Chapter 2
Towards a Community-Centered Knowledge Management Architecture for Disaster Management in Sub-Saharan Africa

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Abstract Disasters in developing nations are typically caused by frequent and intense climate changes, which contribute to the socio-economic vulnerabilities of such nations. It is important to be strategic in the management of disasters in such regions in order to minimize their impact on thriving communities. There is therefore the need for effective disaster response that allows for access, analysis, and integration of information from varied sources. This Chapter presents architecture for managing knowledge on disaster in Sub-Saharan African nations. This architecture captures the critical contextual variables using process view of knowledge management to assist citizens who are less knowledgeable about disaster management to understand the various forms of knowledge on disaster response while developing extensive knowledge and building capability necessary to address disaster response and management. It also addresses issues with building IT expertise on disaster response in developing nations. More importantly, the architecture facilitates the creation, storage/retrieval, transfer, and application of knowledge on disaster response and management especially for ordinary citizens. The architecture also helps overcome issues with lack of collaboration and coordination across disaster response and management agencies.

Keywords Disaster management • Disaster response • Knowledge management • Sub-Saharan Africa • Awareness • Architecture • Enforcement

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2.1 Introduction

The conventional approach to sharing information on disasters with the public typically emphasizes response to unexpected disaster that has adverse devastation of infrastructure, lives, and property. This information-sharing approach has created the notion that disasters are abnormal situations that occur rarely. This notion is catastrophic as it promotes negligence for effective plan development for potential hazards that may result from the location of settlements, infrastructure, and commerce. This approach is particularly problematic for the developing nations, especially the Sub-Saharan African (SSA) nations, where culture and other contextual factors may prevent individuals and communities from developing effective mechanisms because of the belief that there is little that they can do. In the context of developing nations, the predominant sources of disasters are those from natural causes such as climate change. Climate change potentially causes damage to vulnerable communities as a result of frequent extreme weather events such as flooding, earthquakes, and tsunamis. Damages from such extreme events contribute to recession in development of the disadvantaged populations. An incumbent problem that is associated with disasters is the availability of information from multiple sources, which lends itself to multiple interpretations and consequently to inaccurate information about the impact, source, and progression of the disaster. It is therefore imperative to create awareness about threat likelihoods, accurate estimates of the extent of threats, and potential project implementation decisions as well as policy implications that may enable vulnerable communities like those in SSA to prepare for and better manage rather than merely respond to disasters, whether man-made or natural.

Since the early 1990s, various perspectives that have been employed in the exploration of the potential association between development and disasters report that the impact of disasters is largely dependent on the current and historical developmental activities in the region under investigation (Allen, 2006; Baker, Sciglimpaglia, & Saghaffi, 2010; Drabek & Key, 1976; Paton & Johnson, 2001; Tobin, 1999; Wisner, Blaikie, Cannon, & Davis, 2003). Social science researchers who have explored developed economies suggest that the impact of extreme natural events could have been mitigated if systems were in place to warn people, if settlement patterns were regulated, and if building codes were strategically established and enforced with the knowledge of their future hazardous vulnerabilities (see for example (Hewitt, 1983; Quarantelli, 1989)). Similarly, in the context of developing nations, researchers reported that disaster relief agencies struggle with disasters that reoccurred with increasing complexity. Particularly, the disaster relief efforts stifled rather than encouraged development initiatives as they failed to properly assess and incorporate potential vulnerabilities that the interventions may induce (Christoplos, Mitchell, & Liljelund, 2001; Hay, 1986; Ross, Maxwell, & Buchanan-Smith, 1994; Siddiqui, 2008). The lack of structured knowledge base in most SSA countries makes it difficult to assess the impact of previous catastrophic events in order to manage the response to future threats.

It has been reported that about 92 % of deaths resulting from natural disasters occurred in countries that are within the low and medium development indices (IFRC, 2009). For instance, although about 37 % of all the natural disasters that occurred in 2007 affected the Asia Pacific region of the world, the actual impact on the reported victims was about 90 % and the economic damage was estimated at about 50 % (UNESCAP, 2008). Such varying impacts are suggestive of the vulnerabilities arising from factors such as insufficient infrastructure, increasingly high population densities, environmental degradation, and poverty that are typical of developing nations (Quarantelli, 1998). It is often the case that possible preventive lessons are learnt after the occurrence of a disaster event. The authors argue that a proactive approach to disaster management is needed to guide how preventive measures are implemented at the individual, regional, national, and international level. More specifically we believe any architecture or framework focused on managing knowledge on disaster in SSA should include contextual factors. For instance the culture indices of the SSA region (Hofstede, 1980) suggest that citizens and communities in SSA may find it difficult to believe that they can deal with natural disaster. Hence, encouraging citizens and providing the necessary information that will empower them to overcome their cultural tendencies and believe that they can plan against natural disaster will be as important if not more important as the technical knowledge management systems (KMS) that have proved effective in other developed regions.

The erratic inevitable changes in the climate continue to challenge historic weather patterns, which potentially make affected regions vulnerable. Disaster preparedness, prevention, and response measures need to be integrated into a broader development strategy that addresses the root causes of vulnerability.

In the event of a catastrophic event such as a disaster, information becomes one of the most important assets. Disaster-related information can occur in several forms, which may include information about the progression of the disaster, information about available resources, and information about available relief agencies with capabilities to provide support or help at a given time. Developing nations have been characterized as having high usage of information and communication technologies (ICTs), which then becomes an avenue for sharing information with the understanding that access to the right kind of information that may be utilized at the right time may save lives, infrastructure, and resources (Coyle & Meier, 2009; Denning, 2006). The role of ICTs in community and national adaptation strategies to the long-term impacts of climate change has been reviewed in several recent publications (Apikul, 2010; Kalas & Finlay, 2009; Ospina & Heeks, 2010). This chapter focuses on the utility of ICTs in contributing knowledge to and sharing knowledge from a knowledge management system to minimize and manage the impacts from acute climate-related events.

To begin to promote awareness and information sharing, effective disaster awareness and management demands seamless access to reliable and accurate data with the ability to analyze and integrate information from multiple sources. This chapter describes architecture for managing knowledge on disasters in SSA nations with the

acknowledgment of the role of governments, non-governmental organizations (NGOs), donors, epistemic communities and businesses as stakeholders as well as the contextual factors that may influence the functionality of the knowledge management system. The use of wireless technologies in developing nations is rather prevalent. Hence the development of multi-stakeholder partnerships and the use of the proposed knowledge management system by individuals with information technology experience will enable the standardization and interoperability, data availability, greater reach at lower costs, and to some extent, transparency and accountability of disaster resource allocation and delivery.

We believe that our research makes several contributions. First, we examine the contextual factors that need to be considered when addressing disaster response and management in SSA region. The challenges of disaster response and management in SSA are different due to context, cultural, and other relevant factors. Understanding and sharing knowledge on disaster response and management can enable organizations and citizens in SSA nations to effectively address the disaster response and management challenges. Thus, we contend that contextual variables are critical when applying existing knowledge management framework in addressing a problem in SSA region. Second, the architecture that is proposed in this paper can facilitate the management of knowledge on disaster response and management such that stakeholders can participate in the creation, storage, retrieval, and sharing, as well as the use of knowledge on disaster response and management. Third, by enhancing the knowledge of stakeholders such as disaster response agencies, first responders, and fire services, expertise can be built up while minimizing the effect of disaster in SSA. Fourth, although our framework focuses on SSA region, it has implications at the global level. For instance, when there is a disaster in a developing nation such as the earthquake in Haiti in 2010, all citizens are called into duty. By preparing the citizens in SSA to deal effectively with disaster will limit the need for other nations to provide assistance. International relief agencies can use the available resources to build the necessary capacity to help citizens deal with disasters in SSA and other nations. Finally, the architecture, if implemented, can help citizens use their mobile and other communication systems effectively in a safer environment, thus increasing customer satisfaction. Eventually this could be beneficial to telecommunication service providers who could use the knowledge management system as an incentive to enhance customers' Internet experience.

The rest of this chapter is organized as follows: Sect. 2.2 presents a review of relevant work on disaster response and management in SSA. It is followed by the framework that serves as a foundation for the architecture of a knowledge management system that can be used to acquire, store, and share information on disaster response and management. Section 2.4 presents the main contextual variables of the SSA environment that may influence the management of knowledge on disaster response and management. We then present the architecture in Sect. 2.5. Section 2.6 discusses the implications of the study and Sect. 2.7 concludes the chapter with potential future research directions.

2.2 Relevant Literature on Disaster Management in Sub-Saharan Africa

A review of disaster management approaches studied by several researchers revealed five different problem areas associated with the responding organizations; they include intra- and inter-organizational interactions between organizations, within systems of organizations, from organizations to the public, and from public to organizations (Quarantelli, 1998). Communication process, the exercise of authority, and a systematic coordination process among responding agencies and with the affected communities have also been reported as problematic to effectively responding to disasters. In the context of SSA nations, the focus of disaster management should be geared towards enabling citizens as well as response organizations to be more prepared in order to better adapt when disasters occur.

The extent to which SSA nations can adapt to catastrophic changes is based on existing preparedness and response strategies. A robust adaptive capacity to manage catastrophic events holds the potential to minimize the degree of social, human damage, and consequently, infrastructural and economic investments in terms of relief aid to recover from the disaster (Mirza, 2003).

It is often the case that responding agencies are created after the occurrence of a disaster, with efforts devoted to training volunteers and setting up a chain of command at the expense of responding to victims and the community under distress. Researchers have warned lending agencies and international humanitarian organizations to reevaluate their investments to focus on building capacity rather than recovery activities. Upon the establishment of the vulnerabilities that developing nations face in the event of a disaster, disaster management and adaptation must be part of long-term sustainable development planning in developing countries (Mirza, 2003).

2.3 Framework

Our proposed architecture is built on three main models. The importance of a community-centered knowledge sharing model to disaster management is argued followed by a presentation of the knowledge management framework (Alavi & Leidner, 2001) and application of awareness and enforcement framework (Kritzinger & von Solms, 2010). The goal of the framework is to provide *home users* (HUs) with information on disaster response and management while ensuring that they protect their systems against cyber attack. All the frameworks are described in this section. We explain how they form the foundation of the architecture presented in a later section.

2.3.1 The Community-Centered Disaster Management Model

Disasters are known cataclysmic events that bring the affected community together to share the grief of the devastation as well as the loss as a result of the event. For instance, the earthquake that struck Haiti in 2010 created a united front across the globe to respond to the event by providing aid as necessary regardless of the responders' race, country of origin, or political allegiances. The tendency to stimulate a sense of community among the disaster-affected population suggests that the impact is localized and should be treated as such. This means decisions about relief efforts need to be made in consultation with the local community members in order for a successful intervention to be implemented. In reference to an old African proverb which states that "the new broom sweeps well, but the old broom knows the corners," the International Red Cross and Red Crescent Movements as well as NGOs remind aid agencies during disaster relief to involve the community inhabitants in the relief planning and implementation. Effective disaster response will ultimately depend on community capacities to reduce their medium and long-term risks as well as the ability to cope with the impacts of acute climate-related events.

The focus of disaster management organizations in SSA nations tends to be national instead of local. In addition, vulnerability in developing nations is often defined in socio-economic terms leaving natural disasters as lower ranking issues compared with other political issues. The authors argue that the focus of disaster management organizations needs to be oriented towards the individual citizen. Risk factors that are germane to individuals during responses to disasters are influenced by the safety of their family members, their possessions, and their source of livelihood. Ordinary citizens in local communities therefore need to make policy decisions as it concerns the risk assessments of disasters in the planning, preparation, execution, and response phases. The involvement of the community in the disaster management will ensure that interventions are implemented with a consideration for the language that is familiar to the locals, which will make it easier for them to adopt and effectively utilize the interventions.

There are strong parallels between the security and disaster domains. In both there is a potential attack, which is unpredictable. Awareness helps in addressing the impact of the attack. Also, in both domains the problems are not just technical, but also cultural and political and require multi-level analysis at the individual, group, organization, communities, regional, and global levels. Like security, a lack of technical knowledge and awareness about disaster management may contribute to ineffective response and management of disaster in SSA. For instance, in the case of cyber security, some researchers have suggested that the lack of technical know-how about cyber crime in enforcement agencies, and among legal practitioners and individual home users contributes to the cyber crime problem in Africa (Boateng, 2009; Danquah & Longe, 2011; Moses-Òkè, 2012).

Kritzinger and von Solms (2010) identified two groups of Internet users, non-home users (NHUs) and home users (HUs). NHUs are "those users accessing the Internet from their corporate workstations within their work environments—such users will

come from the Industry area, Government areas, Academic areas etc." (Kritzinger & von Solms, 2010, p. 841). A home user is "a citizen with varying age and technical knowledge who uses ICTs for personal use anywhere outside their work environments" (European Network & Information Security Agency, 2006). In this chapter, a home user is defined as a citizen of varying age, technical knowledge, and mode of access who uses ICTs from anywhere outside of formal work environments (industry, government, academia), where modes of access include cybercafés, mobile phones, and personal computers. In other words, a home user could be a local farmer, an uneducated citizen in a rural community on a personal (or borrowed) cell phone or computer. Unlike NHUs who have a responsibility to gain and apply knowledge on cyber security and threats, HUs is under no such obligation. However, the HUs still manage cyber security risks on their home computers, networks, and systems. Thus, if HUs are not aware of proper information security knowledge, they will also lack the awareness of cyber risks while managing the responsibility to secure their cyber environment (Furnell, Valleria, & Phippen, 2008; Kumar, Park, & Subramaniam, 2008). The lack of information security awareness by HUs is attributed to the lack of enforcement by a third party to ensure that HUs are secured while using the Internet or that their information security awareness is up to date (Kritzinger & von Solms, 2010).

In the same way, we believe the problems with cyber security may not be different from those with disaster management. In fact, knowledge of disaster management may be problematic, especially for HUs as compared to NHUs, since NHUs may be trained about the disaster management plan of their organization and how to respond in the case of disaster, whereas HUs may not have such training and responsibilities. Besides, federal, state, regional, and district level disaster management organizations in SSA nations have no effective mechanisms to train and/or prepare citizens to respond to natural disasters as is done in other developed nations. In fact mobile systems would be an effective medium through which potential victims can be trained and prepared to deal with natural disasters.

Drawing from Kritzinger and von Solms (2010) definition, we refer to NHUs as individuals who work in areas such as the public, government, and non-governmental agencies and have access to information on disaster response and management because they are trained to protect the organization's assets and their own safety during disasters. Home users are those who do not work in formal organizations and therefore have no training and knowledge on disaster management and/or response strategies. Based on the above description of HUs and NHUs we assert that because of the knowledge available to the NHUs and the specific expectations of the NHUs to protect themselves against corporate systems, NHUs are more knowledgeable about disaster management. Thus, they are more likely to use this knowledge to protect their organizations, families and their own self-interests, whereas HUs might not be capable to do so. Given the challenge with disaster management in Africa in general and SSA in particular, the focus of this paper is on managing knowledge on disaster in SSA. In this paper, we expand the notion proposed by (Kritzinger & von Solms, 2010). We propose an incentive-based enforcement approach where governments and telecommunication organizations will provide incentives for citizens that

comply with disaster management awareness programs. More specifically, the current work presents architecture for sharing knowledge on disaster management in SSA region. This architecture which is based on Alavi and Leidner's (2001) framework supports the exchange of both tacit and explicit knowledge. The architecture also considers contextual factors including economic, cultural, social, technical, governmental, and legal and diverse knowledge management perspectives. We believe that HUs can benefit from the knowledge that NHUs have. One of the challenges with disaster response and management is awareness. Hence, we present an incentive-based approach to push information on disaster response and management to citizens, especially HUs. In this architecture, we identify *knowledge users* that may include HUs who may use the knowledge base in the architecture to enhance their knowledge and improve their awareness on disaster management to better protect themselves against disaster. We also describe *knowledge contributors* who are those who contribute knowledge to the architecture. These include NHUs, disaster management experts from governmental, non-governmental institutions, well-meaning individuals with knowledge on disaster response and management, and HUs who develop expertise even as they learn from others through the proposed architectural solution presented in this paper.

2.3.2 Knowledge Management

Tacit and Explicit are two forms of knowledge that have been identified in the knowledge management literature. Tacit knowledge comprises the beliefs, perspectives, and mental models ingrained in a person's mind. This is knowledge that has been acquired by the individuals as they gain experience through repeated tasks and activities. This knowledge is difficult to codify, share, or verbalize because it cannot be broken down into specific rules. Several authors assert that this type of knowledge can be articulated, captured, and represented (Goldman, 1990; Grant & Gregory, 1997; Howells, 1995; Nonaka, Takeuchi, & Umemoto, 1996; Pylyshyn, 1981). In the knowledge management literature, two types of tacit knowledge have been classified (Alavi & Leidner, 2001). One type is cognitive (mental model) and the other is technical (know-how applicable to a specific task). Both types of knowledge will be relevant in the disaster response and management environment and need to be captured, stored, and shared.

Knowledge management (KM) is defined as "a systemic and organizationally specified process for acquiring, organizing, and communicating both tacit and explicit knowledge of employees so that other employees may make use of it to be more effective and productive in their work" (Alavi & Leidner, 1999, p. 6). While this definition focuses on organizations, others have defined knowledge management in a broader sense as the formal management for facilitating the creation, access, and reuse of knowledge, typically using advanced technology (O'Leary, 1998). In this paper, we use the broader definition. KM systems are "a class of information systems applied to managing organizational knowledge. That is, they are

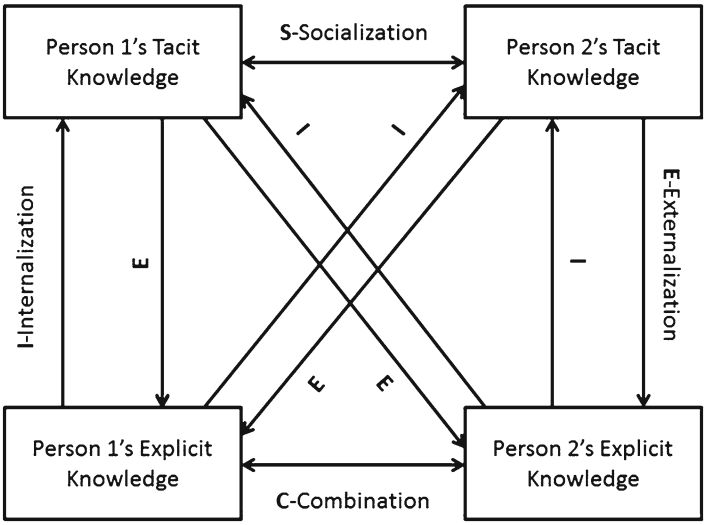

Fig. 2.1 Knowledge creation modes (adapted from Alavi & Leidner, 2001)

IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application" (Alavi & Leidner, 2001, p. 114). HUs and NHUs can gain knowledge about disaster response and management, lesson learnt as well as response and readiness strategies as they share their experiences.

Alavi and Leidner (2001) present the various perspectives of knowledge and their implications for knowledge management. In this paper, we take the process view perspective. Managing knowledge from this perspective emphasizes the process of the flow, and the creation, sharing, and distribution of knowledge. Alavi and Leidner (2001) describe the different knowledge types. Effective knowledge management requires that various forms of knowledge are acquired, stored, and shared. Based on the extant literature, Alavi and Leidner (2001, p. 124) argue that the "four knowledge processes of creation, storage/retrieval, transfer, and application are essential to effective organizational knowledge management." They also present various information technologies that enable the four knowledge management processes. A brief description of each knowledge process is presented below.

2.3.2.1 Knowledge Creation

As shown in Fig. 2.1, knowledge creation involves externalization, internalization, socialization, and combination. The figure shows that externalization and internalization can occur between an individual or between two or more individuals, whereas socialization and combination only occur between two or more individuals and not within a single individual.

Externalization (E) involves the conversion of tacit knowledge to explicit knowledge. It allows the explicit specification of tacit knowledge. An example is when an expert enumerates different approaches to several courses of action. New knowledge is learnt during the Internalization (I) process. In this process, explicit knowledge is converted to implicit (tacit) knowledge. This is when an individual internalizes what they have learnt from another individual over a period of time and gets new insights, which becomes their tacit knowledge. Socialization (S) is the sharing of tacit knowledge, e.g., during a response event, experienced emergency response officers share their tacit knowledge with other responders and less experienced responders or citizens of the affected community learn new techniques by watching the experts. Combination (C) is the knowledge conversion step where explicit knowledge is converted to new explicit knowledge.

2.3.2.2 Knowledge Transfer

Figure 2.1 depicts the transfer of knowledge among individuals and groups. Once person 1 shares (transfers) some knowledge with person 2, this may trigger person 2's knowledge processes. For example, the transfer of knowledge from person 1 may lead to the creation of knowledge in person 2. Person 2 may choose to apply the knowledge, consult with other members, or record the knowledge. Hence, knowledge flows between individuals and a major challenge of knowledge management is to facilitate these flows so that the maximum amount of transfer occurs (assuming that the knowledge individuals create has value and can improve performance).

2.3.2.3 Storage and Retrieval

The storage, organization, and retrieval of organizational knowledge, also referred to as organizational memory (Stein & Zwass, 1995; Walsh & Ungson, 1991), constitute an important aspect of effective organizational knowledge management. Organizational memory includes knowledge residing in various component forms, including written documentation, structured information stored in electronic databases, codified human knowledge stored in expert systems, documented organizational procedures and processes, and tacit knowledge acquired by individuals and networks of individuals (Tan, Teo, Tan, & Wei, 1998). Organizational memory is defined as "the means by which knowledge from the past, experience, and events influence present organizational activities" (Stein & Zwass, 1995, p. 85). Organizational memory extends beyond an individual's memory to include other components such as organizational culture, transformations (production processes and work procedures), structure (formal organizational roles), ecology (physical work setting), and information archives (both internal and external to the organization) (Walsh & Ungson, 1991). Emergency responders and volunteers can benefit from stored knowledge in order to address issues they may encounter during the response process.

Stored knowledge repository is useful when it is easily available. Advanced information systems storage technology and sophisticated retrieval techniques, such as query languages, multimedia databases, and database management systems, have been effective tools in enhancing the utilization of stored knowledge. The effective appropriation of the technology for retrieving knowledge can encourage volunteers and citizens to leverage knowledge stored in knowledge systems that is available to responders at different levels.

2.3.2.4 Knowledge Application

Organizations can only gain a competitive advantage from the knowledge they create when that knowledge is used (Alavi & Leidner, 2001). Three mechanisms can be used to create organizational capability from knowledge integration (Grant, 1996). These are directives, routines, and self-contained task teams. Directives include sets of rules, standards, procedures, and instructions that are developed by specialists. The specialists convert their tacit knowledge to explicit knowledge which can be integrated and efficiently communicated to non-specialists. Routines refer to the developed task performance and coordination patterns, interaction protocols, and process specifications that allow individuals to apply and integrate their specialized knowledge without the need to articulate and communicate what they know to others. The knowledge integration mechanism is the creation of self-contained task teams. In situations in which task uncertainty and complexity prevent the specification of directives and routines, teams of individuals with prerequisite knowledge and specialization are typically formed for problem solving (Alavi & Leidner, 2001, p. 122). However, in the context of SSA, where responding agencies are short of experienced emergency response officers, a repository of stored knowledge on how similar events have been responded to becomes invaluable as a starting point.

2.3.3 Disaster Management Awareness and Enforcement

Kritzinger and von Solms (2010) present an awareness and enforcement framework that we use in this study. According to them (2010), HUs typically would take the preferred route of going directly to the Web with little or no consideration for the security consequences. They propose an approach that would force HUs to use a route where they would be guided by policies, procedures, guidelines, best practices, and awareness courses before they access the Internet. In the case of disaster, we argue that since HUs may lack knowledge on disaster management and response mechanisms, making them aware of and providing them with knowledge on disaster and response strategies can help them be proactive in dealing with disasters.

2.4 Relevant Contextual Variables

The disaster response and management solutions proposed in the literature are typically based on developed nations' context. However, Muriithi and Crawford (2003) argue that the prescriptions should be made with consideration being given to how cultural, economic, and other variables may influence the validity of the orthodox approaches in SSA region. Organizational theorists argue that western-oriented management techniques may not be valid in non-western contexts. Therefore, factors such as culture and economics have been shown to play a potent role in determining the shared norms, values, attitudes, and beliefs about work organizations, among both managers and employees. Thus, what works in one context may not necessarily work in another (Muriithi & Crawford, 2003). Hence, while the architecture that we propose uses the Alavi and Leidner (2001) and Kritzinger and von Solms (2010) frameworks, we address the SSA contextual factors as well. Specifically, we discuss the economic, cultural, technical, social, governmental, and legal frameworks. These variables have been found to be relevant when dealing with ICT in SSA nations (Akuta, Ong'oa, & Jones, 2011; Andoh-Baidoo & Osatuyi, 2009; Atsu, Andoh-Baidoo, Osatuyi, & Amoako-Gyampah, 2010; Boateng, 2009; Foster, Goodman, Osiakwan, & Bernstein, 2004; Ngwenyama, Andoh-Baidoo, Bollou, & Morawczynski, 2006; Roztocki & Weistroffer, 2011). Table 2.1 highlights the main conditional variables and the conditions in SSA. We argue that these conditions, which are peculiar to the SSA environment, would influence any specific KMS that is built to enhance the knowledge of HUs on disaster response and management. We will discuss the specific effects of these conditions and their implications in later sections.

Table 2.1 Contextual variables affecting disaster management solutions

Factor	Conditions	References
Economic	Low GDP, low income, call for using scarce resources for healthcare and education	Ngwenyama et al. (2006), Roztocki and Weistroffer (2011)
Cultural	High power distance (PD), high collectivist-individualist (CID) society, high uncertainty avoidance (UA)	Atsu et al. (2010)
Technical	Lack of technical expertise, high usage of mobile devices especially cell phones, lack of national data on citizens, poor infrastructure	Akuta et al. (2011), Andoh-Baidoo and Osatuyi (2009), Foster et al. (2004)
Social	Low computer literacy, resistance to change, digital divide, higher usage of cyber café	Andoh-Baidoo and Osatuyi (2009), Boateng (2009), Foster et al. (2004)
Governmental	Generally weak democracy, relatively lack of continuity of projects	Akuta et al. (2011), Atsu et al. (2010), Roztocki and Weistroffer (2011)
Legal	Lack of legal frameworks, weak laws, weak enforcement	Akuta et al. (2011), Atsu et al. (2010), Boateng, Olumide, Isabalija, and Budu (2011), Moses-Òkè (2012), Roztocki and Weistroffer (2011)

Table 2.2 Cultural dimensions and definitions

Dimension	Definition
Power distance	This is the extent to which a society accepts the fact that power in institutions and organizations is distributed unequally (Hofstede, 1980, p. 45)
Uncertainty avoidance	This is the extent to which a society feels threatened by uncertain and ambiguous situations (Hofstede, 1980, p. 45)
Collectivism individualism	Individualism implies a loosely knit social framework in which people are supposed to take care of themselves and their immediate families only, while collectivism is characterized by a tight social framework in which people distinguish between in-groups and out-groups to look after them and in exchange for that they feel they owe absolute loyalty to it (Hofstede, 1980)
Masculinity vs. femininity	This expresses the extent to which the dominant values in society are masculine, i.e., assertiveness, the acquisition of money and things and not caring for others, the quality of life or people (Hofstede, 1980). In feminine societies men can assume nurturing roles, quality of life is important to both men and women and there is equality among the sexes (Hofstede, 1980)
Long-term vs. short-term orientation	Long-term orientation can be said to deal with virtue regardless of truth. Values associated with Long-term orientation are thrift and perseverance; Values associated with Short-term orientation are respect for tradition, fulfilling social obligations, and protecting one's "face" (Hofstede, 1983)

Hofstede (1980) defines culture as "a collective mental programming of the people in an environment" (1980, p. 43). Therefore, the culture of the actors or institutions influences the structures that may be enacted which may facilitate or impede effective management of knowledge on disaster. Table 2.2 provides brief descriptions of the dimensions of culture as defined by Hofstede (1980, 1983).

With respect to the cultural dimensions studied by Hofstede (1980), individuals in SSA are generally very different from those in developed nations. One of the key differences is the orientation towards individualism or collectivism: the people in SSA usually have a more collectivist outlook compared to those in developed nations. People in SSA nations exhibit especially strong ties to extended families, clans, and ethnic groups and make clear distinctions between those who belong to these in-groups and others who they consider outsiders (Muriithi & Crawford, 2003). Additionally, people in SSA nations feel a substantial responsibility to share scant resources among those within the in-group (Blunt & Jones, 1997). Although urban areas of SSA tend to have a more individualist orientation, the strong influence of African collectivism is still prevalent in these regions (Beugré, 2002).

Another pertinent difference between people in SSA and the developed nations is uncertainty avoidance. People in SSA typically have low tolerance for uncertainty. They are also generally more risk-averse and likely to resist change. Further, people would generally desire to implement rules to reduce or avoid uncertainty (Dinev, Goo, Hu, & Nam, 2009; Hofstede, 1993). As heavily ritualistic countries, individuals in SSA adhere to numerous unwritten rules that have been passed on as tradition, contributing to generally high uncertainty avoidance (Hofstede, 1984).

Conversely, people in developed nations are generally low in uncertainty avoidance (Hofstede, 1980).

A third cultural difference that generally exists between individuals in the developed nations and SSA is related to power distance. People in SSA are more likely to regard people in authority highly compared to people in developed nations. Most SSA nations exhibit a high degree of power distance, as authority is typically allocated based on age and experience (Muriithi & Crawford, 2003). Higher power distance societies find it difficult to challenge authority. In contrast, individuals in developed nations usually espouse a much lower degree of power distance and seek to achieve power equality in both organizations and government (Hofstede, 1980). Hence, people in SSA are more likely to respond to instructions from superiors without questioning and obey authority even when they disagree with the superior's position. Individuals in developed nations tend to exhibit more masculine traits, while people in SSA usually possess more traditionally feminine qualities. People in SSA are more short-term oriented as opposed to the long term orientation of people in South Asia and other developed nations. Hence, individuals in SSA may be more interested in addressing issues that are short term and be less concerned about acquiring knowledge that is needed to meet challenges that are not predicted to occur in the very short term but may happen in the future such as disasters.

The architecture for the knowledge management proposed in this study would provide a platform for sharing knowledge while building capacity against disaster among the stakeholders, particularly the HUs in the SSA region. Given the differences in the adoption and appropriation of information systems between developed and developing nations (Roztocki & Weistroffer, 2011), the proposed architecture for managing knowledge will incorporate customized, contextual interactions. In SSA, where the adoption and use of the Internet is still in its nascence, HUs are completely oblivious to disaster response and management implications. The proposed comprehensive framework prescribes context-based strategies to create avenues for HUs to acquire the awareness they need in order to be informed about disaster response and management so as to prepare them for potential disaster.

In the disaster response and management environment both tacit and explicit knowledge are relevant. NHUs and experts in disaster management can assess a situation in a disaster response and management awareness training session and deliver information to the HU in an effective way because of their individual experiences. The way a specific question or situation is addressed may depend on the type and level of the threat. The NHUs or expert use their mental models to effectively lead HUs thus using their cognitive tacit knowledge (Alavi & Leidner, 2001). Since the process is carried out intuitively, the experts may not be able to explain exactly how they adapt to a situation. However, this process can be stored in a knowledge system for others to access, retrieve, and use to solve or address similar problems or situations.

As noted in an earlier section, the perspective that we have taken is the process view for managing knowledge, therefore it is essential to improve the knowledge flows. We believe that to address disaster response and management problems in SSA, knowledge that exists on disaster response and management needs to be shared among the citizens, the majority of whom are HUs who are in the environment where there is little enforcement in ensuring that they protect themselves and

their properties against disaster. We argue that IT can be deployed to link existing sources of knowledge to HUs who need such information. While the focus of the proposed solution is on process perspectives, it is important that other perspectives are considered to ensure the effectiveness of the solution. For instance, the object perspective will ensure that the knowledge gathering, storage, and transfer activities are efficient and effective. If the access perspective is not considered, the solution is endangered because HUs may not be able to search and retrieve specific relevant knowledge that is needed in a particular situation and/or time. The capability perspective is relevant in our solution because in SSA there is a lack of expertise in IT in general and disaster response and management and knowledge management in particular. Hence, even as the solution seeks to encourage awareness and enforcement of disaster response and management, it is very important that stakeholders build the necessary capabilities in various areas such as fire fighting, first responders agencies, and technical IT experts in SSA nations to ensure that the proposed solution can be maintained and expanded to keep abreast of new threats and new approaches in response to the dynamics of the disaster phenomenon.

Here, we argue that addressing the various perspectives of knowledge management in the design of a knowledge management system for disaster response and management in SSA will enable the IT personnel to employ the various tools necessary to support all the different requirements in the domain. More importantly, the different perspectives will enable HUs to appreciate the distinction between various knowledge forms through the contribution of knowledge acquisition, storage, and sharing all the way to building capability in SSA. Hence, the different knowledge perspectives prescribed by Alavi and Leidner (2001) should be considered in developing a knowledge management system. First, there is the need for HUs to understand the differences between data, information, and knowledge. In the information age, where the presence and advancement in social network technologies and infrastructure facilitate the sharing of the various types of knowledge, the inability of HUs to distinguish valid information from rumors may prevent them from treating disaster response and management information seriously. The proposed architecture should facilitate the validation of information on disaster response and management so that stakeholders would be able to differentiate between information and rumor and thereby respond appropriately to disaster response and management.

Alavi and Leidner (2001) present the various knowledge types. The proposed architecture seeks to capture both tacit and explicit knowledge. In addition, an effective knowledge management system should capture the declarative (know-about), procedural (know-how), causal (know-why), conditional (know-when), relational (know-with), and pragmatic (useful knowledge) knowledge types (Alavi & Leidner, 2001).

2.5 Architecture

The architecture that we present in this paper will serve as a portal that home users can access to learn about disaster response and management and apply this knowledge to address situations before, during, and after disasters. Specifically the architecture

has the following components: domain ontology, knowledge-base, and user interface (knowledge contributor and knowledge consumer). The domain ontology includes the metadata that defines a consistent description of the data types coming from the different data sources. It provides comprehensive information such as the data sources, definitions of the data warehouse schema, dimensional hierarchies, and user profiles. A metadata repository is used to manage and store all of the metadata associated with the knowledge base. The ontology also defines the relationships between the various data types in the knowledge base.

The benefits of adopting an ontology include: communication, interoperability, reusability, reliability, specification, and distinction (Nogueira & De Vasconcelos, 2007; Uschold & Gruninger, 1996). First, the ontology enhances communication between stakeholders with different needs and viewpoints arising from their differing contexts. Second, the ontology allows information sharing among different computational systems by facilitating translation between different modeling methods, paradigms, languages, and software tools. Third, the shared understanding is the basis for the formal encoding of entities/concepts and their relationships in the domain of interest. This formal representation may be a reusable component in information systems. Fourth, an ontology-based information representation makes possible a consistent and more trustworthy implementation. Fifth, the shared understanding can assist in the process of identifying requirements and design specification for an IS. This is especially true when the requirements involve different groups using different terminologies in the same domain, or multiple domains. Sixth, an ontology allows the domain knowledge to be separated from the operational knowledge.

The knowledge base contains all the information on disaster response and management and awareness information. Specifically, knowledge on disaster, severity, likelihood of disaster, effects and mechanisms, documentation of disaster scenarios, prevention mechanisms, prevention strategies, best practices, origins of disasters, etc. would be captured in the knowledge base.

Finally the user interface has two components: (1) knowledge contributor: where knowledge contributors such as NHUs contribute knowledge on disaster response and management, and (2) knowledge users where HUs can access knowledge on disaster response and management and awareness information. Also, the knowledge base allows the sharing of metadata among tools and processes for capturing new knowledge.

In the next section, we describe in more detail how the framework presented in Sect. 2.3 is used to support knowledge sharing on disaster management including how awareness and enforcement programs can be implemented for HUs.

2.5.1 Application of Research Framework to Proposed Architecture

The proposed architecture is comprised of three main components as shown in Fig. 2.2 below. The first component is the access interface which allows actors to

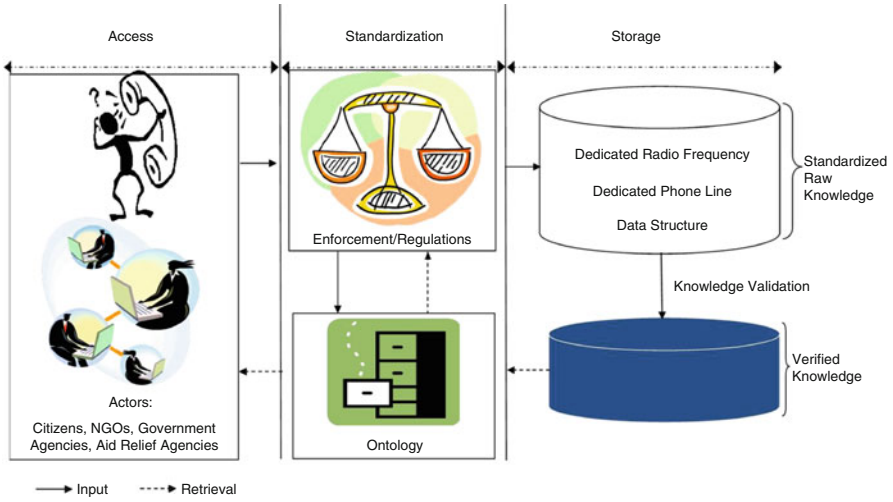

Fig. 2.2 Ontology-based knowledge architecture for disaster management

interact with the knowledge management system. Interaction can only be in the form of information input or retrieval from the knowledge management system. The second component is the standardization module that includes enforcement policies, regulations, and ontologies used to standardize information in the knowledge management system. The third component is the knowledge base that is used to store information in various formats such as audio, video, and documents. Particularly in developing nations, a dedicated radio frequency for the purpose of creating awareness during disasters should also be considered as another format for sharing information from the knowledge base.

The proposed architecture has actors: knowledge contributors such as citizens, knowledge validators, NGOs, governmental agencies, aid agencies, and law enforcement representatives. Actors will interact with the architecture through the multiple ICTs available to them. A dedicated radio frequency will be generated and maintained that allows citizens to tune in to the knowledge base of the knowledge management system to relay information in the form of updates that are relevant to the disaster event. A dedicated phone line will be maintained to allow citizens to contribute information to the knowledge base. Three roles are defined to represent the privileges of the three types of actors. Knowledge consumers can only read from the knowledge base. Knowledge contributors can both contribute knowledge to and retrieve information from the knowledge base; thus, as knowledge contributors they can create new knowledge. They can also modify and delete the knowledge that they create before it is validated. A knowledge contributor can also make a request for information from the knowledge base where they have read-write-only privileges. A knowledge consumer, on the other hand, has read-only privileges. A knowledge validator can modify, delete, assess the usefulness, and validate any non-validated knowledge in their subject areas.

2.5.1.1 Knowledge Creation

The first step in managing knowledge in the architecture is the creation of knowledge which involves externalization, internalization, socialization, and combination. First new knowledge has to be elicited from the knowledge contributor (knowledge elicitation). During knowledge elicitation, tacit (cognitive and technical) knowledge is captured via the knowledge contributor interface. Knowledge captured is stored in the knowledge base with a flag indicating that it is not validated. The domain ontology is responsible for validating new knowledge as well as changes to existing knowledge based on the predefined attributes in the metadata schema. Non-validated knowledge is not made available to users until it is released by validators who are respected disaster response and management experts who have been granted privileges to validate knowledge in this domain. Knowledge validators will query the knowledge base for non-validated knowledge items, review each item and, if it is found to be appropriate, validate and release it so that it is then available for use. Thus, only validated knowledge is returned from the knowledge base as a response to user queries. During knowledge capture and validation, each knowledge item can be categorized (e.g., level of severity, recency, relevance, and likelihood of incident or information) so that during knowledge retrieval, the user is presented with the most relevant information. The domain ontology ensures that these categories are consistent.

2.5.1.2 Externalization

Externalization involves the tacit to explicit knowledge conversion. The architecture allows knowledge workers to respond to a series of hypothetical events ultimately resulting in a scenario. A scenario is a customized, goal-oriented narration or description of a situation, with mention of actors, events, outputs, and environmental parameters (Cheah & Abidi, 1999). Similarly, a scenario can be considered an ordered set of interactions between partners, usually between a system and a set of actors external to the system for generating some output. Domain experts (who are the knowledge contributors with knowledge of disasters) can be prompted to provide or suggest informational values to the attributes of a scenario in the electronic form. In order to facilitate an assortment of knowledge acquisition activities, scenarios are distinguished as: Solved scenarios, which are scenarios of actual circumstances and problems encountered and solved by knowledge workers. Scenario bases typically start out as having only solved scenarios. Solved scenarios may be modified to form challenge scenarios. Challenge scenarios represent hypothetical situations and are presented to domain experts to challenge their expertise. Domain experts respond to such challenges and explicate their tacit knowledge to address or solve the posed problem.

Internalization converts explicit knowledge to tacit knowledge. New knowledge is learnt during the internalization stage. Explicit knowledge is converted to implicit knowledge. Explicit to implicit knowledge conversion occurs with the modification of the knowledge worker's or a knowledge consumer's mental model and can occur

after discovering new relationships. As knowledge workers gain a better understanding of how they can improve their activities through the shared knowledge from the architecture, they gain new tacit knowledge by performing as the architecture suggests. The architecture becomes a support system as the knowledge workers validate the new knowledge that has been created.

2.5.1.3 Socialization

Socialization allows tacit to tacit knowledge conversion. The ontology facilitates the creation of common vocabulary for communication among the knowledge consumers and knowledge workers, who include knowledge contributors and knowledge validators. This vocabulary then serves as the basis for expressing knowledge contents and for sharing and managing knowledge on disaster response and management. Kritzinger and von Solms (2010) observe that there can be an overlap between HUs and NHUs. However, there is no such requirement with respect to their personal mobile and home computers and networks. With the experience from their workplaces, these individuals are more likely than the HUs to practice good disaster response and management behaviors with their personal and home systems. In so doing, they build tacit knowledge on disaster response, management, threats, likelihood, strategies, and mechanisms for addressing disaster. Such tacit knowledge can be shared with HUs through socialization.

Interestingly, several HUs in the SSA have a presence on social network sites. Hence, knowledge workers may be able to interact with HUs using social networks instead of by face-to-face interaction. The knowledge management literature suggests that the sharing of tacit knowledge through socialization is effective in small groups. Hence, Google Hangouts for instance, a service that allows individuals to organize meetings for small groups, may be useful. Knowledge workers may invite HUs into their meetings where the tacit knowledge they have acquired on disaster response and management can be shared in these informal settings.

Story telling is a mechanism that has been practiced all over the world, but especially in SSA, for centuries to teach children about culture, morals, and ethics. In Ghana for instance, Kwaku Ananse is used to represent a wise individual who seems to have answers to all the world's problems. Hence, typically children will group under a tree in the evening where an older woman will tell a story depicting a problem that Kwaku Ananse solved. In information systems design, storytelling has been used effectively to capture system requirements from users. We believe that story telling can also be used effectively as a mechanism for knowledge workers to share knowledge on disasters to HUs in SSA. For instance, a story on recent disaster can be told to HUs where the specific characteristics of the disaster and its effects can be shared. An imaginary figure such as Kwaku Ananse can be employed to explain to HUs planning for future disasters how, where, when, and why an attack happened; the tools to address problems; and how to detect, prepare and respond to such disasters to assist them. This, according to Alavi and Leidner (2001), helps to capture the various knowledge types. This type of socialization can take place in

various ways including face-to-face environment, as a push of relevant information to HUs mobile phones or in a social network setting.

Combination is the explicit to explicit knowledge conversion. The ontology reconfigures the explicit knowledge in the architecture. Through daily interaction with the architecture, knowledge workers explicate knowledge that has been captured from diverse knowledge and data sources (e.g., archival data, books, experts on disaster, relief agencies, HUs, and NHUs). Knowledge consumers can also use the explicit knowledge in the architecture in the process of settling a cognitive conflict. A cognitive conflict is regarded as one's awareness of contradiction between the cognitive structure (prior knowledge) and the external information.

2.5.1.4 Knowledge Transfer

When knowledge workers share or transfer knowledge on disaster response and management with HUs, it may trigger the HUs' knowledge processes. Once HUs acquire such knowledge, they may apply the knowledge to address problems they have or they may learn new knowledge. Hence, in some situations, HUs can become knowledge workers since they may be motivated to contribute to the knowledge storage because of the benefits the system provides. Hence, knowledge transfer can be expanded between a knowledge worker and a knowledge consumer, a knowledge worker and another knowledge worker, or between two knowledge consumers and also from a knowledge consumer to a knowledge worker. This will ensure that the maximum amount of transfer occurs (after the knowledge has been validated to ensure that it has value).

2.5.1.5 Storage and Retrieval

The storage, organization, and retrieval of organizational knowledge also referred to as organizational memory (Stein & Zwass, 1995; Walsh & Ungson, 1991) constitute an important aspect of effective organizational knowledge management which is the purpose of the domain ontology and the knowledge base. The domain ontology metadata specifies validated set of vocabulary that is consistent among the diverse sources and maintained by the knowledge workers more specifically the knowledge validators. New vocabulary from new knowledge is used to modify the systems and is communicated among the knowledge workers. Each piece of data, information, or knowledge has its own data source. As all these sources are captured into the integrated system, inconsistencies may occur. The ontology-based metadata therefore represents a common global metadata that manages all the other metadata associated with the diverse data, information, and knowledge sources and also provides explicit semantics. It therefore presents a source–independence vocabulary for the domain that the architecture supports. The ontology-based metadata also facilitates the sharing of metadata among the diverse tools that would be used for knowledge elicitation and sharing. It has been recognized that ontology-based metadata

enhances users' accessibility to domain knowledge. The ontology forces the explicit specification of this conceptualization and ensures that information is stored consistently in the knowledge base. Given that schema definitions are based on ontology definitions, and vice versa, a symbiotic relationship is constructed between the domain ontology and knowledge base. Knowledge consumers can retrieve knowledge from the knowledge base through the knowledge consumer user interface.

2.5.1.6 Knowledge Application

This is where awareness and enforcement become relevant. We advocate that governments and private institutions will come together to encourage the use of the system once it is implemented. Telecommunications organizations particularly would be key to the success of the knowledge application. As the majority of people use mobile phones, one way of encouraging use of the knowledge is by prompting users, through push mechanisms, to visit the portal where the knowledge resides to improve their awareness of disaster response and management knowledge.

2.6 Implications

We have presented an architecture that allows knowledge contributors and knowledge users to share knowledge on disaster response and management in SSA. We anticipate that a prototype of this architecture can be implemented to test the validity of the claims made in this paper. When such a system becomes operational, it can be made freely available to all users but it would be managed by a non-profit organization to ensure that access policies are adhered to. We have also noted that there are contextual variables that would impact the success of such a system, if implemented. In this section, we discuss the implications of the contextual variables on the management of knowledge on disaster response and management using the proposed system. First, as noted in an earlier section, HUs are more vulnerable to disaster and knowledge gained from an information technology infrastructure on disaster response and management awareness and mechanisms to address catastrophic events as well as enforcement mechanisms to ensure that HUs are protected against disaster are critical issues that need to be addressed. Kritzinger and von Solms (2010) attribute the lack of information security awareness by HUs to the lack of enforcement by a third party to ensure that HUs are secured while using the Internet or that their information security awareness is up to date. In this paper, we propose that governments and telecommunication organizations that provide Internet services will encourage the use of the system. Most citizens in SSA purchase modems with limited units that allow them to connect to the Internet. Few citizens buy unlimited packages. Hence, citizens (including HUs and NHUs) who cannot afford to buy unlimited units and are likely to use the proposed system to enhance their knowledge on disaster response and management and also use tools that could be

made available through the system to protect themselves against disaster may be given incentives such as free units for Internet access. Similarly, those who contribute to the knowledge base can also be granted similar incentives. Governments can also offer tax breaks to telecommunications organizations that provide free units and other offerings to enhance citizen's knowledge on disaster management. Telecommunication organizations and the government can benefit from this practice because increasing safety and preparedness of individuals against disasters will encourage the use of the Internet for electronic commerce and electronic government.

Although SSA typically with has challenges with infrastructure, mobile technology has made it possible for those with mobile phones to have access to a wide range of online services. Hence, organizations and governments need to expand wireless networks. In addition, social network infrastructure has become widely acceptable to people in SSA. Therefore, knowledge contributors can point users to the system or knowledge from the systems can be disseminated to social networks such as Facebook, Twitter, and MySpace.

Making people aware of disaster response and management and solutions alone will not be enough to get HUs to protect themselves and their systems against disaster. Awareness should be accompanied by training. Most awareness studies have addressed training issues (D'arcy, Hovav, & Galletta, 2009).

The legal systems as well as response agencies should be encouraged to use knowledge from the proposed systems so that they can effectively help. The use of the system can also enable effective communication and coordination between the various agencies so that common knowledge can be sent to individuals in the affected communities to alleviate confusion that often results from diverse conflicting information from different disaster response agencies during crisis. Governments should provide training for the legal and enforcement agencies to equip themselves with the knowledge and tools needed to effectively deal with disaster.

2.7 Conclusion

In this paper, we have presented an architecture for managing knowledge on disaster response and management in SSA. This architecture captures the critical contextual variables and the various perspectives of knowledge management to ensure that home users, who are less knowledgeable, understand the various forms of knowledge on disaster response and management while developing extensive knowledge bases and building the capability necessary to plan and respond to disaster. The architecture also addresses issues with building IT expertise on disaster management and response strategies in the SSA region. More importantly, the architecture facilitates the creation, storage/retrieval, transfer, and application of knowledge on disaster response and management especially for HUs. Finally, the architecture provides awareness and enforcement mechanisms to help home users protect themselves against disasters. We have identified various actors who would contribute to

the creation and sharing of knowledge and those who can use the proposed systems. We have discussed the implication of an implemented system from the proposed architecture.

There are limitations. For instance, we have not implemented the architecture. Future research can implement the architecture to evaluate the validity of the claims proposed in this paper. Here, we have discussed in detail how story telling can be used to support knowledge sharing in SSA. We believe that several such tools may be useful in the managing of knowledge in SSA that future research can include.

Paramount to the design of disaster management systems is the need for interoperability among stakeholders who will interface with the system. For data integrity, the commitment to standardizing disaster data collection and processing is imperative and may be enforced on NGOs as well as the community members. The proposed system allows for ubiquitous usage since it can be accessed via simple cell phones and with limited functional requirements.

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