential problems at the initial stage. This requires a back-and-forth iteration from problem identification to solution formulation in design theorizing. This phase is devoted to identifying and developing relevant justificatory knowledge for the designing DT4AEIS. As highlighted in the introduction and literature review section, there are limitations in the sufficiency of kernel theories for producing design guidelines, and hence the need to draw design insights from other sources of justificatory knowledge. Empirical observations can add to this and the justificatory knowledge for the development of the DT4AEIS is drawn from both the kernel theories as well as the empirical observations from an exploratory case study, so as to incorporate context and better justify the DT4AEIS.

Justificatory Knowledge: Kernel Theories/Reference Theories

At this stage, the researchers identified initial kernel theories for the problem situation. The selection of the initial kernel theories at this point was guided by the initial problem understanding. Accordingly, the service dominant logic (S-D logic) (Vargo & Lusch, 2004) and constructs of frugal information systems and principles (Junglas & Watson, 2006) were identified, and selected as initial kernel theories after thorough review of the extant literature. In the context of developing economies, approaching a service gap from a service perspective is considered important (Srivastava & Shainesh, 2015) and the S-D logic (Vargo & Lusch, 2004), together with constructs of frugal information systems (Junglas & Watson, 2006) and frugal principles, serve as initial kernel theories in this research. The S-D logic is selected as a kernel theory, because the researchers understood that the service is offered by different, but networked stakeholders. This further provides insight that those stakeholders need to be identified to more easily identify the parties involved in the process of receiving or giving the agriculture extension information service. The S-D logic, coupled with the frugal information system, can serve this purpose, and hence the two initial kernel theories are selected. However, the initial kernel theories were not only insufficient to provide insight by means of which to understand the problem holistically, but also the initial problem understanding itself needs to be well-articulated and developed. Hence, further empirical analysis was crucial to developing a good understanding of the problem domain in detail, and to guiding the search for additional relevant kernel theories.

Justificatory Knowledge: Empirical Observation

Design knowledge from kernel theories needs to be enriched with insights from empirical data (Siponen et al., 2006). This is because it is difficult to formulate prescriptive statements that describe 'what ought to be done' purely from an explanatory statement (Goldkuhl, 2004). Rather, ISDT needs to be grounded in multiple sources of justificatory knowledge (theoretical, empirical, or internal grounding) (Goldkuhl, 2004). This section concerns the generation and application of empirical observations to ground ISDT to substantiate the justificatory knowledge from kernel theories. On the one hand, empirical knowledge has been applied in this DT4AEIS process by applying the results of an exploratory case study and evaluation of the artifact, as discussed below. On the other hand, internal grounding refers to ensuring the cohesion and consistency between the design theory components, such as whether the ISDT is grounded on goals and values (Goldkuhl, 2004).

The exploratory case study was conducted to draw justificatory knowledge from the empirical observations and as an attempt to ground the DT4AEIS on multiple sources of justificatory knowledge. The exploratory case study in this research was conducted for four purposes: 1) to develop a good understanding of the agricultural extension service context; 2) to generate justificatory knowledge for the development of the DT4AEIS to reflect the context of the local development and stakeholder's realities; 3) to be used as a basis to the search for additional kernel theories; and 4) to contextualize the kernel theories selected. A single case qualitative study is adopted as a research method in this study for the following reasons. First, it helps to explore patterns that are not guided by a priori expectations from the qualitative data (Mills et al., 2010). Second, the researcher can deeply understand, describe, and explain the situation by focusing on the nature of the research problem (Baskarada, 2014). Third, a single case study approach can provide an advantage to focus on the real-life experience and contexts of the phenomenon in question (Eisenhardt & Graebner, 2007; Yin, 2009) and in environments where users' context of action is critically important (Benbasat et al., 1987). Fourth, a single case study can help the researcher to cover the contextual conditions (Yin, 2003) in this study. Finally, a single case qualitative research approach is a widely used approach in qualitative IS research (Sarker et al., 2013) as

a suitable approach to exploring a phenomenon from its natural setting (Benbasat et al, 1987; Sarker et al., 2013). Accordingly, the researcher will be able to fully understand the problem situation and its complexity as completely as possible (Mills et al., 2010). This provides a smooth, logical transition from rich qualitative evidence to mainstream deductive research (Eisenhardt & Graebner, 2007).

Sampling and Data Collection Techniques

The data were collected from different stakeholders in the agriculture extension service system in Ethiopia. Data collection involves smallholder farmers, the development agents supporting the stallholder farmers, authorities at the agriculture extension information structures, and authorities at the research institute, who develop improved agricultural technologies; farmers' associations and cooperatives, who play key roles in distributing agricultural inputs and marketing of the smallholder farmers' produces; and agricultural information systems solution providers at four organizations. The four organizations are the Ministry of Agriculture in Ethiopia, the Agricultural Transformation Agency, Digital Green, and eCom PLC.

As part of this activity, a semi-structured interview was conducted to collect empirical data. Two protocols were used for the exploratory study: the first protocol was for development agents, farmers' associations, research experts, subject matter specialists, smallholder farmers, and cooperatives. The second protocol was for the IS solution providers, who have been engaged in developing information systems to support agricultural activities. The list of topics discussed during the interview includes stakeholders' roles, objectives, and values and the agriculture extension information provided/needed to/from a stakeholder, the collaboration made with other stakeholders, and with whom, problems or challenging issues the stakeholders face in the overall local agricultural extension development practices and the mechanisms they apply to solve it; the types, forms, and functions of information systems they use/apply to support their local development practices; factors for success and failure in the existing agriculture extension information and communication mechanisms; the methodologies applied to design, develop, and implement agricultural extension information systems; and user and system related challenges experienced in the use of information systems. Individual interviews and focus group discussions were conducted depending on availability and convenience, where a focus group consists of a maximum of seven participants. Data were collected from the participants using the Amharic language. Recruiting participants follows a snowballing technique. The process of recruiting participants and data collection was interleaved and iterated, especially at the beginning of the process. This is to check whether the data collection instrument serves the purpose of data collection and to evaluate the content.

Sixteen individual interviews and eight focus group discussions were conducted for data collection, which took place in two phases. A total of thirty-seven (37) participants were selected using snowballing as key informants in both phases. Among the 37 key participants, 29 were used in the first phase of data collection. The first phase was conducted from January 4 to February 24, 2017. The interviews started with the Director, followed by the Agricultural Extension Department Head of the Amhara Region Agricultural Research Institute (ARARI), to discuss the overall agricultural extension service in the region. The interviews conducted with the director and head were followed by two interviews at the Woreda (the lowest administrative structure next to a kebele) Agriculture Extension Office with subject matter specialists holding the positions of Head of Agricultural Extension and Head of Agricultural Extension Input Supply Unit. These experts, in consultation with kebele officials (a kebele is the lowest administrative structure in Ethiopia), facilitated the recruitment of three kebeles, nine development agents, and two individuals at the Woreda Cooperative Office. While the development agents helped the

recruitment of farmers in those rural kebeles, the Woreda Cooperative Office, which works closely with farmers' associations and is responsible for providing technical and administrative support to them, facilitated the recruitment of interviewees from three farmers' associations. Additional interview participants were recruited based on the recommendations from ARARI's Agricultural Extension Department Head. These include an employee at the Research Extension and Socio-Economic Unit of Adet Research Center and a project director at Bahirdar University (BDU), College of Agriculture (BDU) working on enhancing knowledge of the DAs. Moreover, to collect data about the information systems currently supporting agriculture extension services as well as plans, the Head of the IT Unit at the Agricultural Transformation Agency (ATA) was interviewed. The ATA is an entity working to enhance the capacity of key stakeholders in the agriculture sector. Structurally, the ATA operates at a national level, but not under the agricultural extension structure.

The second round of data collection was conducted in August 2021, as part of the evaluation process of the artifact designed for supporting the agriculture extension information service in Ethiopia. This round of data collection managed two individual interviews and two focus group discussions, following a purposive sampling technique. The individual interviews were conducted with participants from the eCom PLC and the ICT Director of the ATA. The two focus group discussions were conducted at the Ministry of Agriculture and Digital Green. This second round of data collection techniques was used to collect data from expert information systems solution providers to the stakeholders in the agriculture extension information service system. A total of eight individuals were involved in the second round. On average, each of the interviews and discussion sessions lasted from 24 - 110 minutes. All the interviews were conducted using the Amharic language, as the language of the stakeholders, and audio recorded for later transcription and analysis.

Data Analysis Procedure

Data analysis involves processing the empirical material collected to make contribution claims via data coding processes (Sarker et al., 2013). Analysis has proceeded with organizing the data collected from the same stakeholder's group together. However, some research questions were not fully addressed by all stakeholders. For example, farmers, development agents, those in the farmers' associations as well as the subject matter specialists did not fully respond to questions dealing with forms and functions of the information systems they require. They were able to list details of the information they needed from the stakeholders within their network. The interview data were first transcribed verbatim and then translated from the Amharic language to English language by the researcher. This helped the researcher to understand the data and the phenomenon under study before coding begins. The transcription and translation were later checked by an English language professor for correctness. The check involved comparing the Amharic and English transcripts to verify that no content was lost or misrepresented during the translation process. Then the data was sorted to make it manageable (Flick, 2014) and organized according to specific interview questions once transcription was completed. Thus, data collected from the same stakeholder groups were managed together. In qualitative data analysis, a sentence has a great potential to generate ideas (Bazeley, 2013). As a result, codes were developed from sentences until the last line of each interview in the case database is finished. This coding technique provides the advantage of applying "all relevant codes to the whole meaning unit" (Bazeley & Jackson, 2013, p. 144) and generating initial categories (Strauss & Corbin, 1998). The open coding technique is applied to develop codes by reading and rereading the data iteratively based on Saldaña (2009) and then categorized based on concepts in the research objective and interview questions. Further analysis of the codes produces categories and sub-categories. The categories were further analyzed for conceptual similarities to develop higher-level categories called themes. According to Saldaña, "a theme is an

outcome of coding, categorization, and analytic reflection" describing and organizing observations in a unit of data and its meaning or interpreting aspects of the phenomenon (p. 139). The themes were developed based on the relationships or connections between categories and sub-categories within and across the stakeholders (Strauss & Corbin, 1998).

Phase Two: Developing the DT4AEIS

This phase involves multiple activities that are important to produce the desired artifact: defining the purpose and scope, defining the constructs, defining the principles of form and function, developing principles of implementation, developing testable propositions, and evaluating the mutability of the DT4AEIS artifact.

Define Purpose and Scope of the DT4AEIS

The purpose and scope specify the boundaries of the DT4AEIS and its requirements in terms of its operational environment based on information drawn from the results of the empirical observation. Agricultural extension service is inherently an information transfer service (Gebremedhin, 2006) involving uniquely identified stakeholders. The IS to which the DT4AEIS is to be designed is expected to function as an access point to a basic agricultural extension service. The exchange of services is facilitated through information (Breidbach & Maglio, 2016) and agricultural extension service is inherently an information transfer service (Gebremedhin, 2006).

Define Constructs of the DT4AEIS

Constructs of an ISDT define "representations of the entities of interest in the theory" using words, mathematical symbols, or diagrams (Gregor & Jones, 2007, p. 322). The entities of interest for the DT4AEIS are defined from the combined insights drawn from the justificatory knowledge sources, namely from the set of kernel theories and results from the empirical observation. The constructs of ISDTs represent subsystems providing an advantage of decomposing design problems into parts with some degree of independence (Gregor & Jones, 2007). Similarly, the constructs of the DT4AEIS are designed to achieve this in order to make the design theory simple and easily understandable. The research draws the constructs of the DT4AEIS from the justificatory knowledge, where a construct targets a problem or closely related problems.

Principles of Form and Function

The principles of form and function component refer to the blueprint or architecture of the artifact that defines the "structure, organization, and functioning of the design product or design method" (Gregor & Jones, 2007, p. 325). The design principles of the DT4AEIS define the forms and functions that the agriculture extension information system (AEIS) is expected to accomplish, based on the concepts derived from kernel theories and further developed from exploratory study results. Stakeholders, stakeholder networks, and their information needs are identified in the exploratory case study. The design principles are mapped from the justificatory knowledge and presented following the Chandra et al.'s (2015) guideline in such a way that it can be used in the practice of building a purposeful AEIS. The details of this guideline and how the development of the design principles is drawn from and guided by the justificatory knowledge is presented in the Findings section.

Principles of Implementation

The principles of implementation component of an ISDT are a description of the processes to reach the product/method or how the design is realized in the context of the research (Gregor & Jones, 2007). This design component is guided by the problem context and reflects on the findings of the previous phases: the justificatory knowledge, the purpose and scope, the constructs, and the principles of implementation. According to Gregor & Jones, principles of implementation and expository instantiation are additional components in information systems design theorizing, where the first six components (also called core components) detail what the artifact is about. This design component is an additional one showing the component is optional. Accordingly, mobilizing for effective use of existing resources in resource-constrained environments is the core concept around which the implementation principles revolve.

Testable Propositions

One of the requirements of an ISDT is to provide testable propositions or hypotheses about the artifact (Gregor & Jones, 2007). Propositions are the truth statements about the design theory exemplifying scientific propositions (Mandviwalla 2015). The DT4AEIS draws truth statements from the justificatory knowledge that is from theoretical insights and empirical observations. Testable propositions are more precise statements that can be evaluated and compared to previous and future knowledge (Mandviwalla 2015). Accordingly, a range of such propositions is drawn from the justificatory knowledge insights which can be tested by researchers in different settings. Hence, this set of testable propositions is open to being tested empirically.

Artifact Mutability

The artifact mutability principle defines the changes in the state of the artifact anticipated in the theory or the extent of the artifact being incorporated is informed by the theory (Gregor & Jones, 2007). However, justificatory knowledge from empirical observation is also important in this explanation, and the mutability of the artifact is informed by the context. The application of the knowledge from the two justificatory knowledge sources will change the nature of the artifact, and such a change due to the emergent properties and behavior from evaluation accounts for either a system state or changes in the basic shape/form of the artifact (Gregor & Jones, 2007). Mutability can be informed by the principle of form and function and principles of implementation (Gregor & Jones, 2007).

Phase Three: Evaluating the DT4AEIS

Evaluation is done as a proof of concept (Gregor & Jones, 2007) to ensure the usefulness and practicality (Gregor & Hevner, 2013) of the DT4AEIS. There are different arguments regarding instantiation as techniques for proof of concept in design science research producing a form of artifact in general. Those who viewed instantiation as an optional activity of design theorizing (Baskerville & Pries-Heje, 2010; Moody, 2009; Ploesser, 2012) suggest analytical generalization as a method of evaluating the artifact. Those who do not opt for expository instantiation argue that expository instantiation generates system instances that can be tested using other methods again that generate statements about the quality of system instances, but not the quality of the design theory itself (Baskerville & Pries-Hije; Ploesser, 2012). As a result, ISDT should follow a technique that can measure both the design theory level (system class) and artifact level (system instance), such as applicability and actionability (Ploesser, 2012). The same evaluation technique has also been used by other researchers as means for a proof of concept (Möller et al., 2020; Ploesser, 2012; Yassaee et al., 2019). Moreover, Gregor and Hevner have also suggested the use of such evaluation methods for complex designs of IS,

as it consumes substantial time to develop the conceptual artifacts. According to Ploesser, two properties, namely the relevance and novelty and the utility variables are the parameters to be evaluated. Evaluation of DT4AEIS also examined these parameters. Hence, the DT4AEIS is assessed whether the outcomes from the design theorizing satisfy the purpose of the design.

However, the evaluation must be done in a rigorous process that may apply observation, analysis, experiment, simulation, test, and description (Hevner et al., 2004; Shedlock et al., 2016). The degree of the evaluation required needs to be flexible as any proof of concept that is based on a final summative test in case studies, experiments, expert review, simulations, statistics on usage data for implemented systems, and evidence of impact in the field may be sufficient (Gregor & Hevner, 2013). They further explain that "when a researcher has expended significant effort in developing an artifact in a project, often with much formative testing, the summative (final) testing should not necessarily be expected to be as full or as in-depth as evaluation in a behavioral research project where the artifact was developed by someone else" (p. 351).

The research adopts a focus group discussion technique (Tremblay et al., 2010) and key informant interviews to evaluate the DT4AEIS. The purpose of the focus group is to examine options for further improvement of the DT4AEIS and as a confirmatory technique to assess the utility of the DT4AEIS discussed above. Among the utility variables, this research applies applicability, actionability, perceived usefulness, perceived ease-of-use, relevance, and novelty of the design theory.

One of the needs of doing the evaluation is to ensure the validity of the research outcomes. The validity of the DT4AEIS has been ensured at various stages of the research process. For instance, the fact that the DT4AEIS is derived from the two justificatory knowledge sources guarantees the DT4AEIS components are generalizable to a class of requirements and a class of system solutions constitutes one measure of validity. Moreover, the observations made through the exploratory case study entail the requirements are also grounded in empirical data, which further supports the truthfulness and applicability of the solution to a class of requirements. However, this is not enough, and a formal method of evaluation founded on empirical data is important.

The evaluation of the DT4AEIS is made with different organizations that are involved in rolling out agricultural IS. The subjects involved are experts in the field, i.e., the IS developers and decision-makers in the relevant organizations selected for evaluation. In this way, the evaluation process is triangulated across organizations. This offers the opportunity to iteratively adapt, empirically examine, and reformulate the DT4AEIS with the contexts with newer contexts (Sarker, 2016). The organizations are included purposively for evaluation due to the difficulty involved in obtaining a complete list of organizations involved in rolling out agriculture extension IS in the sector. The selection of the organizations then follows a purposive sampling technique and applied snowballing method. The inclusion of the subjects within the organizations is based on their expert experience and the role and involvement of the subjects in the design, development, and implementation of agricultural IS. The organizations include the ATA, eCom Technologies PLC, digital green, and the Ministry of Agriculture to the Federal Democratic Republic of Ethiopia. ATA is an institution organized to operate under the Ministry of Agriculture in the Federal Democratic Republic of Ethiopia, with the responsibility to lead the transformation of the agriculture sector in Ethiopia. One of these responsibilities is identifying potential digital interventions in the agriculture sector and rolling out the interventions at the country level. The ATA is selected due to the extensive experience it has in rolling agriculture information systems (mainly an interactive voice response (IVR) system and a small messaging service (SMS) system). Snowballing started with the recommendations given by the ATA for the next organization to be approached where the ATA has indicated the eCom Technologies PLC and Digital Green. The

organization, eCom Technologies PLC, is a supplier engaged in the design, development, and implementation of agricultural extension information systems needed by other organizations. The eCom Technologies PLC is selected due to its extensive experience in the design, development, and implementation of AEISs, including ATAs' IVR and SMS systems. The third organization included in the evaluation process is Digital Green. Digital Green is involved in rolling out ICT interventions in the agriculture sector to empower smallholder farmers via supplying agriculture-related information. It is selected due to its experience in providing agriculture-related information to smallholder farmers via an IS they rolled out for this purpose. The Ministry of Agriculture to the Federal Democratic Republic of Ethiopia is working on and coordinating various digital interventions as the responsible organization at the top level of agricultural practices in the country. The procedure for evaluation follows four steps: first, informal contact was made with the organization and the subjects of evaluation. Following the informal contact, the evaluation material was sent to the subjects for them to read it ahead. This is purposefully done so as to enable subjects to grasp the contents before the evaluation, so that they can provide reflections on further improvements of the DT4AEIS. Then arrangements were made for a further face-to-face discussion on the contents of the evaluation. Second, the researcher physically presented the context and issues, and challenges of the agriculture extension information service. Following this presentation, subjects were asked to present their questions according to their prior readings of the evaluation material in such case that they have problems clearly understanding the material and to give them a chance to present the problems they experienced in the current agriculture extension information service. Thirdly, the researcher presented the need to improve (if any) the AEIS in terms of the purpose, scope, and requirements, and the context of the agriculture extension information service. Finally, every component of the DT4AEIS is presented and subjects were asked about potential improvements to the above utility variables.

The same protocol is applied to all subjects approached for evaluating the DT4AEIS. Focus group discussions were made with the subjects, except for the ATA and eCom PLC, where individual interviews were conducted instead. A single individual is approached at the ATA because the ATA lacks the programmers required to develop its IS. This is due to the fact that the Ethiopian finance system does not allow payments for IS developed by internal staff for government organizations. Hence, the ATA is only allowed to procure for external organizations and can hire experts for support and assistive services for already installed systems. This individual has participated in the development and implementation of the ATAs' system and is currently heading the ICT department at ATA. The subject at eCom PLC is the owner and the Chief Technology Officer of the company. He was the project manager during the design, development, and implementation of the ATAs system. These two subjects have experience both in decision-making processes and in developing agriculture IS in the organizations. In terms of their education level, all subjects hold master's degrees.

Phase Four: Refining and Presenting the Final DT4AEIS

The DT4AEIS is refined following the multiple evaluations made with the subjects from different organizations. The iterated evaluation with subjects from different organizations offers the advantage of further grounding the design of the DT4AEIS empirically and considering the context of the local development practices and stakeholders. The iterations also include moving between refining the justificatory knowledge and the design components of the DT4AEIS. In this respect, it provides the opportunity of multi-grounding the DT4AEIS. The final DT4AEIS is presented according to the guideline of the design theory components (Gregor & Jones, 2007). Hence, the results of the study will be structured and organized based on the principles presented in Gregor & Jones (2007). This final

DT4AEIS is presented under the design theory for AEIS. Finally, the researcher presents the contributions of the design theorizing and concludes the design theorizing process of the AEIS.

FINDINGS

Demographic Characteristics of Subjects

The demographic data of the subjects used for data collection shows mixed characteristics in terms of their educational level, gender, and access to digital infrastructure. In terms of educational levels achieved: two have a third degree, eleven of them have second master's degrees (MSc/MA), thirteen have first degrees (BSc/BA), five have diploma certificates, and six of them have low levels of functional literacy. Among all subjects, five are female, where two are farmers, two are development agents and another is from organizational experts who provide information systems solutions. All have access to mobile devices, either feature phones or smartphones, aside from two smallholder farmers.

Stakeholders, Communication Mechanisms, and the Challenges or Issues

The findings of the exploratory data analysis are organized under stakeholders, information communication mechanisms they apply, and the challenges or issues they face to effectively communicate agriculture extension information so as to support their day-to-day agriculture development practices. Because part of the data used in this manuscript is published in other manuscripts (Atinaf et al., 2020; Atinaf et al., 2022), and because the focus of this manuscript is on the contextualized methodology, the main findings will be presented here.

As part of our understanding of key stakeholders and their agricultural extension information needs, we analyzed actors followed by their agricultural extension information needs from other stakeholders. The unique codes developed for this purpose were further analyzed and resulted in 39 categories, and then five major themes of agriculture extension services, about which stakeholders need information to support their local development practices. These include crop production, animal health and breeding, natural resources protection and use, market price information, and feedback on new (improved) agricultural technologies priorities. Each participant stakeholder in the local development practice has specific information that needs to be fulfilled. This implies participatory or pluralistic nature of the information service. An agricultural expert at the Woreda agricultural extension department described this as follows:

> The agriculture extension information service is delivered in collaboration with the stakeholders. It involves smallholder farmers themselves, development agents, and development groups formed from selected smallholders, agricultural input suppliers, agriculture research institutes, cooperatives, farmers associations, agricultural experts (subject matter specialists), and non-governmental organizations operating in the specific local agricultural development community practices.

The stakeholders are networked for the services they seek, or that they render from/to the other stakeholder groups. The involvement of different stakeholders and the associated heterogeneity in different institutions and at different levels of the agriculture extension structure opens room for different requirements to be met by the information system. Analysis of the factors that helped stakeholders to easily communicate agriculture extension information indicated that the existing social structures at the smallholder farmers' community level, the diffusion of mobile cellular phones in the case study area, and training offered to the social structures by the experts in their local residence are

key enablers of agricultural extension information communication. A development agent working with smallholder farmers in a local village described this as follows:

> Development agents are very small in number compared to the total size of smallholder farmers who need the service. However, the existence of the farmers' development groups and leaders within the groups, the diffusion of mobile phones in households, and the training administered by the development groups themselves and experts locally supported us in meeting the objectives.

The stakeholders also showed their preference if the information systems to be designed in the future would help them get linked to research centers, get support on exchanging multimedia information, get access to market information, meet with supervisors, get feedback information from experts, and get locally adaptable (localized) agricultural information services. The results from such analysis provide insight regarding how an IS for the agricultural extension service system is to be designed and implemented.

Challenges and issues that affect the agriculture extension information service system that necessitates or constrain information systems interventions are classified into nine categories, and further into four themes. These themes include IS development methodologies applicable to the contexts of local agricultural development practices and stakeholders, lack of/limited access to basic agriculture extension information services, digital literacy, and access to market information. Therefore, the current agriculture extension information service system is also facing challenges that relate to the lack of information systems development methodologies that took multiple contexts of the local agriculture and extension information service practices into account, the lack of/limited access to the information service, the low level of stakeholder's digital literacy, and the lack of/limited access to market information. The challenges related to AEIS development methodologies accounted for two issues. One is the lack of tools that can guide the rollout of AEIS; and the other is the challenges reflected in the information system. One of the respondents emphasized the lack of such AEIS development methodologies and its impact as follows:

> In our country, there is a problem with coding that comes to our mind suddenly; it is the same in this project. The project doesn't follow software development/software engineering principles, lacks documentation, and there are problems while integrating and scale-up.

In practice, the agricultural extension information provision involves different stakeholders whereas the information systems applied are centralized. One of the respondents explained the slowed frequency of updating content as "…information is updated every six months", which forces one to question the currency and timeliness of content stored in the information system. Related to the above description, an informant explained the situation and the impact it had as follows:

> The information package and best practices are not transferred appropriately and timely from agricultural research institutions, the frequency of updating the information in the system is once in six months, and the system requires farmers to describe their agro-ecological zones which even vary at a level of a small village, and they are also asking the specific administrative locations and agro-ecologies of the smallholder farmer who is seeking assistance. Smallholder farmers rarely know this information and that also requires the expert to know the agroecology of every location in the country, which is difficult to do.

Access to market information is a challenge to the local community within the environment. Coupled with the unpredictability of market prices that do not last uniformly for a long time, this adds challenges for smallholder producers. It is also evident from the data that the agricultural extension information

service is limited in its geographical coverage. For different reasons, some of the services are not reachable to stakeholders. Two such reasons contributing to this are the low number of agricultural extension information service support staff; and the geographical distance that the service seekers must travel to get the information service. Some of the smallholders at the grassroots level even lack capacities to apply the information received to solve their contextual problems. A respondent described this as follows: "There are problems in transferring information packages and best practices properly and timeously because of the receivers' ability and the frequency of knowledge being updated in the existing information system."

Some of the members at this level also lack access to digital devices such as mobile phones or computers. There are still other stakeholders who have access to the devices, but are not proficient in retrieving, locating, and applying the information presented as digital content in the information systems. The other issue related to stakeholders is the limited access to/lack of AEIS in general. One of the smallholder farmers explained this as follows: "…the problem is serious for female Das, who cannot walk for long-distance and cross dense forests due to security reasons; and also, farmers, who are near to them seek information frequently, but those at some distance do not."

In addition to the cognitive gaps to apply the information received to solve own problems, the low level of digital literacy is a critical issue for some of the stakeholders. An interviewee from one of the stakeholders has reflected on his doubts about whether the experts at the grassroots level can apply information technology, as "though smallholder farmers own mobile phones, I doubt whether they can properly use the devices to get information from stakeholders."

Most ISDT development starts with defining its purpose and scope, which implies that the researcher is aware of the context of the research setting a head. This is not the case for every context, such as in the case of this research, which demands a deeper understanding of the local development practices and stakeholders (organizations, people, associations, and groups) contexts. Hence, it would be difficult to define the purpose and scope of the ISDT before conducting an exploration of the context in which the artifact is to be implemented. Such exploration has four purposes: one, it is used to understand the problem context; second, it guides the search for further kernel theories; third, the result should also be produced in a form to be used as a source of justificatory knowledge, and fourth, it is used to contextualize the theoretical insights from kernel theories.

From the stakeholder's perspective, the agriculture extension information service involves different, but networked actors. They are networked for a specific type of service, are/should be identified, they apply different mechanisms of communication. Therefore, stakeholders, stakeholder networks, stakeholders' information needs, information communication mechanisms applied, reasons or factors for effective communication of agriculture extension information, challenges/issues in the agriculture extension service system, AEIS development methodologies, and content development, types, forms, and functions of current AEIS, stakeholders' digital literacy levels, and social structures in the communities, all have implications in contextualizing the information system needed and the existing knowledge on information systems design theorizing. However, the challenges discussed above are also the factors to implement successful information systems.

Having the initial problem understanding established, this research started with identifying relevant justificatory knowledge that can provide useful insights to theorize the DT4AEIS and develop a contextualized methodology. As described by Hong et al. (2013), justificatory knowledge is drawn from two sources, where empirical observation and kernel theories present one of the contributions and improvement areas via inclusion of context into the existing ISDT components. To include the context

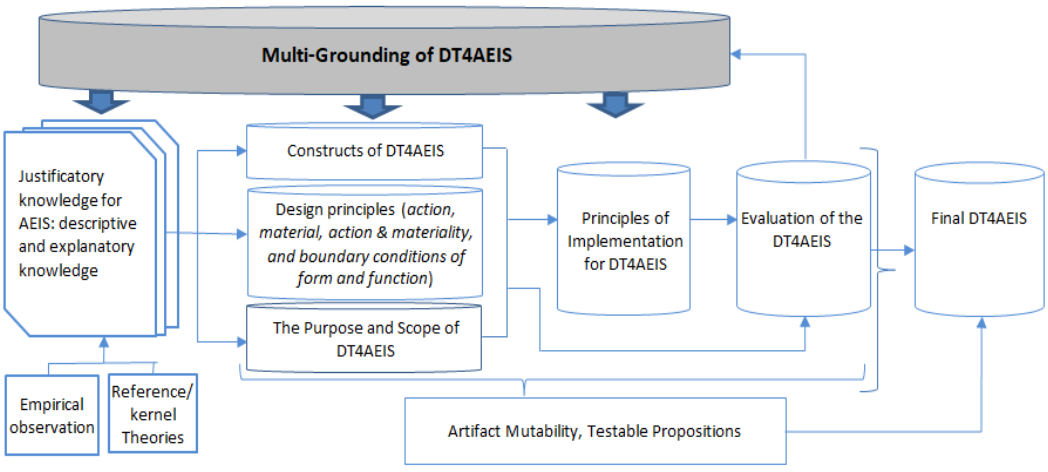
of the research setting, the sources of justificatory knowledge for the DT4AEIS are grounded on insights drawn from kernel theories and empirical observations.

The case study results enabled the authors to refine and conceptualize the initial kernel theories as well as to search for additional kernel theories. The human-computer interaction and the agentic perspective of social cognitive theory are added to the initial set of kernel theories. The networked/pluralistic information service delivery also informs stakeholders are not only users of information, but also generate content. The S-D logic offers four theoretical constructs to shed light on this phenomenon: actor networks, applying the actors' resources and creating resource density, resource integration, and decoupling information resource so it cannot be limited across space and time. The frugality principles and frugal information systems offer four constructs, namely: uniqueness, ubiquity, unison, and universality. The frugal constructs offer unique identity of stakeholders, enable access to information without the limits of space and time from a common source and format, respectively. The human-computer interaction principles provide design and use mechanisms to users with different digital literacies levels. The agentic perspective of social cognitive theory on the other hand offers three constructs to address issues of agency, namely: direct personal agency, proxy agency, and collective agency. This theoretical insight sheds light onto how users of mixed digital literacy levels be agents given the context of the research setting, where there are stakeholders who can have full control of the IS, those who do not have, and where there is a collective entity such as in the case of farmers groups and farmers' associations. The findings are also applied to contextualize the kernel theories i.e., to explain the features of the constructs the kernel theories offer and describe them in the context of the problem.

Context is also continuously adapted to the DT4AEIS from the iterated evaluation made by the authors and the evaluation of the DT4AEIS, which is triangulated by different experts at different organizations. This has adopted the concept of multi-grounding ISDT by Goldkuhl (2004) and applied the Chandra et al. (2015) template in order to formulate design principles together with the Gregor and Jones (2007) framework in developing the DT4AEIS (see Figure 1 below).

Figure 1

The DT4AEIS



Note. Adapted from Gregor & Jones (2007); Goldkuhl (2004), and Chandra et al. (2015). DT4AEIS = Design theory for agriculture extension information system; AEIS = Agriculture extension information system.

As depicted in Figure 1 above, the research starts from identifying justificatory knowledge to the development of the prescriptive knowledge for the DT4AEIS. The kernel theories suggested as justificatory knowledge sources in prior research (Gregor & Jones, 2007; Walls et al., 1992) were complemented with results from empirical observation, which allowed incorporating context at this stage producing descriptive and explanatory knowledge for the DT4AEIS. The set of kernel theories from which theoretical insights were drawn includes the S-D logic (Lusch & Nambisan, 2015), frugal principles and constructs (Watson et al, 2013), information availability (Qadir & Quadir, 2016), HCI principles (Qadir & Quadir, 2016), and agentic perspective of social cognitive theory (Bandura, 1999). The empirical observations that complement the kernel theories include: stakeholders; stakeholder networks; stakeholders' information needs; information communication mechanisms applied; reasons or factors for effective communication of agriculture extension information; challenges and issues in the agriculture extension service system; AEIS development methodologies and content development; types, forms, and functions of current AEIS; stakeholders' digital literacy levels; and social structures in the communities. These observations are used to contextualize the insights from the kernel theories and describe the artifact features.

In turn, justificatory knowledge is used to define the purpose and scope of the DT4AEIS that lays the ground to define the requirements of the IS and the constructs needed. Accordingly, the purpose and scope of the DT4AEIS are grouped into four main requirements. These include addressing the requirements of the participatory/pluralistic agriculture extension information service; building contextually relevant information content that fits stakeholders' agronomic practices and contexts; improving accessibility of the IS by actors in terms of the devices used, infrastructure, literacy, and linguistic diversity of stakeholders, especially smallholder farmers; and improve the use and adoption of the agriculture extension IS by the stakeholders involved. This is followed by the development of the design principles that address the forms and functions of the IS that satisfy the requirements defined above. These components were developed being guided by justificatory knowledge and further contextualized with the descriptions from empirical observations. The principles of implementation and testable propositions of the DT4AEIS are also informed from the justificatory knowledge sources.

The justificatory knowledge sources offer principles from which the testable propositions were drawn and contextualized, with the results from observations of the empirical study and the evaluation process. The constructs of the design theory also emerge from the contexts of the local development practices and stakeholders' contexts. Moreover, the design principles that define the forms and functions of the DT4AEIS are derived from the justificatory knowledge appropriated through evaluation. The activities and the learning from the preceding steps to develop the final DT4AEIS are iterated by the researchers for multiple times. Then the result is ready for evaluation and hence, follows the evaluation of the DT4AEIS. In parallel, testable propositions were developed and the mutability of the artifact is assessed. The testable propositions are drawn from justificatory knowledge as well. Similarly, the mutability of the DT4AEIS is assessed not only from the perspectives of the kernel theory insights, but also from the empirical observations, which reflect the contexts. Hence, artifact mutability is a result of both mutability in the kernel theories applied and the empirical observations from the exploratory case study. The results of the evaluation lead either to further grounding and justifying the previous components of the DT4AEIS or to producing the final and refined artifact.

The multi-grounding takes place to any of the components of the ISDT as depicted in Figure 1 above. Multi-grounding in this model refers to justifying and validating the components of the DT4AEIS through reference/kernel theories and empirical observations as justificatory knowledge, and from evaluation of the artifact. It is done through additional justificatory knowledge or improving the use of

the selected theories to close the issues, refining the purpose and scope, the constructs, the principles of form and function, the principles of implementation, or the testable propositions of the DT4AEIS according to the insights from the empirical observations or the reference theories. The process ends with developing the final artifact, the DT4AEIS.

DISCUSSION

The findings show that context-specific information systems design theorizing should take local resources, knowledge, stakeholders, and access to resources into account. In this research, a qualitative exploratory case study was conducted to depict this. The result from the exploratory study was used as sources of justificatory knowledge, and complemented the kernel theories, which were granted as sole sources of justificatory knowledge in prior studies. Moreover, the findings from the exploratory case study were used to refine the selection of kernel theories, as well as to validate the definition of the design principles. The authors have developed manuscripts on the results from the exploratory case study, the design principles, and the justificatory knowledge in other studies (first revision due). The context shows the stakeholders and their networks, the resources they have access to, or they own, their literacy levels both functional and digital literacy, the mechanisms they applied to create, store, access, and disseminate information/content, and the type of agency required to engage them in an actor-to-actor networked environment. In turn, this has offered an opportunity to further refine the initial kernel theories, development of contextualized design principles by justifying through the above findings, defining, and contextualizing the purpose and scope and constructs of the DT4AEIS; as well as a better understanding of the mechanisms needed to implement the information system, to define contextualized testable propositions, and to complement the set of justificatory knowledge drawn from kernel theories.

The importance of context in design theorizing begins from understanding the problem situation in terms of the context of the local agriculture development practices and the stakeholders. Heiden and Beverungen (2022) have also suggested providing a description of the context to understand how an artifact must be designed to fit the context. Though we agree with this recommendation, we extended the description beyond problem understanding and reflection of context and its purpose in each of the components of the DT4AEIS provided. For instance, the requirement to meet the participatory information service and the information content to be stored or communicated with stakeholders are among the contextual reflections to be presented as requirements. Agricultural content is dependent on the specific agro-ecology where the information is needed. Third, the stakeholders' contexts demand the AEIS be adapted to the devices used by the stakeholders to access content, the infrastructure specifically the telecom service, the literacy levels of stakeholders, and linguistic differences of the agriculture community at different locations. Fourth, the IS is also required to be adopted and used effectively by the stakeholders, most importantly, by the smallholder farmers. As a participatory information service system, the concept of a user is different in this context. The participation of stakeholders in the creation and dissemination of the information service makes them social actors, who are not only consumers of information supplied, but also contributors (Lamb & Kling, 2003). Hence, the stakeholders and the service networks in which they are involved need to be identified and should be given known roles in the IS, and this information needs to be stored.

The other component of the ISDT in which context ought to be incorporated is the constructs of the IS. Constructs are considered subsystems of the IS, which embed the forms and functions explained by the design principles (Gregor and Jones, 2007). Hence, context at this stage is embedded in the design principles of the DT4AEIS. Design principles are formulated in such a way as to incorporate the boundary conditions that specify such specific contexts of development practices and stakeholder

contexts. The boundary conditions of the design principles specify the contexts of the local development practices, the stakeholders' contexts, and information describing the phenomenon about which they seek information (such as the plot of land where their crop is growing and the situation). Those socio-technical information requirements are specified as features in the DT4AEIS.

The principles of implementation should also be in line with the local development practices and stakeholders' contexts in terms of the above specific stakeholder conditions. For instance, the principles of implementation should specify the need for a method to co-create content and enhance the actions of the stakeholders, mechanisms of enabling adoption and effective use of the AEIS, enable roles to support the participatory information creation and dissemination, empower the agriculture community a self-help community, towards a resilient agricultural practice and community. Testable propositions need to be formulated as per the contextual settings identified. The testable propositions are drawn from the principles applied to the DT4AEIS. These principles were actor-to-actor networking, the resource liquefaction and resource density principles, the resource integration principle, the frugality principle, the HCI principles, the direct personal agency principle, the proxy agency principle, and the collective agency principle. These principles were drawn from the set of kernel theories and appropriated using the empirical observations from exploratory study and evaluation of the DT4AEIS artifact. Kernel theory involves the linking mechanism for goals, shapes, processes, and materials and "provides an explanation of why an artifact is constructed as it is and why it works" (Gregor & Jones, 2007, p. 328). Those goals, shapes, processes, and materials ought to be reflections of the contexts of local development practices and stakeholders' conditions. Finally, the mutability of the artifact should be a result of the degree of artifact change encompassed by the justificatory knowledge sources, viz. both the reference/kernel theories and the empirical observations. The artifact is of course changing the context of the stakeholders' information exchange. Hence, there will be a change in the context of information exchange.

Proof of concept about the usefulness/utility of the DT4AEIS is an important component of the DT4AEIS process. Evaluation can be undertaken using different techniques. Gregor and Jones (2007) suggest instantiation as a means for proof of concept for the ISDT. However, this method of evaluation is criticized for its focus on system-level instances as it leaves the other components of the ISDT (Ploesser, 2012). Moreover, instantiation is considered a secondary outcome where the underlying artifact is the conceptual meta-artifact (Iivary, 2015) which is more than the system features and characteristics of an instantiated system-level artifact (Ploesser, 2012). Gregor and Hevner (2013) have also suggested a different mechanism of evaluation can be followed based on the nature of the artifact produced and the novelty and complexity of the artifact. The purpose of the evaluation is accepted as ensuring the utility of the artifact (Gregor & Jones, 2007; Ploesser, 2012) but evaluation methods differ in the utility variables used to evaluate the artifact. A design theory for a context-specific multi-stakeholder agricultural extension IS is required in order to follow an evaluation method as proof of concept that can at once minimize the above limitations but is also inclusive of the context discussed above. Those utility variables can be adopted according to the context of the research environment and can incorporate as many variables as important. Regarding the evaluation of context-specific artifacts, Heiden and Beverungen (2022) suggested conducting this in different contexts. Table 1 below shows how context can be reflected in the components of the Gregor and Jones (2007) ISDT guideline.

Table 1

Embracing Context into the Gregor and Jones (2007) Information Systems Design Theory Components

Core Components	Description of how context is embedded into it
Purpose and Scope	The purpose and scope explain the contexts of the development practices, the problems, and the solution in a way to better address the contextual requirements described under the purpose and scope.
Constructs	Should be inspired by the contexts of the development practices, the problems, and the solution in a way to better address the contextual requirements described under the purpose and scope.
Principles of Form and Function	The design principles that abstract the blueprint of the artifact are drawn from the justificatory knowledge sources which are contextualized through the empirical observations done. However, the design principles that define the form and function of the DT4AEIS need to explain the boundary conditions of the contexts.
Artifact Mutability	Mutability is reflected in the artifact as per the changes both from the theoretical and empirical knowledge.
Testable Propositions	The testable propositions are drawn from principles of justificatory knowledge implying that this component is already contextualized. These truth statements about the design theory need to allow the test of the context in which the theory applies.
Justificatory Knowledge	Explanation of the artifact is driven by the interplay between reference/kernel theories and empirical observations to address contextual factors.
Additional Components	
Principles of Implementation	Considered context of the local development practices and stakeholders' conditions which was also informed by analysis of existing IS (design—reality gaps).
Instantiation	Evaluation of the whole DT4AEIS in place of instance—level instantiation may give advantages.

Note. DT4AEIS = Design theory for agriculture extension information system; IS = information system.

CONCLUSION

ISDT has produced important knowledge on information systems design theories. However, the extant knowledge base lacks methodological guidance on context-specific information systems design theorizing, and knowledge on how context can be embedded into the existing ISDT guidelines. Moreover, the ICT4D research is criticized as acontextual, due to the limitations to grasp context holistically and embed it into the information systems to be implemented. This research builds on the existing ISDT knowledge to incorporate context into it. To address the problem, the research uses empirical knowledge as an additional justificatory knowledge source to the widely known and accepted kernel/reference theories. Moreover, it showed how context can be embedded into the ISDT components from the results of an exploratory case study or the learning of the evaluation results. Application of insights from reference/kernel theories, empirical knowledge from the exploratory case study, and empirical evaluation results to designing the artifact offers an opportunity to multi-ground the design theorizing process.

The process has helped to identify and inclusion of context of the local development practices and stakeholders' conditions in the design of the DT4AEIS. By this, the research builds on the Gregor and Jones (2007) ISDT framework and contributes to the development of a methodology for context-specific information systems design theorizing in the ICT4D domain, and inclusion of context in the theorizing process. The research shows how context of the local development practices and of stakeholders can be reflected in the DT4AEIS.

CONTRIBUTIONS, LIMITATIONS, AND FUTURE RESEARCH

This study has theoretical and practical contributions both to ICT4D and mainstream IS research. It specifically brings three different contributions into context. First, the study contributes to the well-known method of grounding design theorizing on reference theories by empirical observations as sources of justificatory knowledge. Second, it demonstrates how and when context can be reflected in the specific ISDT components to contextualize the ISDT to the local realities building on the well-established knowledge in the discipline. Furthermore, it advances the methodology following the academic roots of the socio-technical IS research to develop a process model for context-specific DT4AEIS research. The model developed has practical contributions, as it gives guidance on the design of agricultural extension information systems to practitioners to roll out context specific ICT4D interventions.

The research limitations relate to the exploratory case study and the evaluation applied to the outputs of the research. First, this study uses a single case study that is specific to a certain context, where multiple case studies may help in understanding the AEIS problem context in a broader way in this regard. Second, the artifact is evaluated against the utility variables of the design theory by practitioners in the domain of application. Other techniques of evaluation may still be valuable to further contextualize the model developed in this research. Therefore, future research can be conducted on applying multiple case studies towards understanding multiple contexts of local practices and on using different evaluation techniques to adapt the proposed method to other settings.

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