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Muluneh Atinaf

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# Reimagining Socio-technical ICT4D Interventions: Nexus between Context, Resilience, and Sustainability

Muluneh Atinaf

IT-Doctoral Program, Addis Ababa University, Addis Ababa, Ethiopia

muluneh.atinaf@uog.edu.et mulunehatinaf@yahoo.com

**Abstract:** Information technology for development (ICT4D) is embedded in complex socio-technical contexts. This presents challenges to resilient and sustainable of the ICT4D interventions. The problems is partly rooted in the lack of fully understanding context of the local development practices and transform it to resilient and sustainable interventions and in the gap to understand the relationships between context, resilience, and sustainability. The purpose of this research is to address how context, resilience, and sustainability relate to each other. The research draws empirically from the literature to develop propositions to show how the concepts relate and from review of the extant literature and qualitative data collected from a local agriculture extension information service to support the claims. The results contribute to theory by conceptualizing the links between context, resilience, and sustainability and inform practice through the recommendations made on how resilient and sustainable socio-technical information systems interventions be approached.

**Keywords:** context, resilience and sustainability, the socio-technical context of ICT4D interventions, resilient and sustainable ICT4D interventions, socio-technical ICT4D.

## 1. Introduction

Context, resilience, and sustainability are becoming the core pillars of mainstream information systems (IS) and ICT4D research and practice. Yet, the relationship between these triple concepts is not explored sufficiently. Thus the purpose of this research is to explore how the triple concepts of context, resilience, and sustainability relate each other in the context of ICT4D interventions. The research adopts the definition of ICT4D [45, 46] as the attempt to use information and communication technology (ICT) tools to undertake their actions and exploit opportunities for societies; the concept of “development” to refer the “long-term societal transformation” which recognizes the historical and spatial diversity of countries [38] expressed in terms of technological infrastructure and institutional arrangements [47]. The importance of ICT4D in enabling the multifaceted, dynamic, and contentious socio-technical processes of societies is a well-recognized fact [38] though the social and technical factors continue to be critical for its success [1]. For instance, the frequent technological change, the complex social dynamics, and development processes are presenting challenges to ICT4D interventions and research [38]. The socio-technical approach has been applied to grasp the factors in complex socio-technical systems as a means to analyze the problems and the solutions [2] as socio-technical systems. However, many ICT4D initiatives are criticized for the techno-centric focus over the social-centric aspect of the intervention [11] assuming that providing access to technology creates the required capability [11] which resulted in a socio-techno divide [9]. This is against the widely accepted conceptualization of socio-technical systems which perceives socio-technical systems as involving human and technology components and the interactions between the two [3]. Recent work has produced useful knowledge on the triple concepts of context [4, 5], resilience [6-8], and sustainability [9] of ICT4D interventions but the relationship between the concepts and attempt to build on the existing socio-technical knowledge is rare. ICT4D research can benefit from consideration of prior cumulative socio-technical knowledge to contribute to ICT4D and mainstream IS research [53]. Moreover, resilience and sustainability should unlock the potential of the socio-technical to take advantage of both the digital and the social components.

Context, resilience, and sustainability are attracting ICT4D scholars and the concepts are becoming core conceptual and practical research agendas in major IS and ICT4D conference proceedings and journals. However, the concepts are treated in isolation limiting our understanding of the links existing between the triple concepts. Context refers to “the processes and conditions, other than the constituent causal sociomaterial interactions (or intra-actions) of IS phenomena, that affect their formation and are affected by them [36, p. 13]. Context-based research in the ICT4D domain rarely goes beyond understanding and describing the lived experiences of stakeholders to incorporate the local development practices and the existing information systems artifacts [13]. Resilience on the other hand refers to the ability of a system to perform its objectives in the face of challenges through different mechanisms to continue to thrive [15]. One can understand from these definitions that resilience is related to maintaining the functions and operations of a system during stress either through unlocking potential from the technology or human potential.

Sustainability refers to enduring those interventions, specifically the ICT4D interventions in the development arena and keeping target users to continue using the interventions [10] effectively so that users can attain their desired goals through the systems they apply [18]. The concept of sustainability adds the notion of development to the above explanation. Those to whom the intervention is for would not continue using it unless it adds value to their livelihoods in any way. Context, resilience, and sustainability are related to the three foundational premises of ICT4D research and practice, i.e., context, technology, and socio-economic development [36]. Therefore, ICT4D research and practice needs to address these concepts together. This has importance in achieving sustainable ICT4D interventions that are transformed from and considered local development contexts having the properties of resilience during times of external stress.

Context matters to any information systems interventions [4, 5] regardless of the methodological challenge associated with it in IS research in general and ICT4D in particular [4, 5]. The impact of ignoring context when the interventions are for enabling development is serious. For instance, many ICT4D interventions in African countries fail because the interventions are a-contextual which lack adequate reflections of the cultures and values of local realities [56]. Hence, disregarding context in ICT4D research and practice leads to failures of the interventions [57] which again limit understanding of how contexts in ICT4D should be theorized [14]. The consequence of risks that may arise is not predictable during this time of socio-technical dynamism. The problem is serious in an interconnected environment such as in the agriculture extension information service system considered in this research context. Ethiopia, where the context of this research is conducted is being challenged by external shocks presenting pressure to the resilience of the agriculture extension information service system in different locations. The agriculture extension information service has to deal with multiple and overlapping shocks and treats such as the recurrent climate change, the COVID 19 pandemic, pests and diseases, local conflicts including the current civil war, economic slowdowns and the role that the agricultural sector is expected to play. These have impacts on the local agricultural development practices and on the economy at large. Putting resilient ICT4D interventions in place to communities where there are differences in accessing technology, digital literacy, and cognitive issues to apply the information content received is another issues be dealt with cautiously. Provision of technical telecom infrastructure, for instance, to a socio-technical problem without providing the required capability to the diversity of stakeholders cannot be a resilient intervention [16]. However, those systems are expected to be sustainable assisting users to achieve their development goals. The general sustainability literature looks at sustainability from the perspective of efficient use of resources, i.e., from the economic, institutional, social, and environmental dimensions through innovative use and reuse of the resources [9, 33]. ICT-enabled development interventions pose an enduring question as to how these initiatives can become sustainable at the community, regional, country, or global levels.

This research follows a multi-method and multi-theoretical approach to conducting ICT4D research as suggested by [32] for applications involving such interconnected issues of context, resilience, and sustainability. Therefore, a socio-technical analysis of the local agriculture extension information service system will enhance and further our understanding about the relationships between the triple concepts of context, resilience, and sustainability of ICT4D interventions. Hence, research on ICT4D needs to be reimagined back to the socio-technical foundations and move from descriptions of silo conceptual explorations to linking up the concepts with a purpose of holistic knowledge creation. This research will address the following research question: how do context, resilience, and sustainability relate to one another.

The rest of the paper is structured as follows. The next section discusses the literature to assess and develop the conceptualizations of context, resilience, and sustainability. This is followed by a discussion on the research methodology applied to address the research question in this study. Then the paper presents preliminary results followed by discussion of the results. Finally, the research is presents the conclusion and next steps to be done during the next iteration the research.

## 2. Review of the Literature

ICT4D research targeting development goals in specific settings should not be studied in isolation but together with a deep investigation of the historical processes of development and governance that have evolved in that context [44]. This approach offers advantage to emphasize and ask the question of how, under what circumstances, and for whom do ICTs, embedded in social practices and processes lead to development? [38] This is a critical question for ICT4D research because the interventions are meant for those who need them which in turn help to abstract it to the local context. Such closer abstraction to those who need it or to the context reveals local truths [52] and the impact of information technology in this interconnected world often depends on context [5]. Zheng et al [38] explicitly acknowledged context and the socio-technical nature of development processes in ICT4D interventions. Such agreements by the scholarly and practitioner community on foundational ICT4D questions should be furthered to the trending ones too. Hence, we have to also ask how resilient and sustainable the ICT4D interventions are given the contexts within which the interventions are planned for implementation. The understanding we had so far about the issue of context reveals that ICTs do not provide linear solutions and there is no one-size-fits-all kind of solution [44] to all settings rather attention needs to be given to the complex socio-technical contexts of the interventions [12]. ICT is considered as part of the context and as an ensemble artifact encompassing the conditions and processes in the environment of an observed phenomenon [48]. This emphasizes ICT4D interventions need to have a holistic view and

conceptualized as embedded in a system, a network, a project, or social structure [38]. This positions ICT4D research extending contextual research from organizational perspectives in which the systems are implemented and used in domains of inquiry such as communities, countries, or global institutions [36] to resilient systems concepts.

Protection of information systems has been an issue of decision-makers to safeguard the organizations information systems from risks [7] than resilience. However, recently emerging risks become borderless and unpredictable limiting the capabilities of traditional or a priori risk mitigating plans implying the need for other assumptions than following classical risk and security management [7]. Though resilience is getting greater attention both in the ICT4D and ISs research, there is no common agreement on what resilience means for development projects [10]. Resilience has been approached from the technical, the social, and the socio-technical perspectives by different authors and disciplines. There are initial works which tried to treat context and resilience together via some mechanisms in a way to inform the technical aspect of resilience so it can be materialized into digital interventions for its effective use [6]. Effective use can be understood through [18]: (i) understanding how a network of affordances supports the achievement of organizational goals, (ii) understanding how the affordances are actualized, and (iii) using inductive theorizing to elaborate these principles in a given context. Effective use of socio-technical information systems to be deployed in resource-constrained environments need more than what is suggested by Burton-Jones and Volkoff such as understanding the context and how the interventions could be made resilient. However, most sustainability studies ended up with understanding sustainability factors than looking at such links. For example, Baduza and Khene [10] see the sustainability of projects from three important factors: technological, social, and financial sustainability. A wider perspective of sustainability is given by Liu [17] who categorized the factors of sustainability into financial/economic, cultural/social, technological, political/institutional, and environmental sustainability. Each of these explanations deals with the social and technical components of sustainability. If we look at each of the technological, social, and financial sustainability they tell us about the continuity of technology use, continuity of social practices, or continuity of financial sources or funding which of course have importance to sustaining the intervention. However, what should be done for instance on ICT as an enabler of all or some of these sustainability elements is not clear.

### **2.1. Information Systems as Context-Specific and Socio-technical Systems**

The practices of stakeholders in agriculture are expected to operate within a network of interdependencies that apply ICTs in a bottom-up and top-down logic to incorporate indigenous knowledge into their farming practices or nurture value-chain integration [55]. According to Karanasios and Slavova [55] the nature of ICT4D initiatives in agriculture are step-wise processes to be attained gradually. Similarly contextualized knowledge needs to be founded on the existing socio-technical one and built over a longer-term gradually. In reality, many ICT4D interventions experience failures resulting in design-reality gaps because the interventions are still a-contextual [56]. Hence, one of the key steps toward successful ICT4D interventions is a deep understanding of the contexts [19] such as the information requirements, access to technology, digital literacy levels of stakeholders, institutional and social structures, the processes of information generation, and dissemination, the values and objectives of the stakeholders in the local agricultural development practices, and the staffing and skills of employees [12]. This further support the argument that explains all research models and theories are restricted within their contextual applicability where the impact of the outcome depends on the context [5]. A gap in fully understanding context challenges the transformation of user needs into desired solutions [10]. Traditional software development approaches such as systems analysis and design cannot be easily adapted to suit contexts implying the need for contextual development methodologies to meet the needs of communities and stakeholders [10].

The socio-technical dimension involves people, task/process, structure, technology, and data [2]. The people dimension refers to human subjects characterized by certain behavior, skills, and values; task/process describes any form of action having certain goals and deliverables; structures describe the hierarchical relationships in individual projects, social groups, or entire organizations; technology refers to the application of knowledge through machines, digital methods, and processes such as development tools or technical platforms; data refer to the values and observations that are recorded, processed, and analyzed using information systems [2]. Avgerou [36] suggested the need for addressing two decisions to contextualize within a specific setting: the first is the choice of conditions and processes in the environment of a focal phenomenon to be investigated. The second is the choice of domains to be researched as issues in the environment. According to Avgerou [36], the choice of domains refers to the domain of application of the information system which would be implemented either to empower the stakeholders with information and information processing or change the behavior of their actions such as the impact of their actions on the environment, the way they use a certain infrastructure, utility, and natural resources. Therefore, information systems as enablers of some behavior or actions that people want to take to achieve their goals or objectives need to considerate of the above socio-technical aspects.

### **2.2. Context, Resilience, and Sustainability as Socio-technical Phenomenon**

Most ICT4D literature focuses on technocratic projects implemented by government agencies, NGOs, or international donors [38] for a mere description and understanding of the interventions [14, 50]. This makes ICT4D interventions in Africa, where most of those interventions are situated, a-contextual contradict the local development realities, cultures,

and values [56] resulting in failures [57]. Thus, context is determinant to the sustainability of ICT4D interventions. The nature of ICT4D being embedded in a system, a network, a project or a social structure [38] implies its operation within a socio-technical context. In other words, ICT4D interventions are expected to function as systems involving stakeholders, their networks, and the social and institutional structures within a certain context. However, the notion of context in ICT4D is being challenged due to the components it involves and the interactions between the components that require our understanding of context [38]. Context varies from setting to setting though there could be common elements such as technology, usage, and users [49]. Culture, socio-political and geopolitical space, novel ICT communities, ICT characteristics, and novel ICT users are also relevant contexts in ICT4D research [49]. Therefore, context is a key socio-technical phenomenon in the study of ICT4D interventions. Similarly sustaining the interventions, sustainability in other words, is considered as a socio-technical [20] phenomenon.

Resilience is approached from different perspectives. Some literature treated it from the technical point of view [8] and others tried to look at resilience from the social dimensions only [7]. From the social dimension, resilience is an emergent property enabling the organization's capacity to continue its functions in the face of external stressors through mindfulness, agility, elastic infrastructure, and recoverability [7]. But resilience combines technical design features [8] too along with organizational features. There is limited literature that covered both the technical and social together or from the socio-technical perspective. Such literature emphasized the importance of putting resilient development within the communities and the technical systems they applied [6]. This approach is in line with the argument by Baduza and Khene [10] who narrated that resilience for development projects represents the materialization of local learning and community ownership focusing on human capability development than on technological development only. Hence, resilience is a socio-technical phenomenon involving the two components where both the technical infrastructure and the social structures need to be maintained in the face of external shocks. Therefore, placing resilience in the context of ICT4D research can be rooted in the study of ICT4D interventions in the context of development practices and stakeholders to enable sustainable societal changes. It is this socio-technical nature of resilience that is attracting scholars' attention [7] in addition to its potential to enable sustainable development. Therefore, new strategies are needed for organizations and communities to sustain their services, associated technology assets, people, and facilities [7].

Sustainability of ICT4D projects has been a core argument and most of the findings on sustainability are related to factors for sustainability [10]. Such knowledge is important because ICT4D research is applied within specific contexts where the applications require a nuanced understanding of the socio-technical processes [38] and factors to make them sustainable. Socio-technical changes may take place in a certain context where individuals are not only recipients of development benefits but also agents of change [38] implying the social, technical, and interaction between the two is key to a socio-technical phenomenon. Therefore, the technical component in the socio-technical ICT4D is important to enable the interaction and ICT can play an instrumental role in facilitating social interaction [51]. The interaction between the social and the technical offers the advantage of enabling engagement and ownership as the social is the primary owner of their development practice. An important point related to the whole concept of ICT4D interventions is suggested by Zheng et al [38] who stressed researchers and practitioners in the ICT4D domain should critically reflect on their implicit assumptions about development and technology, consider where the research or practice is situated in the broader picture of social transformation, and what may be missing in their implicit theory of change (societal transformation) of ICT4D as the phenomenon is a contentious socio-technical process. In other words this refers to context, sustainable development, and ICT as sociotechnical phenomenon. Avgerou [36] described this in the ICT4D context as the phenomena in ICT4D are constituted by a dynamic human and technology entanglement (intra-actions) where neither the technical nor the social have an independent, self-contained existence but they are epistemologically inseparable, i.e., impossible to understand by studying them as independent entities. Development in this regard should embrace multiplicity, heterogeneity, and openness as a concept and as a socio-technical process [38].

### **3. Research Methodology**

The purpose of this research is to explore the relationships between the triple concepts of context, resilience and sustainability in ICT4D interventions. To meet its objectives, the research is conducted in two phases. The first phase is devoted to explore the conceptualizations of context, resilience, and sustainability and draw propositions that show the links existing between the triple concepts. Hence, this phase explores the meaning of the concepts along with the relationships existing between them as a socio-technical phenomenon. The extant literature is used as a source of data in this phase. The second phase provides empirical evidence for the propositions given in the first phase above. The purpose of this step is to show support of the propositions about the relationships between context, resilience, and sustainability using evidence from empirical data. The case study method is adopted for this round of the research. A case study has the advantage of deeply understanding the real-life experience of different stakeholders and their context of action [58]. Empirical data were collected from a multi-stakeholder and multi-context agriculture extension information service system in Ethiopia.



### 3.1. Research Context and Data Collection

As discussed above, the research draws from two types of data for the two phases of the research. The research applies data collected from the extant literature and empirical data collected from stakeholders in the agriculture extension information service system. For the first phase, articles from mainstream information systems and ICT4D specialist journals and conference repositories were accessed. The materials were retrieved from the following journal databases and conference proceedings: Information Technology for Development, Information Technologies & International Development, Electronic Journal of Information Systems in Developing Countries, the proceedings of the series of conferences on ICT in developing countries organized by the IFIP WG9.4, and the AIS eLibrary. Cross-references and keyword search strategies have been used to retrieve relevant literature. Content evaluation of the sources accessed is done by the author. As the research is interested in the relationships between the triple concepts, research articles that cover one of the concepts and connects to one or more of the concepts is considered for further analysis. In addition to this, which of the socio-technical components (the social, the technical, or the interaction between the two) does the research gave focus is also considered for analysis. According to this criteria, a research article that focuses on context but doesn't mention the socio-technical nature of context and didn't connect it to either resilience or/and sustainability is not a target for review. This phase produces the propositions to show the links between context, resilience, and sustainability.

A case study method is adopted as an approach for the second phase of the research. Case study offers an advantage to focus on the lived life experiences of stakeholders [29, 30]. This is useful to analyze the contexts in the research setting as deeply as possible. Specifically, it is important in environments where users' context of action is critically important [31] inquiry in the research. The agriculture extension information service is one of the socio-technical kinds involving networked stakeholders interacting to support stakeholders' daily agriculture extension development practices. The agriculture extension information service in the country is characterized by multifaceted socio-technical contexts involving multiple stakeholders with different characteristics. The stakeholders can be individuals, collectives, or institutional support systems involved in the public agriculture extension service. A holistic understanding of the triple concepts of context, resilience, and sustainability is not easy through a single research approach. For this reason as well as to harness the issues holistically, the research has adopted a multi-method approach [32].

Data has been collected from stakeholders following snowballing technique and data were analyzed following qualitative data analysis techniques. A total of 37 subjects were involved as subjects for data collection. Data were collected in two rounds and in different years. The first round of data collection and the research context was done during Feb, 2017; it is included in [12]. The second round of data collection was done between Dec 2020 and Aug 2021. The second round of data collection was made to substantiate the first round by adding data from the supply side of ICT4D interventions, i.e., information systems developer. This phase involves a total of eight subjects who are expert information systems developers and managers in agriculture extension information systems development and management from four organizations. The subjects were selected purposefully as they are the ones who have been involved and are with the highest experience in rolling out information systems to be applied in the agriculture extension information services. Analysis of this second round data is in progress and the primary purpose of this paper is to establish the links between the triple concepts and communicate that to the wider ICT4D research and practice community. Part of the data along with the context of the agriculture extension information service is presented in prior published manuscript, hence can be found in [12].

## 4. Findings

The first round of the research is completed at this stage and the research's report on these preliminary results is presented below. In this round, the research has tried to look at existing work in terms of the focus and approaches being followed by the author to explore the context, resilience, and sustainability of ICT4D interventions. A total of 58 papers were assessed based on the criteria set but only few were qualified for further analysis. The literature analysis is done in terms of the socio-technical components (the social, the technical, the interaction between the social and technical) the work has covered and how it relates to the other concepts. This is supported with the arguments drawn from the literature to show the links between context, resilience, and sustainability. It is a well-accepted understanding that most of the ICT4D literature focuses on context as the work of Davison and Martinsons [5] boldly noted "context is king". However, most of the research done treated context independently from the concepts of resilience and sustainability research. Table 1 below presents the results from the categorization of the literature reviewed according to the methodology discussed above. The categorization is made according to the focus of the research work selected, i.e., technical, social, or socio-technical, and the specific dimension the work have focused on.

**Table 1.** The focus of prior research on context, resilience, and sustainability

The focus of the Socio-technical Dimension	Dimensions seen	Context	Resilience	Sustainability
The Technical	Technical		[8], [24]	
	Scalability		[10], [35]	[10], [35]
	Digital resiliency		[35]	[35]
	Information systems architecture		[40]	
	Infrastructure		[41]	
	Model		[43]	
The Social	Social (organizational/institutional)		[7], [33]	[33]
	Economic/financial		[10], [33], [35]	[10], [33], [35]
	Ecology/ecosystem		[25], [33]	[33], [35]
	Social-ecological		[26]	
	The intention of stakeholders to use ICT	[9]	[9]	
The Social and the Technical	Emergency management		[34]	
	IT use		[42]	
	Human-computer interaction (HCI)		[39], [6], [20]	

The literature surveyed on context, resilience, and sustainability is presented in a table of matrix according to the components of the socio-technical dimensions, the dimensions seen, and the triple concepts of context, resilience, and sustainability. According to the data, there is significant work related to contexts in the ICT4D literature done to explore the lived experiences of stakeholders' local development practices. However, the number of works that tried to link context to resilience or sustainability is limited. The limited number of work under context in Table 1 above doesn't mean there is little work done on context rather very few of them connect context to resilience and sustainability. There is a voluminous literature on context but it focuses on describing the phenomenon than incorporating it to the designs of information systems needed [37] or transforming it into digital solutions without connecting it either to one of or both of the other concepts. On the other hand, good size of work explores the concepts of resilience and sustainability together.

Different issues have been raised under the technical, social, and interactions of the social and technical components. Research done on technical and social components of the socio-technical phenomenon discusses the concepts explicitly. However, research papers that discuss the interactions between the social and technical components do not explicitly mention it. Concepts raised under the technical component include the purely technical aspects that tried to conceptualize resilient information systems [8, 24], the intentions of stakeholders to use the ICT4D interventions [9], scalability of the information systems [10, 35], digital resilience [35], information systems architecture [40], resilient infrastructure [41], and building a resilient model [43]. The concepts raised under the social dimension include the social (organizational/institutional) in general, the financial/economic aspects [10, 33, 35], ecology/ecosystem [25, 33, 35], and social-ecological [26]. The works that indicated the interactions between the social and the technical components raise issues of emergency management [34], IT use [42], and human-computer interaction [39]. Others have covered issues that involve both the social and technical components. For instance, [10] and [35] have raised the importance of financial or economic resources for scaling ICT4D projects. These are the preliminary results to show how context, resilience, and sustainability relate each other and how the concepts are treated in the literature. Further research is required to support the propositions given in the model based on empirical data that reflect the socio-technical nature of the three concepts.

#### 4.1. The Link between Context, Resilience, and Sustainability in ICT4D Interventions

As it is presented in Table 1 above, there are few sources that linked context to resilience. The size of the papers is reduced due to the criteria being used to consider the papers for further analysis. That is, only research work that deals with either to two or three of the triple concepts is considered. Had it considered work that has dealt with only one of the concepts, the size would have been huge. Context is about the phenomenon taking place in the research setting, and exploration of such phenomenon is not a new one. One of the reasons for this could be because resilience is an emerging research domain in the both the mainstream and ICT4D. Hence, prior research gave focus to sustainability than to resilience of the interventions where resilience is a trending research in ICT4D. Such understanding is reflected in Marais [9]. The other potential reason could be existing information systems were not considered as part of studying context rather understood as constraints [13]. Information systems development as a means of intervention in any context is known to be both situated and socio-technical [21] where the situated action perspective implies the form and nature of IS development activities are interrelated with, and inseparable from its contextual setting [22]. Therefore, the existing artifacts applied by the stakeholders operating within a contextual boundary [13] are part of the socio-technical context surrounding the research setting [5]. However, existing ICT4D interventions are often treated as black boxes serving as resources or constraints on development giving much focus primarily to the new intervention for development [13]. This contradicts the prevailing knowledge that states newer designs of IS can be

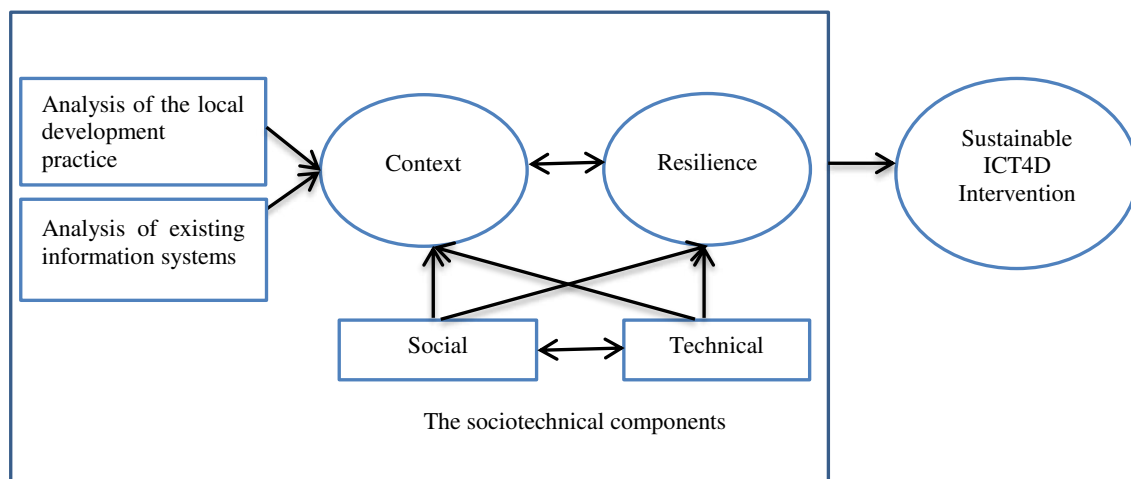


shaped from the experiences and learning of the material constraints [13]. Therefore, the inclusion of existing information systems artifacts in the study will offer an opportunity to understand the details of the sophisticated socio-technical ICT4D phenomena. Existing information systems discussed above can be analyzed in a way to understand the gaps in implementing the socio-technical requirements [12]. The literature offers independent assessments on design and reality gaps though it doesn't try to explicitly connect it to either resilience or sustainability. The design reality gap analysis framework offers the dimensions of analysis: objectives and values, processes, technology, information, management systems and structure, investment resources, staffing and skills, milieu (OPTIMISM) [23]. Given the above rich analysis dimensions, the OPTIMISM framework is appropriate to understand the context in terms of the gaps and the fit between the current information systems and the socio-technical requirements [12].

In the literature, resilience is approached from different domains such as from a technical dimension [8, 24], a social (organizational/institutional, individual, collectives) dimension [7] ecological perspective [25], and social-ecological perspectives [26]. This research adopts the perspective of the perspective proposed by the wider ICT4D research but with a view from the socio-technical foundations. Thus, the socio-technical issue is what defines both contexts of local development practices and resilience. Context emerging from the social dimension influences the technical resilience and context in the technical context guides the technical resilience for a sustainable intervention. This needs to prioritize the development of new knowledge paying attention to the socio-technical elements than focusing solely on the social or technical aspects [27]. As ICTs are primarily enablers of human development, such development strategies should be discussed where self-reliant relationships are built via networks from the bottom-up spanning local, regional, and national levels [9]. Therefore, it is when the interventions are resilient and when resilience is mapped from the socio-technical contexts of the stakeholders and local development practices that sustainability of the ICT4D interventions be ensured. Hence, ICT4D interventions can be sustainable when they are resilient both from the social and technical dimensions. However, it should be noted that sustainability is one of the many factors for successful ICT4D interventions [9]. Recent research on resilience has produced attributes and markers that characterize and define information systems resilience from the technical perspective [8]. Heeks and Ospina [8] have tried to attach their framework meant for analyzing the technical resilience of information systems to a social component just listing the markers. That is a good start to consider the social component but it only lists some features as markers for the attributes of resilience. It would have been very informative to research and practice as well as change both practices if it is presented in a way how those markers can be transformed into technical resilient information systems. According to Heeks and Ospina [8], the information systems resilience attributes are grouped into foundational and enabling attributes. Foundational attributes include robustness, self-organization, and learning whereas the enabling attributes include redundancy, rapidity, scale, diversity and flexibility, and equality each of them having resilient attribute markers.

Given the above discussion, it is important to look at the details of the proposed model for sustainable ICT4D interventions depicted in Figure 1 below. The literature shows the existing relationship between the concepts of context, resilience, and sustainability. To summarize it once again, the arrow from context to resilience shows that resilience is informed by the context of the local development practices and the stakeholders. Context is socio-technical as it is discussed above. Therefore, the resilience of the technology is reflected from the socio-technical context in that it should be either to maintain the social resilience or support it through a resilient technical system. The technical context and the interaction between the social and the technical inform resilience in a way that both resilient solutions should consider the social and technical contexts of the local development practices and the stakeholders. Hence, resilience is also socio-technical which refers either to maintaining the continuity of organizations and their services to operate smoothly in the face of external stressors or the technical systems to resist and continue functioning during external stressors. This is a dyadic relationship between context and resilience, hence the double arrow between them. In turn, sustainability is informed by the combined socio-technical context and resilience. However, as ICT is one of the components to be considered in ICT4D research the properties of sustainability in this research case the ones to motivate users continued use of the artifact should be embedded in it.

Based on the literature review made and the discussions that follow the research proposes the following diagram presents the link between the concepts.



**Figure1.** Relationship between Context, Resilience, and Sustainable Digital Solution

## 5. Discussions

In the literature, there is no clarity on the dimensions that constitute resilience and the factors that have importance for sustainability. The different concepts raised under resilience imply the lack of agreement between scholars on the dimensions of resilience. This is mainly due to the emergence of resilience as a new pillar of ICT4D research and the continued development of the technology. Most of the literature in the ICT4D domain focuses on technical resilience. Work that focuses on the technical dimensions of resilience has been published recently by Heeks and ospina [8]. Though there are sources that focus on the social component of resilience there is also inclination to treat resilience and sustainability as one and the same. This is in line with the findings of [59] who reported that most of the ICT4D literature is approaching resilience and digital resilience synonymously emphasizing the technical component only. The dimensions of the technical resilience suggested by [8] are useful attributes but the framework needs further evaluation for the purpose of whether the it is complete as a generic tool to be applied in any context and whether each of its attributes are in line with the purpose and definition of resilience.

The reviews made show that only a few of the papers discussed two or more concepts together. This is evident between the concepts of resilience and sustainability or the concepts of context and resilience. However, those papers which raised resilience and sustainability do not discuss the links between the concepts but most of them viewed the concepts either as related concepts or as a necessary condition for the other. For instance, [10, 35] discussed the importance of economic/financial availability to sustainability and resilience of projects but didn't discuss how the two relate and the relational factors between them. One may also ask a reasonable question about the links between context and sustainability. There is a lot of work on context both in the mainstream and ICT4D outlets. However, most of it focuses on description of the context [14] than transforming it into sustainable interventions.

Unlike the link between context and resilience, some ICT4D literature claims resilience and sustainability have relationships and differences as well. For instance, Zhang and Lin [28] reported that sustainability and resilience are related where the two can learn from each other; however, they also differ in that resilience measures regeneration of resources and sustainability focuses on supplying the resources. Regeneration of resources is the continued existence of the services or resources via different forms, media, or mechanisms to the stakeholders whereas supplying the resources makes available or existence of the resource with no interruptions. Therefore, if one of the properties of resilience is regenerating the resources then that act will lead to the sustainability of the ICT4D intervention. This is one implication of how resilience and sustainability reinforce and influence each other as well. Even in most cases, what is being discussed as sustainability is the sustainability of ICT itself, i.e., continuity of ICT use which cannot be a new concept or construct if we have context, resilience, and sustainability altogether.

Moreover, there are also shared attributes between resilience and sustainability from the technical perspective, for instance scale/scalability. The work of Baduza and Khene [10] tried to look at the resilience and sustainability of ICT4D along with the need for scalability. However, the link between the two and the importance of context either to resilience or sustainability or to both of them is not given. Resilience is dynamic and the capacity for adaptation to adversity is distributed across systems where individual resilience depends on the resilience of other systems [16]. This makes resilience similar to the concept of sustainability [10] through the intentions of stakeholders to use the intervention [9]. But this would be possible only when the stakeholders' resilience intents (the social) are mapped into the intervention solution. As discussed above there is a match in some of the dimensions of context, resilience, and sustainability. Though this can be taken as what makes the concepts similar it doesn't mean that they are one and same to be treated together. Rather more research is needed to clarify how the concepts differ or relate each other. ICT4D

intervention can benefit from embracing the three foundations of ICT4D research, i.e., context, technology, and socio-economic development.

Context of the ICT4D interventions can be explored from the local development practices and the stakeholder's which takes the existing IS into account. Moreover, the technical component of resilience can support sustainability of the local contextual development practices. The link between context and resilience shows two points: first, the link from context to resilience shows that context informs the development of resilient information systems, and second, resilience on the other hand ensures the continuity of the functioning of the context that is the social component. It is therefore within the interventions that one can embed the sustainability action behaviors as sustainability doesn't have material existence. Some unique attributes to be drawn from the socio-technical analysis of the contexts of the local development practices and the stakeholders and resilience analysis of the information system will add to this. For example, technical resilience cannot be a solution for a community that is challenged with digital divides, connectivity issues, access to digital content, and gaps in applying the content received into its context. Therefore, looking at the triple concepts together will offer a holistic view of the ICT4D intervention than conducting isolated research on each of the concepts can contribute. The proposed model can be further evaluated with empirical data to test the propositions given in the model. Further research is needed to test the propositions using empirical data that reflect the socio-technical nature of context, resilience, and sustainability.

## 6. Conclusion

Context, resilience, and sustainability are becoming the pillars of ICT4D research and practice. Hence, the research concludes ICT4D research and practice needs to be reimagined in accordance with the three core issues discussed and the foundational socio-technical components. These core concepts are attracting attention both in mainstream information systems and ICT4D research domains. Approaching the triple concepts in a holistic way has an advantage to understand the required interventions in a holistic way and to reinforce the concepts in the interventions. Hence, context, resilience, and sustainability in ICT4D research should be approached together than in isolation. For instance, technical resilience cannot be treated without considering the context in an environment where there are issues of literacy, access or digital divide, connectivity, etc. Therefore, while considering the triple concepts of context, resilience, and sustainability in an ICT4D intervention the concepts should be explored within the foundations of the socio-technical framework. One reason for this is because; ICT4D interventions are shaped by the social, the technical, and the interactions between the social and technical components. The other is such an approach offers a systemic level of understanding encompassing the socio-technical (social and technical/artifact) components. The concepts are interrelated and one influences the other in the process of putting a sustainable ICT4D intervention in place. The second round of the research and the findings and the discussion that follows will improve and complete this research. This research in progress work contributes to both theory and practice. For theory, it contributes by developing a sustainability model showing the conceptual links between context, resilience, and sustainability of ICT4D interventions. The research contributes to practice through the outputs which provide insights to practitioners to understand the socio-technical contexts of the community's local development practices and the socio-technical nature of resilient ICT4D interventions leading to sustainability.

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