Designing Appropriate Information and Communication Technologies for the Base of the Pyramid

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A Dissertation Defense

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ABSTRACT

Information and communication technology for development (ICT4D) continues to enable provision of essential human services through digitization of human interactions and service delivery. Domain-specific design methodologies such as Rapid Application Development (Software Development) or Service Learning (Education) as well as conventional systems and economic frameworks have informed the design and creation of ICT4D systems. However, these frameworks do not adequately capture the perspectives of and barriers faced by individual beneficiaries, and soften the multi-faceted nature of economic and technological constraints. Thus, the modern challenge lies with creating collaborative, sustainable, and evolving changes that are not just designed *for* the beneficiaries, but *by* them as well. The author proposes Inclusivity Systems Framework for Communication Systems to describe the multi-dimensional, multi-stakeholder nature of systems at the base of the pyramid. The framework is built on the theory that trust drives success in community-based groups, and inclusive communication in turn drives trust. The framework includes economic inclusivity, technological inclusivity, and participatory inclusivity, all of which in turn have underlying factors and attributes. The author submits that the resulting framework can be used to capture the current capability maturity of ICT4D in a certain region or organization, and inform the design of new platforms that may provide capability uplifts. An interdisciplinary, service learning research partnership between University of the Free State, University of Virginia, and HiComm LLC demonstrates the framework in action across several use cases in South Africa. Lastly, the author discusses future work that is necessary both to expand the framework of Inclusivity Systems into other domains as well as explore new horizons for communication platforms such as HiComm.

1 INTRODUCTION TO COMMUNICATION SYSTEMS AT THE BASE OF THE PYRAMID

1.1 Motivation for Understanding the Role of Information and Communication Technology in Community Development

The Millennium Development Goals reached their 2015 deadline, and there is much to celebrate by the numbers. Several worldwide goals have been reached, including halving by 2015 the percentage of people that are earning less than $1 per day and the percentage of people without access to improved water supply (UN 2015, UN 2017). Jeffrey Sachs has been the intellectual cheerleader behind the MDGs, and his optimistic viewpoint that dedicated intervention leads to economic development is certainly understandable given the demonstrated progress worldwide. However, just going one layer deeper into the numbers reveals scenarios that cause Sachs' cautionary critics, like William Easterly and Claudia Williamson (2009) and Dambisa Moyo (2009), to speak out against the possibility of the long-term realization of the MDGs or the new Sustainable Development Goals. A key aspect of the truth behind these numbers concerns the sustained effectiveness of aid programs that provide essential human services (EHSs), which include access to long-term employment, water provision, affordable energy, food security and others. These tensions between sustainability as long-term, scheduled access to service and development as the achievement of external goals constitutes the ongoing philosophical battle between Easterly and Sachs. It can be summarized by the question: how is development best accomplished?

From Sachs' perspective as argued in *The End of Poverty: Economic Possibilities of Our Time* (Sachs 2005), intervention by agents from outside the community brings the advantage of a wealth of resources, technology, and knowledge capital (Sachs); but this inorganic growth often requires a robust strategy for implementation, monitoring, and evaluation to validate, not just verify, that the intervention was indeed successful, transferable, and sustained (Metzger and Guenther 2015, Clarke et al. 2013, Moyo 2009).

On the other side of development aid philosophy, organic or "core"-focused growth has the advantages of an empowered citizenry with decentralized agency, participatory action, and asset-based innovation (Chambers 1983, Chambers and Conway 1991, Moyo 2009). Note that asset-based innovation has since evolved into to asset-based community development with a domain focus on racial justice and urban community development; however, the theory of change remains fundamental in that change is catalyzed from the strengths within the community (Kretzmann and McKnight, 1993). However, this latter mode of change is susceptible to vicious cycles in which a lack of internal technical knowledge and economic resources increases the likelihood that projects fail, which in turn leads to lost opportunities to learn successful change strategies, a depletion of already scarce economic resources, and a continued lack of access to the needed human service. In the latter case, Easterly argues that outside intervention can still help through enabling market-based networking between community nodes. Easterly's main point, however, is that the catalyst for change cannot be a superpower's multi-lateral global development policy, which he contends to be more harmful than effective (Easterly 2003, 2006, 2007, and 2015).

In either scenario, these are not definite outcomes, but rather probable outcomes given project reviews by academicians and groups such as the Independent Evaluation Group in the World Bank (Clark et al. 2013, Easterly 2003, Sachs 2005, Moyo 2009). In both scenarios, underlying factors are the value of information and information networking as critical success factors in sustainable societal growth. Thus, both communities-in-need and EHS-providing organizations have incentives to build core capabilities that promote and streamline multi-stakeholder collaboration (Sen 1979, Sen 1989).

Given that these development efforts constitute multiple stakeholders with multiple objectives and limited resources, an inclusive approach serves as a framework to understand and assess these complex systems (Gibson et al. 2007, Pailla and Louis, 2011). Particularly, systems integration becomes a necessary activity in aligning, balancing, and coordinating the activities of these stakeholders so that an end goal of a healthier, more

resilient society may be achieved (Bouabid and Louis 2015, Barrett and Constas 2014). The strategies, or what may be termed as alternatives, to accomplish this greater goal have been said to differ due to philosophical and sociocultural principles (Sen 1979, Sen 1989, Easterly 2007). For example, a guiding principle brought forward by Amartya Sen focused on the concept of "capabilities." In a lecture (1979), Sen argued that people may have been born with certain rights, but the role of policy makers to either guarantee or proliferate those rights equally among the populace is an impossible task. Instead, Sen suggested that the basic capabilities of citizenry – what the people can do or achieve on a day-to-day basis – be considered as the foundation of the social construct with governing bodies. Essentially, Sen provided a linkage between a bottom-up vs. top-down approach to development issues (Sen 1989). Thus, the challenge of economic development in low-income developing communities, such as those in Sub-Saharan Africa or rural India, may also serve as an opportunity to refine aspects of inclusivity systems by borrowing from integrating guiding principles economic, philosophical, and sociocultural theory.

In this chapter, I attempt to highlight the role that information networking plays in the overall inclusivity systems framework, and the benefits it may have to development of low-income communities. I also reflect on the impact that information and communication technology for development (ICT4D) has had on addressing information asymmetry problems in which external agents wishing to implement development aid projects have access to information and communication technologies to push their vision onto and into target communities but those communities, which are the hosts and beneficiaries of development projects, lack the technologies to communicate their preferences to the external agents (Medis 1980, Heeks 2008, Cole and Fernando 2012, Diallo and Thullier 2005, Williamson 2010, Jamison et al. 2013). This asymmetry, present from the very conceptual stage of a project to its completion and handover by the external agents to the community, has the potential to cause a mismatch between the intentions of the external agents and the expectations and preferences of the host communities. The result is often a collapse of the project shortly after the external agent has withdrawn involvement (Adedokun et al. 2010, Aker and Mbiti 2010, Williamson 2010, Moyo 2009). With over 5 billion people in the developing world now having a subscription to one or more mobile

communication services and over 90% of the world having coverage of 2G telecommunications capability, ICT4D's mobile revolution is current and real (GSMA 2018, UN 2017). For most, ICT4D represents a potentially emancipatory technological movement for development efforts, as it gives the recipient of development aid a heretofore muted voice in decision making about projects planned and implemented in their communities. As such, stakeholder perspectives and limitations of ICT4D are explored. While the ICT4D is a positive addition to the field, its evangelists and designers must not lose track of the motivation behind its creation: empowering the community.

1.2 Literature Review: Importance of Information in Community Development

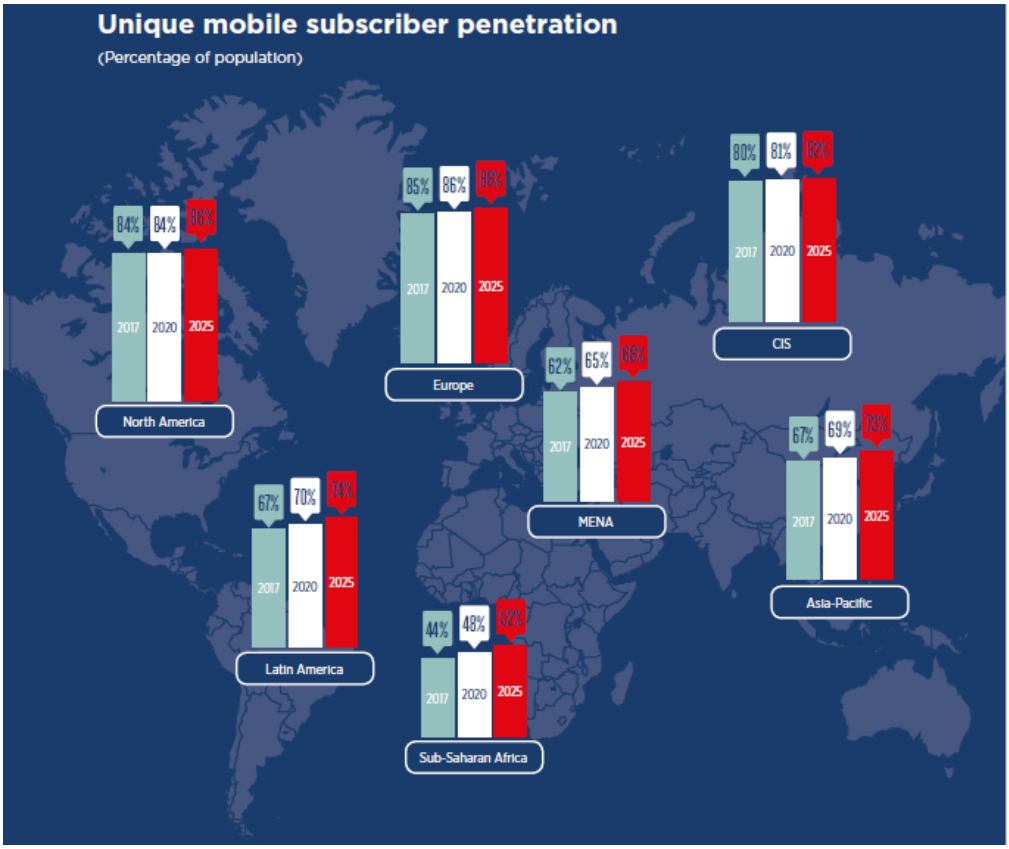

Figure 1: Unique mobile subscriber penetration in 2017 and forecasted forward to 2020 and 2025. Unique SIM-person matching adjusts for a single person with multiple cell phones, a statistic that would otherwise inflate the true penetration. Note that the absolute value translations of above percentages yield approximately 2+ billion persons without access as of 2017. Source: GSMA 2018.

Rural, less developed parts of the world have often been characterized by imperfect information, which in turn resulted in monopolistic and moral hazard tendencies (Hoff et al. 1993, Aleem 1993). Such an assumption may seem unrealistic in the modern age that is thriving due to the penetration and proliferation of mobile internet. However, the penetration has not been equal. As of 2017, while Europe and North America (excluding Mexico) have had mobile penetration of over 84% and mobile internet penetration over 70%, Asia-Pacific, Middle East and Northern Africa, and Sub-Saharan Africa all have mobile penetration levels of 45-70% and mobile internet penetration of 20% - 40% (GSMA 2018). Other areas of the world fall somewhere in the middle, with Latin America leaning lower. Unlike Western Nations, which include the US and EU, much of the developing world is still far behind in basic telephony and networking infrastructure, much less advanced cables or satellites to connect to servers for internet access (GSMA 2018). This has had tremendous impact economically, but to understand why that may be the case, it is necessary to review the role that information has in economic development.

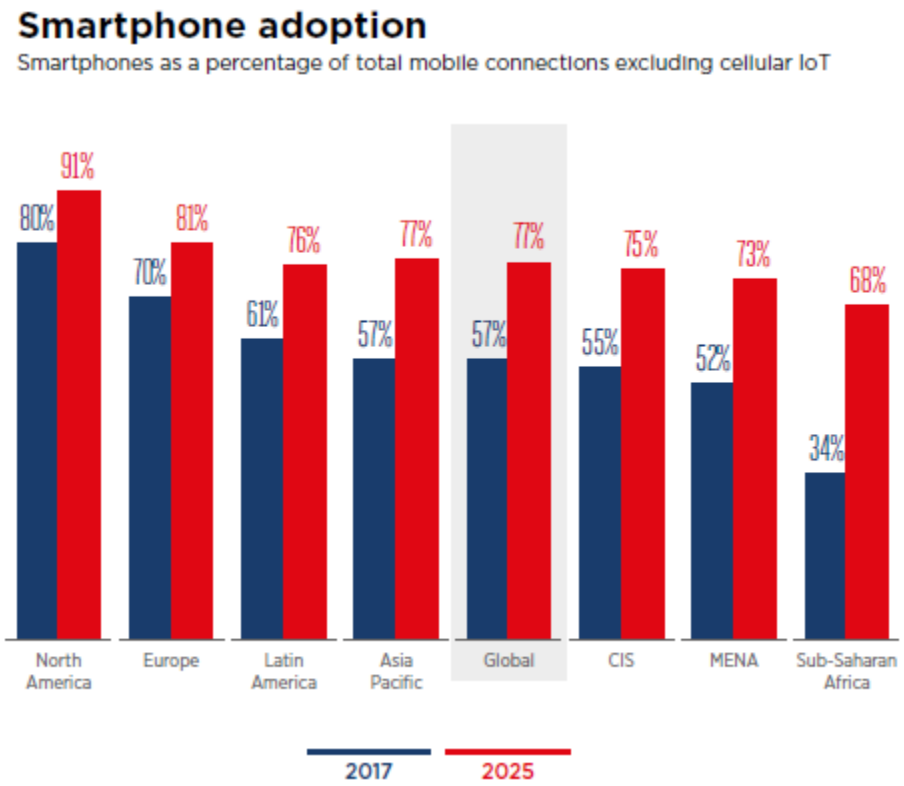

Figure 2: Smartphone adoption (based on unique SIM-person matching). In general, over 3.5B do not have access to smartphone technology, which in turn translates to mobile internet access. Source: GSMA 2018.

The assumption of perfect information simplified long-term economic analyses. However, philosopher-economist, Karl Marx, was one of the first to point out the role of externalities of limited information towards selfish decisions that do not provide an equal or fair societal uplift, but rather an appropriation of "surplus value" of the prime shareholder (Marx 1863). William Forster Lloyd, an economist and mathematician, also investigated this path to understand how an individual in a society makes decisions when the positive utility presented to him is far more obvious and palpable compared to the negative utility shared by all (Lloyd 1832). The thought experiment would later be popularized in Garrett Hardin's famous 1968 essay in *Science*, "The Tragedy of the Commons" (Hardin 1968). In the essay, Hardin presents the use case of a cattle farmer that tends to maximize their own utility by capitalizing on shared resources, and how multiple such farmers behaving as such lead to systemic demise over time. Hardin suggests better sharing of information and additional guardrails could improve farmers' behavior and in turn increase the collective good. However, these economists and mathematicians only explored information asymmetry between individual and collective, rather than individual players in an economic transaction. As a result, the general concern of these initial takes was regarding ecological impact rather than an immediate economic impact due to the negligence of maintaining the commons. While ecological and environmental impacts represent an increasing worry, my analysis addresses aid-based economic development in low-income communities.

The philosophical battle between Jeffrey Sachs and William Easterly regarding appropriate strategies in assisting development was already introduced. Sachs highlights the argument for outside aid because the target countries and communities are often resource-scarce, underproductive, and perhaps even incapable of implementing the projects they need. Easterly counters that any outside aid would end up being a waste, if not causing negative impact, because of imposed solutions on an unvocal community (Easterly 2007, Easterly and Williamson 2011). Consider a case where a community requires clean water to improve their health outcomes. Sachs would argue that outside

interventions, including direct provision of clean water, water filtration systems, and even education programs can serve to improve the overall health outcomes. Easterly on the other hand notes that while these may cause temporary relief, over time they may fail or prove inadequate. Thus, the ultimate deciding factor rests on a community and its individuals' own willingness to adopt clean water as a mutually desired end state (Easterly and Williamson 2011, Williamson 2010).

Sachs and Easterly were not the only contenders in presenting strategies in aid and development. Joseph Stiglitz (1989) is one of the first to offer a "why"-based narrative in expressing the pitfalls of disrupting the natural markets of underdeveloped countries with uncoordinated nonmarket institutions, such as multilateral aid groups like World Bank (Hoff et al. 1983, Aleem 1983, Easterly and Williamson 2011, Moyo 2009). Stiglitz is a pioneer in information economics by addressing information asymmetry in markets, for which he would share the Nobel Memorial Prize in Economic Studies with George Akerlof and Michael Spence. To understand why Stiglitz's information asymmetry and its destructive force in the BoP market are important, one must present the backdrop of the work of an earlier pioneer in economics, Kenneth Arrow, another Nobel Prize winner.

Arrow's contribution to this discussion comes in the form of setting a foundation for understand exactly what it is that information does. In the simplest terms, Arrow (1969) argues that a piece of information, or a signal as he calls it, helps an individual or an organization change its predetermined course of thought. Arrow defines an information channel as the pathway for signals to be transmitted, which may be interpreted in its abstract sense or in application as a connection between individuals, individuals and organizations, or organizations and organizations. The value of the signal lies in the impact it has in changing the behavior of the individual or organization. If an individual or an organization has an *a priori* probability distribution towards a specific action, then the signal would be any piece of information such that the *a posteriori* probability distribution is generated that is different from the *a priori* (Arrow 1969). Arrow goes onto say that any technological innovation is an attempt to reduce overall uncertainty altogether, a concept

that will be revisited in a later section. While Arrow's original thoughts on information diffusion related to innovation, his framework holds for broader contexts, including at the BoP (Stiglitz 1989, Williamson 2010).

Of particular importance in Arrow's writings is the qualification of the costs of information. While the production of knowledge itself is quite relevant, what is more interesting, especially in the realm of community development, is the transmission of knowledge. First, he establishes that the number of channels and the signals transmitted via these channels are limited due to limited processing power (1969). Though computing power may be improved to conduct preliminary processing, he casts a limit on an individual and organization's ability to process. Thus, as a result of this dynamic, an important observation is presented. When channels and signals are limited, he observes that individuals predominantly depend on nodes with which they have the most relation or experience. Arrow likens information to an infectious disease, though it would not be in good taste to maintain that analogy. This "familiarity" and "communicability" observation has been supported by recent research conducted by Diallo and Thuillier (2005), which found that trust and communication are proxy variables in a study of project coordinators of multilateral aid institutions in Sub-Saharan Africa. Another study by Saab et al. (2013) found similar results and correlated trust and communication positively and directly to project success, and that the number of communications increased trust. This later point is important – not just that communication in general is a good thing, but *more* communication from trusted sources is a better thing, especially in the context of international community development (Chambers 1983, Williamson 2010, Aker and Mbiti 2010).

Critics of these findings might argue that even with trusted information channels, many signals can become overwhelming rather than augmentative. The warning is not unlike that of Aldous Huxley: too much information may numb and impair human decision-making. It can be argued that social media and present-day news cycles may be prime examples of Huxley's warning. However, in the context of community development

the costs of information prohibit information exchange by a large portion of the beneficiary population. Easterly and Williamson (2011) and Williamson (2010) argue further that the beneficiary population has limited information on purpose, and that this asymmetry allows for the wielding of unnecessary, unwanted power over the beneficiary community. This later point illustrates Arrow's second and third costs of information.

Arrow's second cost of information states that there is significant capital (in the sense of financial or emotional investment) cost, and that this is oftentimes irreversible. Diallo and Thuillier (2005) and Saab et al. (2013) present the current day research for digesting what this cost entails. A nongovernmental aid organization (NGO) often states the immense promise that they are solving the water crisis in South Africa, or the tuberculosis epidemic in India (Easterly and Williamson 2011). However, these are geographic expanses with immense populations, and addressing these problems at such a scope involves tremendous amounts of capital. Thus, the projects on this scale are often only pursued by institutions such as the World Bank, UNICEF, and WHO. Smaller scale NGOs, with the earlier stated promise, often start by working at the household level. Even at this scale, the initial investment costs in terms of time, human, and financial can be hefty. An NGO must first earn the trust of the target beneficiary community over an extended period of time, work with the community's leadership to build cooperative programs, and then invest the capital for the actual program itself. This long runway is also the case for NGO-to-NGO relationships. Saab et al. (2013) summarizes this runway as a series of activities that first starts with cooperation, then increases to coordination, and then ends with collaboration. Through, and only through, this process is the information channel branded as worthy; as Arrow notes, the "channel has greater capacity if receiver regards it as more reliable."

Finally, and perhaps most clearly stated in most publications related to ICT4D, Arrow's third cost for information is stated as the lack of directional uniformity in channel capacity, signal recognition, and signal digestion (Arrow 1969). The imbalance is typically caused by one stakeholder's technological, infrastructural, or economic/financial capacity

far exceeding the other's. Arrow also argues that this is not limited to just resources, but also sociocultural differences. In his book *The Limits of Organization*, he presents the example of one individual speaking in French while the other speaks in English (1974). It is no surprise to the reader that the BoP is not wholly literate, much less literate in a specific language such as English. Easterly and Williamson (2011), Aker et al. (2012), and Adedokun et al. (2010) talk about this information asymmetry in terms of transparency and communal ownership, rather than language. Their research, though motivated more broadly, does indicate that there is substantial lack of transparency between community beneficiaries and their NGO service providers. Easterly and Williamson attribute to the cause of the information problems to "top-down, central planning like style of foreign aid."

Note, it must be clarified here that top-down in this particular section refers the relationship between the service provider and community beneficiary, and the term may easily be confused by John Gibson's top-down, goal-centered approach (Gibson et al. 2007). Top-down relationships indicate an inequitable, and as many of the authors of the cited literature may argue, unsustainable approach to providing aid. Gibson may argue, in fact, that a true top-down approach to aid would involve the community stakeholders during the goal development process. Stiglitz and community development-specific researchers Diallo and Thuillier (2005) and Jamison et al. (2007), Jensen and Oster (2009), and Cole and Fernando (2012), perhaps given the context of the earlier argument, thus note that these disconnected nodes cannot be left to fend for themselves in terms of information. As Stiglitz (1989) notes, one cannot believe in free market adjustment in a market with nonmarket institutions, such as NGOs. Stiglitz and others decry the lack of centralized information sharing, which in turn increases communication and trust. Through better communication, as established earlier, stakeholders' interests are better balanced and there is a greater likelihood for collaborative accomplishment of development goals (Adedokun et al. 2010, Heeks 2008).

When considering strategies in aid and development, thus, it is important to consider and define what information is, how information travels, what it costs, and to

whom. Asking these questions provides the perspectives necessary to intervene at a deeper level that may cause equitable and sustainable change.

1.3 Literature Review: Absorptive Capacity in Community Development

Given the above framework of understanding information production and transmission, it is possible to understand further the role it plays in a specific organization. Cohen and Levinthal (1990) present absorptive capacity as the "ability to exploit new knowledge that was generated by evaluating and utilizing outside knowledge given a set of prior knowledge," and it is signified by three characteristics: cumulativeness, expectation formation, and path dependence. Here already it is easy to see the "salute" back to Arrow's information costs of limitation and capital investment. Cohen and Levinthal's concept of absorptive capacity advances the discussion on the role of information in low-income developing communities in three specific ways. First, it suggests a specific strategy for communication systems: specialized actors are required to transfer and receive information from outside of their organization and daily environment, and in the presence of uncertainty of the signals in the information channel, reliability may be gained by increasing the "receptors" (Cohen and Levinthal 1990). Cohen and Levinthal argue that the later actually enables the organization of interest to become more adaptive. Though their original intention of these systems would be to capture ideas to innovate current processes instead of acting as daily operational activities, their intuition stands correct for the transmission of information between stakeholder groups involved in community development as shown by Saab et al. (2013), Jamison et al. (2007), Jensen and Oster (2009), and Cole and Fernando (2012), and Diallo and Thuillier (2005).

UNICEF's Community Case Management (CCM) strategy displays this aspect of absorptive capacity quite well (UNICEF and frog 2012). Leaders of wards and villages may text updates and alerts to a specially, yet minimally-trained Community Health Worker (CHW) (UNICEF and frog 2012). That data is in turn analyzed, summarized, and

shared with higher-level institutional stakeholders, such as the regional health managers of the national Ministries of Health. With dispersed and specifically-trained health workers, this new model encourages a decentralized means of action from the health workers, but at the same time fulfills the need for a centralized information system to provide other stakeholder groups with a better understanding of the health incidences impacting her or his region. It is noted that this program had positive impact, both socially and economically; one such example is improvements in local clinics' inventories and staffing.

In addition to logistical use cases, community members through their representative leaders become connected to trusted information channels with relevant information for the end users. For example, community members have been able to save valuable time and money. Mothers have now decreased or eliminated their wait time by connecting with CHWs and clinics via their mobile devices and scheduling appointments, thus vastly improving pre- and postnatal care. Community leaders can better express the health issues impacting their particular village, and do so via SMS or feature-phone apps like Medic Mobile. Aker and Mbiti (2010) note that in one case in Niger, community members were able to save 50% in costs by eliminating routine travel, not counting the opportunity gained from substituting that travel time with a more productive activity.

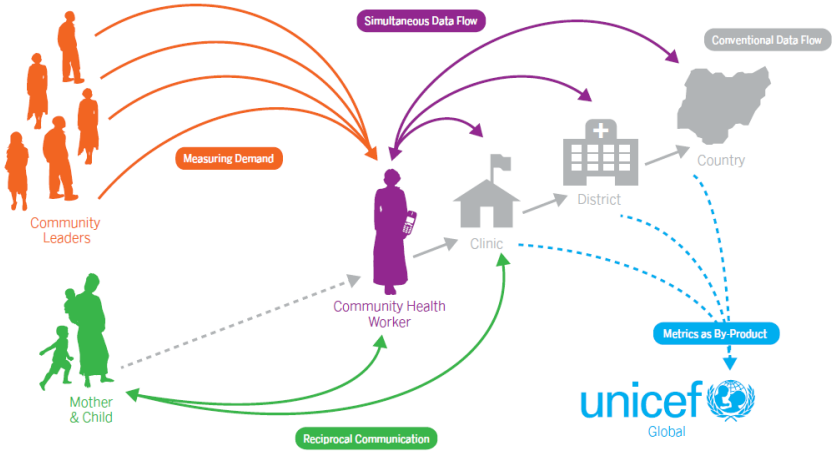

Figure 3: Description of the role CHW in UNICEF's new Community Case Management strategy. Source: *Mobile Technologies & Community Case Management: Solving the Last Mile in Health Care Delivery (UNICEF and frog 2012).*

Second, Cohen and Levinthal's paper (1990) on absorptive capacity notes that there is a constant tradeoff between internal knowledge sharing and external knowledge capture. This strife between commonality and diversity of knowledge exists, according to them, because of two conflicting objectives: a team that better communicates amongst its members is streamlined to accomplish the objective at hand; however, a team that adapts to external information may be better equipped to better accomplish its broader goal. What, then, is the optimal point? As with many of their arguments in the paper, Cohen and Levinthal answer that the optimal balance is not in the extremes but rather somewhere in the middle.

To understand how this plays out in community development, consider again UNICEF's CCM program. In many cases of rural community development, the intervening organization, whether they be a local NGO or a larger one like UNICEF, works with a community that typically hasn't had access to any other NGO help yet. As such, they become the external knowledge link to the community. The services that UNICEF can perform especially through a program like CCM is limited to basic healthcare. From the viewpoint of the community, the services that they seek include agribusiness, water and sanitation, affordable energy, and other interconnected EHSs. From the perspective of UNICEF's CCM, the multitude of services share a large commonality of knowledge in that they may qualify as different categories of health-related services (UNICEF and frog 2012). From the perspective of the community, they become acclimated to speaking only the "CCM language" with UNICEF, and thus tailor and limit their needs and asks to UNICEF accordingly, filtering out possibly related problems such as infected water storage tanks. Essentially, the disconnect on what is possible from the outside, what is scoped within in a system, and what is needed within may cause a suboptimal outcome for all.

What, then, can UNICEF do? As per Cohen and Levinthal (1990), they may broaden and diversify their receptors, effectively creating a different force to address these additional EHS challenges. Alternatively, they may choose to pursue the more realistic and

less capital-intensive option suggested by Saab et al. (2013) by cooperating, coordinating, and collaborating with other NGOs to innovate at the seams. ICT has enabled the rise of such region-focused multilateral NGO and government alliances, such as those discussed in Clarke et al. (2013). It can be argued that these alliances have increased each subcomponent's absorptive capacities. Nevertheless, one must not forget the cautionary thesis of Easterly and Williamson (2011) and Moyo (2009) that large-scale alliances prompt top-down aid strategy, which ignore input from and empowerment of the end beneficiary and thus hurt that beneficiary. The fear here is that the subcomponents within the alliance become the commonality – that information is only shared amongst themselves, the community beneficiary itself ends up being neglected. What started as a way to increase the community's voice, the warning states, could end up being overwhelmed by too many ears, and thus leading the misalignment of objectives and incentives.

One last takeaway from absorptive capacity for community development is that it represents a significant investment. This is not something new, for it was already said by Arrow earlier when discussing the capital costs of information. Cohen and Levinthal's addition comes in the form of theorizing this additional capital cost as an economic opportunity cost to the organization (1990). For the vast majority of NGOs that rely on donations and governmental grants, the activities described by Cohen and Levinthal to bolster absorptive capacity can be perceived as already accomplished by existing activities of information sharing, whitepaper publishing, and conference presentations. There is a significant difference, however, between sharing and collaboration, as noted by Saab et al. (2013) and Crawford and Bryce (2003), especially due to the inherent conflict in each NGO maximizing its own specific revenue (and thus grand and donation) stream. For ICT evangelists like Banks (2011) and information economists like Stiglitz, ICT4D thus represents one of possible transparent transformations in encouraging not just a better form of aid, but a better knowledge structure for the NGOs themselves. Stiglitz's government intervention towards a systemic coordination of activities becomes relevant in this context; with that support, NGOs may be more willing to adopt the latest innovation cycle to hit the community development market (Stiglitz 1989).

In this chapter, it can be concluded that information channels and signals play a particularly important role for community development. ICT4D in particular may be the latest innovation cycle to improve the absorptive capacities of communities and partnering organizations to address EHS needs. Some words of caution were offered, and the limitations of the salvation of ICT4D will continue to be discussed in the next chapter.

2 CURRENT APPROACHES TO INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

Chapter 1 provided a foundational layer of understanding of the important factors underlying information sharing, and how it may interrelate with philosophies of aid and development. It also introduced ICT4D as a growing field in addressing information, communications, and coordination problems in development. Chapter 2 takes a deeper dive to consider approaches to and specific players in ICT4D. The future of ICT4D is also discussed in consideration of the overall development philosophies.

2.1 Literature Review: Approaches to ICT4D

How does information sharing work in the developing world? Who are its biggest players? What are the methods in ICT4D? As noted in the previous chapter, Arrow (1974) leaves the methods of information transfer to the free market, perhaps assuming that another Schumpeterian innovation cycle may address the methods as specific market needs. On the other hand, Stiglitz suggests a more involved government in promoting equal access and making more uniform the information channel capacities of communities-in-need and NGOs, thus encouraging equal power (1989). Countries such as Bangladesh have been known to adopt these principles through innovative ICT4D mechanisms, albeit much of this has been limited to microfinance institutions (MFIs) like the Grameen Bank. National initiatives aside, the ICT4D flag is primarily being carried by the World Bank through a strategic partnership group called *infoDev*, which is charged with researching and supporting specifically ICT4D solutions (www.infodev.org). Initial success stories included MFIs, and quickly expanded to include agribusiness solutions that use SMS-based notifications to inform farmers of price and weather to aid in their decision-making, support networks that incorporate group messaging for social rights organizations particularly focused on women, and mass messaging that sent climate tracking and awareness information to those living in vulnerable areas.

InfoDev pursues a hybrid grant-based incubator model, which borrows from conventional NGO practice and Silicon Valley start-up incubator style. This model has enabled rapid proliferation in Sub-Saharan Africa and now parts of the Caribbean. Currently, they have started four mobile development labs (mLabs), eight mobile development hubs (mHubs), five Agribusiness Innovation Centers (AICs), and three Climate Innovation Center (CICs). The vast majority of these are located on the African continent, but locations are swiftly expanding to Latin America, which represents the next breakthrough market for ICT. Furthermore, infoDev's substantive research and ICT incubator model has encouraged development of copycat institutions led by big names such as Google and Microsoft in Nigeria, Kenya, South Africa, India, and Southeast Asia (www.infodev.org).

However, can such principles be adopted at an organizational, rather than an institutional, level? In the context of multilateral NGO development, Saab et al. (2013) has shown through a case study that better coordination amongst NGOs is possible, as long as the field workers from different groups can communicate via a centralized information sharing channel, which could be in the form of a potential ICT4D solution. Clarke et al. (2013) research ICT4D specifically in terms of impact of MDGs (note that ICT itself was a Target and has since been explicitly added to multiple Sustainable Development Goals SDGs finalized in 2015). They have found that ICT has indeed been helpful in terms of information dissemination, such as the agribusiness market clearing price SMS system described earlier. ICT4D has also been used to measure and report water levels in water wells, present energy solutions in creative ways such as Koolpool (a transportation pooling service in Kolkata, India), help in remote reporting of malarial, diarrheal, and other illness incidences, tracking healthcare records for at-risk populations including children under five, and women's empowerment programs. Many of these programs focus specifically on an essential human service (EHS) problem rather than bluntly focus on poverty eradication, some have confronted poverty more directly, such as LabourNet, a mobile-based job matching service in Bangalore, India.

Aker and Mbiti (2010) offer the bridge between Arrow and Cohen and Levinthal's discussions to help one better understand why specifically ICT4D, specifically mobile for development (M4D) has been working for the community member. They advance their argument for positive ICT4D impact through five steps: first, community members and service organizations adopt mobile solutions because they are accessible and economical; second, due to the new availability of these information channels, community members are motivated to send more signals for a smaller variable cost, thereby potentially increasing their productivity through improved efficiency of information sharing; third, this increase in M4D activity in turn creates a demand for a labor market specifically focused on mobile-based communications; fourth, the growth in M4D activity snowballs into a broader, use case agnostic social network, which in turn may reduce information asymmetry risk through reduction of information constraints; and fifth, finally, the generated market motivates community members towards being not just passive, but active innovators in building new M4D solutions for EHS-based problems. In essence, Aker and Mbiti (2010) have drafted a vision for the evolution of the ICT4D (herein used interchangeably with M4D) in the emerging markets. How closely, then, is that vision in the process of being realized?

Aker et al. (2012)'s findings of ICT4D benefits in adult education programs in Niger, alongside Clarke et al. (2013), Dodson et al. (2012), and Cole and Fernando (2012), support that the community is fully in line with at least the first two steps highlighted above. As mentioned in a previous section, this adoption comes primarily because of cost savings and opportunity for higher productivity. In the terms of Arrow, community members have routine signals that they must transmit to their counterparts. If an innovation reduces the time and cost of transmitting that signal, then that innovation is beneficial. In the case of Niger, as Aker and Mbiti (2010) note, the savings to rural farmers has been close to 50%; and Aker et al. (2012) found immense gains in adult education program outcomes. Beyond cost savings, the increased productivity, they argue, in turn encourage greater usage of their information channels. The reasoning here is simple – if one can dedicate more time to direct

productivity instead of indirect activity such as logistics, then technically one can produce more product; however, that increased productivity also now needs a market, either via the same channel or new channels. The authors identify and present several other research studies that conclude that M4D has improved inter-stakeholder group coordination in addition to the initial cost savings.

Beyond simple usage, how do the beneficiaries become the innovators? Aker and Mbiti also discuss this question through case studies, including that of perhaps M4D's biggest success, M-Pesa – an SMS-based payment platform. With over $91USD billion in deposits in 2012, M-Pesa represents the digitization of currency and a next generation of information transfer (www.safaricom.co.ke). M-Pesa was a tool constructed initially to support farmers in transferring money via airtime instead of cash transfer, which would have required the travel cost and time. It quickly evolved to be adopted by Kenya's middle class as the preferred means of payment. In fact, just as one would rely on paying for a taxi with credit card, it has become norm in urban areas of Kenya to accept M-Pesa as means of payment over credit cards. M-Pesa's model is now being used around the world, and vastly outpacing the digital efforts of mainstream banks. However, where M-Pesa first started as a technology dedicated towards providing financial accessibility for the poor, it can be argued that it quickly pivoted to the more profitable sector of the middle class. Easterly and Williamson (forthcoming) has argued that in some cases, M-Pesa has caused the rise of a gift economy, which spreads wealth around in a given area rather than increasing the overall wealth of a community.

Aker and Mbiti (2010) also discuss the three other major beneficiary industries for the M4D movement: mobile health (mHealth), mobile agribusiness (mAgri), and mobile social issues. MHealth applications such as Mobile Medic, to be discussed shortly, offer new breakthroughs in data keeping and tracking. Whereas organizations relied on costly door-to-door surveys, more and more organizations are adopting a model such as the earlier discussed UNICEF Community Case Management (CCM) program, supplemented with mHealth applications. The accessibility offered by SMS, which covers nearly 90% of the

world's population, and the lower variable costs make it an attractive option (Banks 2011). MAgri, mSocial, and mEdu have faced similar rise due to these technological alternative benefits. Among the most successful has been mAgri, typically featured by SMS applications that respond to rural farmers inquiries for daily market prices for a specific good. Social applications have also become popular. Whatsapp and Mxit are two of the most popular simple data-based group messaging applications in Sub-Saharan Africa (Banks 2011), with Facebook Instant Messenger attempting to take a greater marketshare. The Kenyan government sponsored an SMS application for voting in the recent 2013 elections. With the rise of mHubs and more tech-focused mLabs and driven by demand for idiosyncratic problems, university students have pursued the development of these types of applications, leading to greater proliferation of M4D (Banks 2011).

Banks et al. (2011), amongst his other scholarly work, provides an account of FrontlineSMS, what has come to be known as one of the star ICT4D platforms. Starting with the concept of information access, Banks aimed to improve communication between communities, service providers, and any other stakeholder group in order to streamline community development. This, in fact, was not his original goal, and thus forms the center of his thesis on "reluctant innovation". Banks argues that people working in community development or ecological preservation are not trying to solve the communication problem, but rather that is just a challenge along the way so that they can focus on the main task at hand, such as poverty eradication and wildlife protection. Stuck in a similar rut himself, Banks built FrontlineSMS, which enables digital communication over the GSM network in turn allowing for the poor even in remote areas to receive SMS notifications. FrontlineSMS has served as an open source platform over which ICT4D, or in this case mobile for development (M4D), solutions have been built. One example is Medic Mobile, which tracks health records and pushes health-related notifications on an individual basis to that person's cell phone. In addition, FrontlineSMS has been used to monitor elections in Nigeria, Burundi, and the Philippines, and in some areas, it has been used to elect regional representatives. FrontlineSMS and other such platforms represent the shortening of the technical runway for individuals and organizations that want to cooperate, coordinate, and collaborate (Saab et al. 2012).

Reluctant innovators such as Banks are not the only players in generating frameworks for ICT4D. The growth has also been supported through major institutional support. The World Bank, United Nations, WHO, and USAID have pushed ICT to the forefront of developing nations' infrastructure development, and service organizations have taken to this strategy to augment their absorptive capacity and enable long-term growth through better coordination, monitoring, and evaluation. Two aggressive examples include Bangladesh's digital Grameen Bank system and India's Aadhar ID and BharatNet. ICT stood as one of the targets of the Millennium Development Goals; Target 8.F of the MDGs stated that the United Nations would "in cooperation with the private sector, make available the benefits of new technologies, especially information and communications" (MDG Report 2013). Since 2015, the Sustainable Development Goals included ICT as a part of several goals and objectives, not just a single statement (SDG Report 2016).

The efforts of World Bank, UN, and WHO are not without influence. Groupe Speciale Modem Association (GSMA) is a major stakeholder in lobbying for ICT solutions in developing countries. While infoDev represents the public institutional-backed initiative, GSMA represents the private industry's effort to organize a long-term pursuit of ICT infrastructural development across the world. With over 800 MNOs across over 200 countries, GSMA wields powerful authority in determining ICT standards, measuring impact, and pursuing new technology (GSMA 2018). As a part of its mission, GSMA has also created a GSMA Mobile Connectivity Index to correlate underlying capabilities that enable the existence of a mobile ecosystem (GSMA 2018).

GSMA's umbrella is massive, and one major growing star under that umbrella has been the M4D Impact group. GSMA's Mobile for Development Impact group measures industry data on GSM-enabled phone coverage, data (3G, 4G, and soon to be 5G) coverage, average revenue per usage, number of and type of J2ME (Java environment-based applications that use data) and SMS applications in any given area, and other usage factors (GSMA 2018). Through M4D Impact, best practices for growth of these applications are

also typically published. In some specific areas, GSMA also provides annual funding for novel, relevant, high-impact applications in collaboration with other NGOs such as the Bill and Melinda Gates Foundation and the Global Social Business Incubator at Santa Clara University. Though it is still unclear exactly how much GSMA acts as a market maker rather than an enabler, it is clear that GSMA is a major stakeholder in the overall ICT4D and specifically M4D movement. Their priorities, both in terms of type of service and regional focus, seem very closely intertwined with those efforts by infoDev and USAID. At this point, it is assumed that GSMA represents a major data source and not explore any political consequences of their relationship with infoDev, the MDGs, or USAID.

As shown above, players at multiple levels are engaged in ICT4D, each brining its own approach in generation, execution, and proliferation. From reviewing literature, one can be optimistic that this new stream of ICT has been able to positively impact community development efforts by lowering search costs, improving coordination amongst stakeholder groups, and reducing information asymmetry be empowering community members towards greater access to information databases. However, as with any technology, one must consider the intended use, the consequential use, and the socioeconomic impact before blindly pursuing a broad-based strategy for proliferating ICT4D. The next section considers the difference between technology-centric and community-centric approaches, and why the former may produce more unsatisfactory results with unintended socioeconomic consequences.

2.2 Literature Review: Cautionary Optimism for ICT4D

While this pursuit and innovation-friendly approach is encouraging, an objective view should also present the cautionary aspects of ICT4D. Some such as Williamson and Easterly warn that this may be just a new face to the same old aid story. Stiglitz's own Initiative for Policy Dialogue, which "works to broaden dialogue and explore trade-offs in development policy," is divided on how best to employ ICT in developing nations

(www.policydialogue.org). First, it must be noted that ICT4D is not an end-all-be-all solution, but rather a pathway to streamlining economic markets towards their own specific ends. Heeks (2008) is one of the first to warn that the takeaway from the observation that information is valuable in community development should not automatically devolve into a strategy of ICT4D solution multiplication and proliferation, or "we need an ICT4D solution for everything." It may be human nature that when one sees success, it is immediately attributed to the visible change, not the strategy behind the change. In both engineering and finance, many such hammer-led solutions have self-destructed because they did not have the proper motivation. This subsection briefly covers the major pitfalls of ICT4D under misled design, management, and thinking.

The foremost caution comes in the comparison of top-down instigation of EHS projects to technology-centric development of EHS projects. The works of Easterly and Williamson (forthcoming), Moyo (2009), and Stiglitz (1989) (in a different sense), as discussed earlier, have been dedicated to arguing that the top-down model in aid, that is aid pushed by an outside organization onto a community-in-need, is neither sustainable nor effective. This differs from a bottom-up approach in the sense that the community is the initiator and actively seeks the partnership of businesses, NGOs and government institutions for the development of any particular EHS-need. In practice, the bottom-up approach typically works by the community first pooling cash by asking each household to dedicate a small amount for the project at hand, finding a partner in execution if need be, applying to the government for a matching or augmenting grant, executing the project, and reporting the results to the government so that the community may pursue future funding. These activities are often led by a committee democratically elected or assigned by the community's members. However, herein comes again the tradeoff between personal gain versus personal cost, and collective gain versus collective cost. Sachs' argument for top-down intervention is that due to the lack of communal resources and personal income sacrifice by the committee due to time dedication, the probability for such entrepreneurial community-driven action is little to none (2003). Sachs' critics argue that any other form of intervention would result in objective misalignment, and thus a waste and unfavorable

combination of resources for the community. But isn't that the benefit of ICT4D – to eliminate misalignment?

Dodson et al. (2012) review 40 papers in *Information Technology and International Development*, a leading journal article in ICT4D, to understand whether ICT4D truly is salvation to the realm of community development. They find that technology-centric solutions suffer the same symptoms as top-down aid precisely because an ICT-led project indicates the presence of top-down, mono-directional initiation. For example, the accessibility of SMS has led to a major of ICT4D solutions to become M4D solutions. With the thought that SMS could connect every rural community member, several dissemination-style technologies have come to play, and thus faced Arrow's costs of information. However, little thought has been given to how the SMS channel and stakeholders connected through that channel would be coordinated. The easy option, from the viewpoint of interveners, was to disseminate pre-generated information, rather than create a platform for information generation and exchange. Many of these technologies are mono-directional (such as pushing market prices, healthcare alerts, etc.). As a result, the rural community member is suddenly overwhelmed by signals from multiple unknown channels and unable to have a voice.

Dodson et al. (2012) states that the development results of these ICT4D-centric interventions have been unsatisfactory, perhaps because of capacity misalignment. Dodson et al. (2012) also note that community-centric solutions themselves do not guarantee success. There are many more elements to ICT4D success than just the design: execution, verification, and validation all have uncertainties that may risk greater project failure even with full-minded design. Regardless, both inclusivity thinking and ethical development practice frameworks encourage that community and service partners to collaborate through the design process for better, more robust results.

At this point, it is important to return to a comment from an earlier section in distinguishing the top-down relationship that is so often antagonized in community development literature and the top-down approach that is promoted by Gibson in conducting systems analysis (2007). The negative aspects of the top-down relationship have been covered extensively already, however, though the problem arises from semantic similarity, Gibson's top-down approach must be particularly conveyed in this context of community development. Systemic thinking implies that a system must have a clearly-conceived goal towards which its combined set of resources drive, or otherwise, the system without a goal is simply a chaotic set of resources laying waste. In the context of community development, Gibson would most likely argue that the current processes of understanding and fulfilling stakeholder needs under a set of constraints are all systematic. Rather, the underlying challenge is changing the conventional approach to understand the vision of the community – its normative scenario solidified by social and economic value to its members – and then pursue this vision through a critical thinking process that involves measuring the performance of alternative solutions against a set of independent, measurable objectives and following through to ensure that the executed solution meets the goal of the solution.

Critics of conventional community development compress different failures in the above process to a single root cause of inequitable stakeholder voice during goal development as well as inadequate validation of implemented solution. Hence, a flurry of ICT4D research responded with the conclusion of the growing importance of the community voice. Perhaps somewhat ironically, recent innovation in ICT4D has lost sight of the true goal of bettering the state of community members and instead shifted focus to perfecting technological interventions. Whereas the pre-ICT4D critique of community development was regarding improper goal development and monitoring and evaluation practices, the post-ICT4D critique was regarding the over-reliance on solution-driven approaches. However, some like Heeks (2008), Aker and Mbiti (2010), and Doerflinger and Dearden (2013) believe that the approach may be improved soon in the next Schumpeterian cycle of ICT4D.

Heeks (2008) believes that the conventional technology-centric framework in ICT4D design, which he terms ICT4D 1.0, may soon be evolving to a community-centric ICT4D 2.0. Heeks argues that this evolution would came about because of three main characteristics (or, perhaps, struggles): first, ICT4D 1.0 has faced issues with sustainability (in terms longevity) because stakeholders could not identify with the end system; second, ICT4D 1.0 has struggled with scaling solutions, which resulted in significant, multi-level fragmentation and redundancy in solving any given problem; and lastly, ICT4D 1.0 has not been able to measure its own impact clearly. Heeks argues that to advance past ICT4D 1.0, there are minimal infrastructural and technical requirements such as better telephony and energy coverage. However, beyond these requirements, whose call infoDev and GSMA are already answering, the major change remains the change in mindset. Heeks rephrases the top-down versus bottom-up model debate earlier described by discussing ICT4D innovations in three different realms: *pro-poor*, *para-poor*, and *per-poor*. Pro-poor innovation is that which is developed for the poor to enable the poor to do more and better things. Para-poor innovation works alongside the poor, where the participatory community principle reigns true in project design. However, Heeks argues that one cannot forget that that is just a part of the journey until the poor themselves become the innovating body, or the *per-poor innovation*. This per-poor innovation principle is instrumental in understanding that stakeholders involved in community development are working towards a vision in which the community members themselves may continue to identify and combine resources in such a way that the next iteration is a better state than the current. Here again, Easterly and Williamson (2011), Williamson (2010), and Moyo (2009) (especially with regards to Sub-Saharan Africa) may argue that should indeed be the starting point rather than an aspirational one. In terms of technology development, this distinction becomes important because it shifts a product-focused relationship to a capability-focused relationship, and in so doing, it improves the absorptive capacity of the community itself.

Another important word of caution arises from an earlier discussion of technologies such as M-Pesa. ICTs developed for one specific stakeholder group can in themselves become popular and lucrative for another stakeholder group (Heeks 2008). Business shareholder interests may coerce pivoting of products to more lucrative industries, and of course this is understandable. Whatsapp was started as a messaging alternative to SMS for rural communities, M-Pesa was started as a mobile financial system for rural farmers, and Mxit was started as a social network for underprivileged and disenfranchised populaces. In due course, all such businesses shifted towards wealthier consumer target segments (Aker and Mbiti 2010). These businesses continue to have an impact on the original consumer, underprivileged consumer base, but the pivots have realigned their visions. However, without developing *country*-led businesses undertaking their own developing *community*'s needs, it is possible for communities to stay stuck in the top-down aid rut. As such, it may be wise to consider Stiglitz's request for a heavier hand from the government to incent ICT4D, not just ICT, and thus not succumb to outside non-market institutions' role as externalities that cause information asymmetry amongst stakeholders in community development.

Lastly, academic institutions have a significant role to play as an agent of change in the new development model. Service-learning has been trending across academia in educating the institution's students and providing EHSs to communities-in-need. Tucker et al. (2012) provide a comprehensive reflection on best practices in service-learning. The main theme from this paper resonates as the shift from Heeks' pro-poor to para-poor (2008). While the reflection from the faculty leaders in service-learning is a valuable advancement in refining how service-learning happens and impacts communities, it is still far from realizing full value. Students from western higher educational institutions can work alongside those from peer institutions in developing countries to provide EHS, and the next step is for Western students to *support* the leadership development of their counterparts. The ICT4D movement is like the software boom in Silicon Valley, and the best way for developing countries to grow their institutions' absorptive capacity is to take the leadership role, and for partnering Western institutions to let that happen. Central to this transformation is assigning administrative and leadership roles in communication.

Student partners across the ocean would not be mere data gatherers, but rather active community builders if equipped with appropriate ICT4D. This dynamic has already started in the students, but has yet to be recognized by academic institutions outside of Kenya (note, Nairobi's university-mHub partnership between Strathmore University, University of Nairobi, and mHub Nairobi represents one of the few successful dynamic switches). Schumacher's reflection that "education which fails to clarify our central convictions is mere training or indulgence" (1973) is left to conclude the challenge before educational institutions as they continue "to understand the present world."

While ICT4D can be broadly said to have had positive impact in community development, it can be better aligned with a community-centric perspective. This in turn will increase responsiveness and ownership, and shift the traditional aid model from pro-poor to the ideal of per-poor innovation.

2.3 Conclusion: Information and Communication Technology for Community

In Chapter 1, I started by exploring the economic value of information in the particular context of community development. Then, having established through Arrow's costs of information framework that liberated information channels and streamlined signals may help communities advance, the concept of absorptive capacity was reviewed in application to low-income communities, NGOs, and developing countries. Next, ICT4D was broadly established as a positive force for increasing absorptive capacity of stakeholders. However, no technology is without caution, for it is but a tool in the continued effort to improve the condition of the fellow man.

Throughout Chapter 2, the concept of Schumacher's "appropriate technology" (1973) was explored in the application of ICT towards the goal of community development. A retooling of the approach to design, scaling, and evaluation of ICT4D is needed, and

Heeks (2008) predicts that technology-centric ICT4D 1.0 will evolve to community-centric ICT4D 2.0. Through this newer framework, the emphasis will turn to technology readiness, broad availability, demand-driven uptake, and socioeconomic impact, all of which centers around a central vision for a per-poor philosophy on ICT innovation.

3 RESEARCH GOAL AND METHODOLOGY

Given the context of information and communication technology for development and its current standing in both research and practice, the aim of this chapter is to state the research goal and methodology of this dissertation. The aforementioned problems in ICT4D are synthesized and scoped, and the research goal and objectives are defined to address the problems. Research methodology is discussed to cover qualitative and quantitative forms of analysis. The chapter ends with covering specific tasks that the researchers undertook and the results that were expected from the studies.

3.1 Problem Definition

As discussed in the first two chapters, ICT4D has been growing in importance due to endogenous demand and exogenous policy and innovation pushes. As the field of study itself develops, it is important to consider the intent of the field itself. The intent of ICT4D is to enable the innovations in information and communication technology to reach the Base of the Pyramid (BoP), a substantial population with limited resources that have struggled historically to deliver and receive essential human services. Equipped with ICT, the idea is that the delivery of essential human services within and among the BoP would improve tremendously. Thus, there are three jumps before the eventual benefit. First, the appropriate ICT must exist. Second, the BoP then adopts that respective ICT. Third, the users then apply the ICT to domains of their immediate need, which are essential human services such as healthcare, water, and energy.

The problem, however, is that there's a lack of structure in understanding and influencing the factors associated with exactly what makes an "appropriate" ICT. As covered in previous chapters, what has been missing is a framework that assesses from the perspective of the end-user, who in this case includes community members, leadership, and service practitioners, the underlying capability to interact with ICT systems. The barometers for understanding the interaction between users and ICT4D systems has thus

been either missing or inconsistent. As a result, the intended effect of the ICT4D systems have been likewise inconsistent. Additionally, as the second jump implies, the successful adoption of an ICT4D should theoretically increase the underlying telecommunication capabilities of the respective community. However, that capability leap can at this point only be measured by macro-metrics such as number of people with access to mobile phones or coverage in general. In other words, one does not really know if the introduced ICT4D system improves its ongoing use case by the affected community, and thus it becomes impossible to understand whether there is any improvement in essential human service delivery or other human conditions.

For the scope of this dissertation, the problem is re-defined as three nested questions. First, what consistent and holistic framework can be used to understand the current ICT capability of a set of stakeholders? Second, can an ICT4D be developed based on the results of that framework, and does that ICT4D then increase the underlying capability of the stakeholders? Third, does the new ICT4D marginally improve the delivery of essential human services, such as healthcare, in the stakeholder community.

3.2 Research Goals

To answer the questions stated in the prior section, I introduce three research goals and corresponding objectives. The research goals are driven by an overall vision for improving how ICT4D is considered at the Base of the Pyramid. While the goals presented here are intended to be completed within the research timeline, it is important to note, however, that the activities themselves will continue beyond the snapshot of this dissertation. Thus, the research goals are written with a longer view of the horizon.

Research Vision: The vision of this research is to enable the recipients of development assistance to participate equally in all stages of projects conducted in their community by providing them with a means to voice their perspective and preferences.

Research Goal 1: The first goal of this research is to identify a consistent and holistic framework for understanding information and communication technology systems that intake individual voices throughout service development and delivery. The objectives are:

1.1 To identify core factors and underlying attributes that qualitatively and quantitatively capture the capability maturity of ICT systems in a stakeholder community

1.2 To create capability dashboards that aggregate and summarize quantitative results of capability assessment

1.3 To develop a mechanism of quantitatively measuring the frequency of an individual's participation within a larger group relative to his or her peers, as a proxy for summarizing individual contribution in a group

1.4 To evaluate current ICT capability maturity for target communities in South Africa by using the above methods

Research Goal 2: The second goal of this research is to design, build, and test a new ICT4D that improves the current ICT capability of target stakeholder groups in South Africa. The objectives are:

2.1 To evaluate the factors that act as the sources of strength and weakness in terms if current ICT capability

2.2 To design a new ICT4D system that is more inclusive of multiple demographic groups, and reduces economic and technological barriers to participation.

2.3 To build, test, and verify that the system functions in South Africa and the US per the design requirements of 2.2

Research Goal 3: The third goal of this research is to implement the respective ICT4D system and understand the impact it has on the target communities in terms of improvements in essential human service delivery. The objectives are:

3.1 To deploy the ICT4D system with target stakeholder groups to understand potential benefits or consequences to delivery of essential human services.

3.2 To collect and analyse qualitative data from participants to continue to improve both the design framework as well as the built ICT4D system

3.3 Research Methodology

The above research goals and objectives are ambitious in undertaking as it represents both theoretical and experiential research. To satisfy the three goals, the research underwent three phases. First, a broader survey was conducted of existing practices in international development and essential human service delivery as observed through interviews with service practitioners and communities, as well as through literature. This first survey was conducted by myself with the help of other research partners that lived in South Africa in mid-2013. The literature survey and initial research planning with research partners led to the creation of the framework for assessment (Objective 1.1). Given local cultural standards, the survey was conducted as a form of appreciative inquiry – or a series of questions that explored current strengths through discovery, future dreams, and identification of existing barriers that the respondents would overcome to reach their dream state. Responses were collected through field notes, which were assessed on an ongoing basis to identify the core factors and barriers. The first phase would yield both the framework for capability assessment (Objectives 1.1) as well as the current capability maturity of the surveyed communities (Objective 1.4). After the initial field survey, the data analysis and dashboard summaries were created to better demonstrate the learnings from research (Objective 1.2). Additional detail of this phase is discussed in the subsequent chapter.

Having now established the capability framework and understood the current capability maturity of ICT4D in the target communities, the next phase was to design and build an ICT4D system that would overcome the barriers. The initial design requirements were formed from the initial survey results that formed the current capability maturity

(Objective 2.1). Layering the technical and human factors requirements came next (Objective 2.2). At this point, it was realized that the mechanism for quantitatively assessing individual involvement was still lacking. We also needed a way to automate such an assessment. As such, the participatory equity index was created with the inspiration of the Gini coefficient, which portrays how resources are spread across individuals in a country. The same approach could help isolate whether individuals are participating for themselves, or whether select individuals are dominating the opinion. Thus, the participatory equity index was derived and formulated for automation in the ICT4D platform (Objective 1.3). Then, a team of undergraduate students and I built the application itself, connected it with a Mobile Network Operator (MNO) aggregator that served as the intermediary the agent that would actually send and receive messages (Objective 2.3). In a sense, we built the logistical back end to the mailman delivering and picking up mail. By mid-2014, a working prototype of an ICT4D system was created for initial testing. However, additional iterations were necessary to improve the overall user experience and remove bugs in the code. The process of refinement continued through mid-2015 when in-person testing was conducted with the UFS stakeholders.

Given that the stakeholders at UFS as well as at UVa. had academic obligations and additionally that the end community partners had their own service delivery obligations, the iterations of tests and re-build faced delays. Regardless, by early 2016, the team in the US had formulated a product that was deemed implementation ready. An initial concern here was that the capability maturity had changed in the communities significantly between 2013 and 2016, especially due to the rapid evolution of mobile telephony in developing countries. However, due to the frequent communication with the stakeholders, small adjustments were made to the initial capability maturity, specifically in the realm of access and availability, to account for any improvements. Those were also accounted for the iterations in re-design.

The third phase was to deploy the ICT4D across available use cases to understand whether this particular ICT4D system, adjusted for the intrinsic capabilities for the

community, be able to improve the overall delivery process. In an ideal world, such a change would be measured econometrically through longitudinal studies that span multiple years. In the case of the UFS, we were thankful to already have an idea of health-related afflictions and cases over a multiple-year period. Could the instrument of improve ICT4D, provide a significant uplift in the delivery? And where would be the proper place to look? Initially, we had pitched such a concept to a combined set of grant-making entities including the National Research Foundation in South Africa. The feedback was to conduct a preliminary assessment before a longer-term execution that requires additional investment. As such, the methodology became more practical to understand the immediate impact that an introduction of an ICT4D system would have – for example, would community members actually ever use it? What successes can be built on? What barriers remain to scaling? These became the more immediate research questions to answer, as noted during the use case and discussion chapters.

The third phase, in effect, covered the deployment across four different stakeholder groups and use cases. The demographics varied across the group, but in general the core aspect was that they all had limited access or availability of communication systems hitherto the introduction of our respective ICT4D system. They all had faced issues with communications. The use cases also differed from homeless shelters to healthcare-related communication to experiential learning reflection to support networks. Through each use case, the stakeholder group was engaged to note that they would be working with a specific messaging system, instructions to which were provided and demonstrated. Sentiment coding was done for the messages delivered to a subset of groups that worked directly with UFS. For the fourth use case on virtual support network, the content and message data were held private to the participants. The intention with all use cases was to study the engagement of stakeholders in the system, follow up with questions around feedback, and record them as qualitative data points to suggestive improvements to the system (Objectives 3.1 and 3.2). This information would then be analysed to provide answers to the aforementioned questions, and lay the foundation for future expansion and funding.

It should be noted that the scope of the research, while taking inputs from other regions, was limited to select communities in South Africa. The country was selected because the country has a similar ICT4D demographic profile to other developing countries and because of existing academic relationships established through prior research activity in water and sanitation work in the Limpopo region. An important aspect to any international research is having a sound on-ground academic partner. I found that partner in the Centre for Service Learning at the University of Free State in Bloemfontein, South Africa (Objective 3.1). Two researchers in the centre – Karen Venter and Mabel Erasmus – were interested in improving the way that their nursing students that provided field services to nearby rural communities could better engage with end-patients. Other use cases through community partners connected to the Centre were are also introduced over the course of the research. Over time, a combined team applied to the National Research Foundation (NRF) in South Africa to receive preliminary funding to implement phase three.

3.4 Expected Results

The expected results from the above study also carries three corresponding parts. The results of the first goal and underlying objectives should provide a different perspective on current observations, with an emphasis on individual users. Current frameworks focus on solution-based deployments, and thus focus on factors that are technical or use case-specific in nature (Aker and Mbiti 2010, Adedokun et al 2010). However, there's been a recent trend towards a more holistic, interdisciplinary approach to understanding the needs and capabilities of the end users (Champion et al 2018). As such, it is expected that the framework will similarly focus on the capabilities of the end users from economic, technological, and sociological perspectives. The results of the framework are also expected to be mini summaries across different factors rather than a single number to denote the overall capability (Doerflinger and Dearden 2013). Such a method allows for more qualitative information to flow to design (Champion et al 2018, Doerflinger and Dearden 2013). The expected outcome of the participatory index will likely focus on present day metrics that consider equality and equity, like the Gini coefficient (Chambers 1983, Metzger and Guenther 2015).

The most interesting outcome from the first research goal will likely be the capability assessment for South Africa. It is expected that the current capability maturity results for South Africa are mixed with strengths due to recent re-organization efforts and weaknesses due to technological and economic barriers (Aker and Mbiti 2010, Clarke et al 2013). Certain areas of emphasis, given prior experiential learning that I have done in both India and South Africa, would be around unlocking the potential of the existing phones that everyone has rather than forcing yet another device onto peoples' lives without proper electrical, economic, or maintenance support. Some aspects that could be more mature as of recent would be the availability of basic mobile telephony network or stations where the pre-paid balances of SIM cards could be more readily recharged. Regardless, other constraints likely limit the overall capability and create barriers in communication (Diallo and Thuillier 2005, Dodson et al 2012).

Second, I expect that the ICT4D system would be achieved with some caveats. Construction of an international messaging application is not a simple feat, especially when that involves multiple mobile network operators acting as middlemen both technologically and economically (Dodson et al 2012, Champion et al 2018). Unlike native web applications such as *Whatsapp*, the challenge will be in leveraging something more universal – such as the actual SMS messaging feature that exists as a part of mobile telephony layer rather than in the data layer, which requires additional economic and technological resources and connectivity (Barrett and Constas 2014, Heeks 2008, Doerflinger and Dearden 2013). It is expected that the means achieving free to end user messaging will be identified, but not implemented due to the upfront capital investment necessary to unlock such a feature with mobile network operators. I do believe that the fundamental, multi-stakeholder messaging component of the ICT4D would be accomplished (Clarke et al 2013, Dodson et al 2012).

Third, I think the deployed ICT4D will provide interesting insights and expose the stakeholders to new possibilities. The introduction of an appropriate ICT4D system would mean unlocking the voice of the individual within rural communities (Adedokun et al 2010,

Aker et al 2012, Champion et al 2018, Cole and Fernando 2012). However, I think that cultural and literary barriers will remain before such a voice make immediate impact (Diallo and Thuillier 2005, Dodson et al 2012, Kretzmann and McKnight 1993). I believe that training and education of the system will be just as important as the technical factors of the system (Aker et al 2012). That said, one way to encourage the spread of the use of the system is to introduce the enthusiasm of communicating internationally. When discussing possible use cases, the concept of a long-distance, long-term "pen pal" after a shorter, internationally mixed deployment rose as a new possibility. Regardless, all of these new possibilities will require funding and time behind, without which advances will be limited.

In summary, I expect that the capability framework, the ICT4D system, and its deployment will provide new insights into how communication plays a role in essential human service delivery. I believe that the overall capability of the community would increase as a result, but persistent access to and use of the system may be a necessary for that higher level of maturity to become sustainable. Otherwise, the risk is attrition.

4 INCLUSIVITY SYSTEMS FRAMEWORK FOR COMMUNICATION SYSTEMS

With the understanding of information sharing in Chapter 1 and approaches to and in ICT4D in Chapter 2, the task remains to present a central framework to identify, analyse, and inform design of capabilities that befit ICT4D 2.0. Chapter 4 presents Inclusivity Systems Framework for Communication Systems as a novel framework that builds on conventional systems-based economic and technological requirements analysis by introducing an intentional multi-stakeholder participation pillar.

4.1 Inclusivity as a proxy for trust

Chapters 2 and 3 have identified mainstay characteristics of community-driven systems. Primary amongst those characteristics is trust – the trust amongst participating community members, leaders, organizations, and other external parties. In a sense, the trust may be perceived as a subsidy, rather than a cost, to information signal creation, transfer, and consumption. Plainly speaking, the trust accelerates the process through which different stakeholders unite and collaborate towards a common goal. How do we create an ecosystem that allows for community members to trust each other? How do community members in developing countries build trust amongst each other? How do organizations that interact with community members gain, sustain, and build upon trust?

Earlier presented research attempted to answer these questions by viewing community engagements where community members participated in the design or dissemination of EHSs to the community. The underlying assumption in these engagements was that participation was a proxy for agency and empowerment, which in turn may lead to trust over time. However, the intentional inclusion of the full set of community members precludes the participation of a subset. In the next chapter, a qualitative study of NGOs to understand common problems in community engagement is

presented. One observation from the study is that many NGO leaders and stakeholders feel that their solutions are limited by the participation of a few community representatives. For example, when an NGO stakeholder enters a community to engage the totality of its 100 members, perhaps only 10 may rise as participants. With the influence of these 10 participants, the NGO stakeholder may design and execute an EHS solution in the whole community. However, the NGO stakeholder soon notices that the designed solution may not account for the underlying characteristics of all 100 members. The participation bias creates an exclusionary atmosphere, which may create an environment of lack of trust or even distrust (Medis 1980, Chambers 1983, Chambers and Conway 1991). Thus, inclusion is often the item to consider as opposed to the participating stakeholders. The problem remains that the NGO stakeholder may not have the capacity to take in 100 different perspectives in design, much less engage with those stakeholders. How, then, can an inclusive system be designed with limited engagement?

One way to account for broad-based inclusion is to capture community members' considerations and attributes to understand their inclusivity, which I define generally as the ability of an individual in a community to partake in community activities and interactions irrespective of the respective individual's attributes, means, or state. It is important to parse these different aspects. First, the subject at hand is an individual in a larger community. That individual may have a specific role in the community, for example, as the head of the Water Committee; however, that is not necessary. Second, the individual interacts with other individuals of the community or the institution of the community, perhaps the official governance or a leader that represents a governing body. The method of interaction could vary depending on the goal of the interaction; if the goal is to buy a set of goods and services, the methods may vary from in-person exchange to digital transfer, or a combination. A community may choose to establish a certain method as the standard form, for example, in the form of a formal engagement at the *Chief's Kraal* (a meeting in the Southern African region of Venda where certain cultural traditions are followed and business is deemed official). Third, the individual's attributes, means, or state could influence the intended interaction by serving as a barrier or enabler in an environment of commonly accepted interaction methods. For example, assume that there was a common

method of interaction between community members is WhatsApp, a digital messaging service. WhatsApp requires an individual's access to a data-enabled phone, data, battery energy, and literacy amongst many other things for the individual to be a viable participant in interaction. In the absence of any of these, the individual is *barred* from the interaction and thus not included in the process. Alternatively, in the presence of the same and additional resources or attributes, perhaps smart phone or unlimited data, the individual is *enabled* to interact.

The crux of understanding inclusivity, thus, falls to understanding the barriers and enablers that individuals face in their efforts of partaking in community activities and interactions. The same analysis remains accurate at different scales. For example, the overall level of inclusivity of an organization could be defined by the barriers and enablers that subunits within the organization face in interaction. Aside from the tinge of community development and interaction, the principles hold with Arrow's takeaways of signals, channels, and costs covered in prior chapters. What this means in terms of building a framework for assessment or design is that community development principles and Arrow's principles could serve as inspiration for a unique framework to assess inclusivity, and thus the engine of trust in community-based interactions.

The process is akin to Capacity Factors Analysis (CFA), which is another framework that captures the likelihood that a community can take on varying levels of technological interventions to meet an underlying EHS need (Bouabid and Louis 2015, Pailla and Louis 2011). CFA considers eight capacity factors, which include: Service Capacity, Institutional Capacity, Human Resources Capacity, Technical Capacity, Economic and Financial Capacity, Energy Capacity, Sociocultural, and Environmental and Ecological Capacity. Each factor has a subcomponent (some categorical, some ordinal) that expands on how that factor's capacity may be measured. In practice, a community's capacity level is determined through combination of weighted assessment of each of the capacity factors. The combination algorithm takes the score of a given capacity factor's attribute, weighs that attribute's score alongside other attributes under the respective

capacity factor to combine for a factor specific score. From there, a community capacity level is defined to be the minimum of all capacity factors' respective attribute-weighted score. As such, there's a single source of scoring, adjustment via attributes' relevance to a particular community, and the concept that whatever is the factor with the least capacity actually is the threshold to address during solution recommendation (Bouabid and Louis 2015, Pailla and Louis 2011). However, CFA does not account for the ability of individual members within a larger community to be included in the fabric of the target EHS solution. A framework is still needed to capture the inclusivity maturity of a community, which would then better inform stakeholders in solution discovery and design. In the next section, I introduce an Inclusivity Systems Framework as one way to assess the inclusivity maturity of a given community.

4.2 Inclusivity Systems Framework

The Inclusivity Systems Framework is a systems approach with a focus on individuals, their role in their respective community, their interaction with technology and vice versa, and their interactions with economic factors. The framework looks at the fundamental aspects that enhance or hinder the trust building process amongst multiple members of a stakeholder group. The framework may be used to assess the maturity of a single community's overall inclusivity as a snapshot, assess maturity of an existing EHS system (in this case, particularly in communication systems), extrapolate assessments from multiple communities to paint a broader picture of a set of communities, or drive the design of a new system that has a focus on inclusivity. The latter is present in the next chapter as a case study of HiComm.

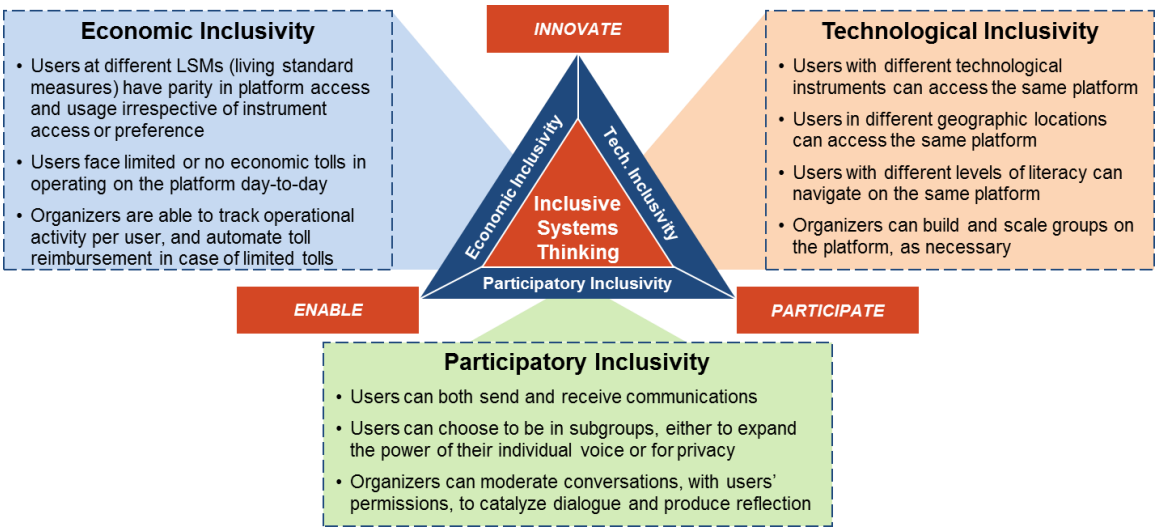

Figure 4: Inclusivity Systems Framework Summary of Inclusivity Conditions

What does the framework consider? I define the Inclusivity Systems Framework with three conditions of inclusivity: Economic Inclusivity, Technological Inclusivity, and Participatory Inclusivity. Economic Inclusivity describes the extent to which individuals face economic barriers, irrespective of their own economic conditions. Technological Inclusivity describes the necessary technological pre-conditions to engagement and the extent of support systems for individuals that may have limited technological experience. Participatory Inclusivity accounts for how the individual currently fits in and is designed to fit in a larger communal context. Each condition has underlying factors and attributes that further describe the conditions, as covered in the subsequent sections. I define the Inclusivity Systems Framework with a domain focus of ICT4D. However, as will be covered in the Discussion chapter, the framework may be more broadly applied pursuant to contextual definition changes under each factor and attribute. Figures 4 and 5 provide brief explanations and summaries of the factors that contribute to the conditions of Inclusivity Systems.

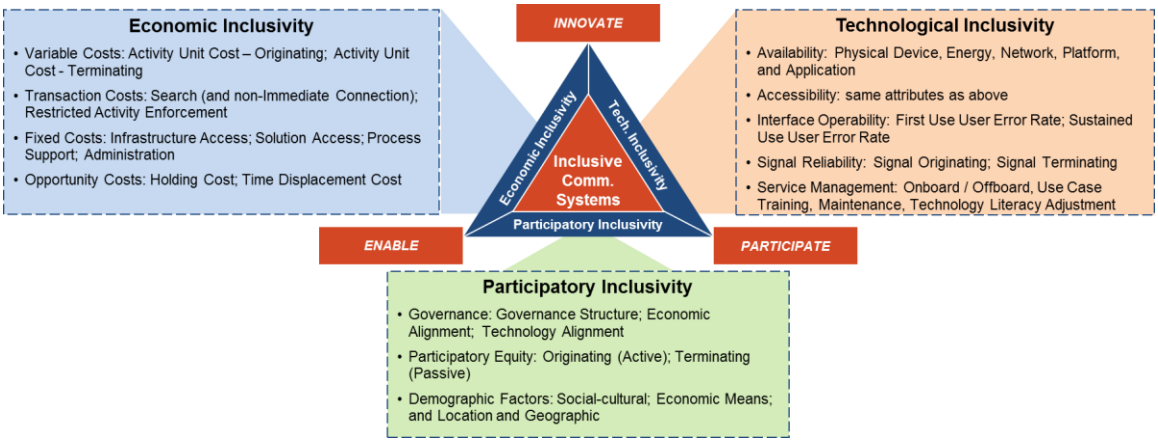

Figure 5: Inclusivity Systems Framework with underlying factors and attributes.

The ISF is envisioned as a framework that is deployed by both community and service stakeholders as a part of the service engagement lifecycle. The framework does not exist in isolation or as a one-off procedural item. When considering the overall value chain of a typical service engagement, it can be summarized as a set as in Figure 6. A series of stakeholders and other variables provide inputs into the strategy and planning of the service engagement. From there, an appropriate service or solution is designed, developed, tested, and iterated, until it satisfies the preliminary functional requirements. Lastly, the service or solution is then delivered to the end stakeholder through a formal release and training, and sustained through break/fix, general support, and external service management.

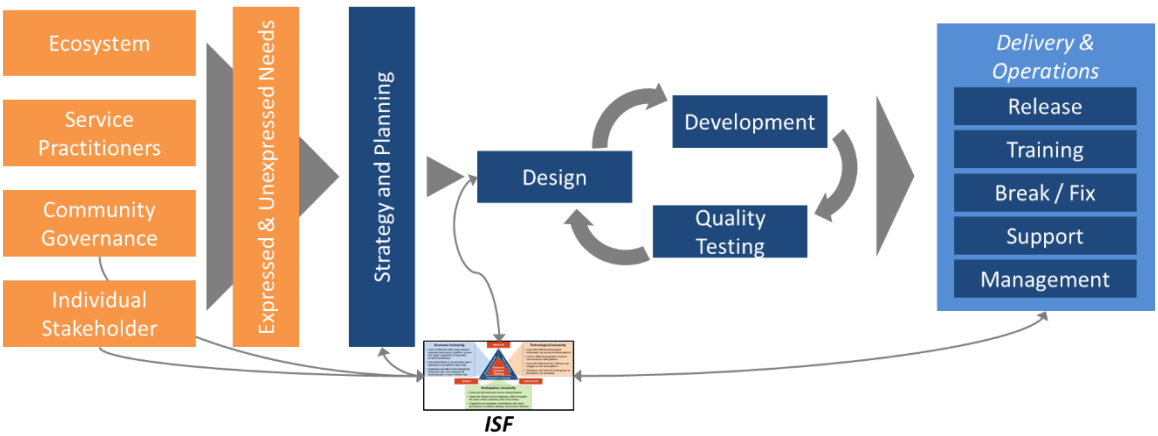

Figure 6: The framework receives inputs from community governance and individual stakeholders to align with the strategy, planning, and design components of an iterative solution development approach.

The ISF framework theoretically (and practically as covered in subsequent sections) plays a role in four of these areas. First, at the input level, the ISF framework could be leveraged to structure the expressed and unexpressed needs from both an individual and a community governance perspective. For example, the conditions, factors, and underlying attributes in the ISF could be reviewed by both sets of stakeholders to understand existing barriers and needs, and form functional and technical requirements accordingly. Second, the results could be aggregated to understand what general strategies could be deployed. For example, in the case that the community in question seems overweighed on the economic burden of prepaid technological services, then a cost-sensitive strategy that relies on basic requirements would be followed. Third, both the detailed and aggregate results could be leveraged to guide the design team stay consistent with the individual stakeholder's perspective while meeting the overall functional requirements of the service or solution in question. Lastly, the ISF framework could provide structure for stakeholder validation during service delivery and operations.

4.2.1 Economic Inclusivity Condition

Economic Inclusivity is the concept that stakeholders are able to conduct mutually-desired activity irrespective of their existing economic resources. The concept differs from Economic Inclusion, which is presented by the United Nations as the right that each individual has to work (to earn income). Economic Inclusivity is composed of four main factors as attributed to the state of stakeholders: Variable Costs, Transaction Costs, Fixed Costs, and Opportunity Costs. These factors are highlighted in different domains of ICT-related research, as covered in the Chapters 1 and 2. As early as 1993, Aleem highlighted the role of different types of costs in a value chain of information sharing. More recent literature in the ICT4D domain that highlight the importance of economic factors include Jensen (2007), Clarke et al (2012), Barrett and Constas (2014), Dodson et al 2015, and Metzger and Guenther (2015). Champion et al (2018) also highlights variable costs associated with end users in their evaluation in Congo.

4.2.1.1 Variable Costs

Variable Costs in business are conventionally described as a cost that rises based on the level of activity in which an individual or stakeholder group partakes. In the case of Economic Inclusivity, the factor is focused on the specific activity-based cost barriers that a stakeholder faces when partaking in an activity. Three specific costs can be used to understand how the Variable Costs factor affect a stakeholder's economic inclusivity: Originating Activity Unit Cost, Terminating Activity Unit Cost, and Variable Energy Cost.

4.2.1.1.1 Originating Activity Unit Cost

Originating Activity Unit Cost is the rate-based fee that a stakeholder is required to pay to send, give, or provide a good or service. For example, an individual in non-US countries that would like to send a text message in a prepaid plan must pay a per unit fee. An alternative example is the toll that someone pays to cross a toll bridge or go through a toll tunnel.

4.2.1.1.2 Terminating Activity Unit Cost

Terminating Activity Unit Cost is the rate-based fee that a stakeholder is required to pay to receive a good or service that is initiated by another stakeholder. For example, most US phones work with a "Mobile Terminating" plan, which means that the minutes are counted on the recipient's side. As such, the person that is receiving the call ends up being economically liable for the cost. A simple example is a collect call, where the recipient of the call accepts the charges of the call. A non-communications example is payment on shipment delivery model.

4.2.1.1.3 Energy (variable) Cost

Energy (variable) Cost accounts for the daily (or lower unit) charge necessary to carry any operational activity. Critically, this cost is differentiated particularly for lower-income communities as they may require paying an outside stakeholder to charge their cell phone in order to place a call.

4.2.1.2 Transaction Costs

Transaction costs are administrative costs associated with preserving the intent of any given transaction, message, or operation. Unlike variable costs that account for the

core purpose of the activity, the transaction costs are focused on support. Two underlying transaction costs are specifically considered: Search (and Non-Immediate) Connection Costs and Restricted Activity Enforcement Costs.

4.2.1.2.1 Search (and Non-Immediate Connection) Costs

Search (and Non-Immediate Connection) Costs are defined as the economic rent lost due to the stakeholder's need to identify the metadata associated with an alternative party in order to transact with that party. For example, Person A needs to talk with Person B, yet the Person A does not have the relevant details associated with Person B, such has his or her mobile number or address. Search Costs increase especially in cases where Person A does not know who Person B is, yet that is the end party with whom they must interact. Such costs are relevant in use cases of stakeholders working with Community Health Workers or incident-catalysed support personnel.

4.2.1.2.2 Restricted Activity Enforcement Costs

Restricted Activity Enforcement Costs are defined as the economic rent lost due to potentially malicious activity associated with the network's operations. Given that each message or transaction needs monitory for possible threats, the costs are often added on at the transaction level. In some cases, step-cost models may also exist. In the realm of community development, agent-inclusive networks may face higher Restricted Activity Enforcement Costs in order to follow the principle of non-malfeasance, and thus correct any false information. Examples include HIV-related NGO workers addressing false information on safe practices, community health workers aiding just circumcised men through pain management and anti-infection, and water and sanitation infrastructure agents maintaining correct data and operations.

4.2.1.3 Fixed Costs

Fixed costs are those associated with the underlying systems and pre-conditions necessary for the operational activity to happen in the first case. Four fixed costs are considered for the Inclusivity Systems Framework: Infrastructure Access Cost, Solution Access Cost, Process Support Cost, and Administration Cost.

4.2.1.3.1 Infrastructure Access Cost

Infrastructure Access Cost is the fixed cost that an individual, organization, or both need to pay in order to access the system in focus. Most often, this access cost is charged as a tax on a broader list of costs. For example, an individual paying for a phone service has an access fee associated with the infrastructure layer in addition to the specific solution or plan for which they are paying. In addition to the actual cost, some infrastructure access costs may not be immediately monetary. An example of this includes the time-value of a child or woman walking to fetch water from a nearby river.

4.2.1.3.2 Solution Access Cost

Solution Access Cost is the fixed cost associated with a specific solution that an individual, organization, or both need to pay in order to be engaged on the same platform. The differentiating factor is that a solution is defined as an item, network, or model existing in the platform or application layer rather than the infrastructure layer. Consider the difference as that of having access to a telecommunications network versus a specific phone offered by that network, or perhaps a villager to a river stream versus a filtered water service. The cost also differs with the models through which the solution may be offered. A growing example is a shared-economy platform like Uber, which not only provides a specific transportation solution but also broader access to the road infrastructure as well as telecommunication infrastructure. For the purposes of scope, Solution Access costs are limited to the incremental, fixed cost, often through the purchase or extended lease of an asset.

4.2.1.3.3 Process Support Cost

Process Support Cost is defined as the combined cost of service launch, management, operations, and off-boarding. In a typical technology service operating model, this cost is often associated with "run" services rather than the build or design services. As such, the cost is classified as an ongoing operating cost to the service provider, which in turn is then charged as a fixed step cost to systems' stakeholders.

4.2.1.3.4 Administration Cost

Administration Costs include extraneous fees and taxes that are not included in the above categories. An example of administration cost includes a one-time network initiation fee that is associated with billing or account generation.

4.2.1.4 Opportunity Costs

Opportunity costs play an important role in economic inclusivity, particularly in cases of toll-paying end users (note, not network or service payers). In general, these costs are generated with Holding and Time Displacement.

4.2.1.4.1 Holding Cost

Holding costs may seem similar to the concept of working capital ratio requirements - when a business requires additional working capital to handle volatility in supply and demand of resources. Holding costs in this case are defined at two levels: for an individual user, the costs indicate the balance of resources that the user anticipates needing for future needs; for an organization, the costs indicated the balance of resources that they need to provide to their user base for future use. An example of both is that of a user holding a pre-paid balance anticipating an emergency call. As with business, the resources tied up in such holding costs are not used for alternative yet viable purposes.

4.2.1.4.2 Time Displacement Cost

Time Displacement costs are defined as the resources lost due to the time allocated to the execution of a given service. An example of such a scenario is someone that must walk to, wait at, and return from a clinic for the purpose of a check-up. In low-income communities where salaried jobs or paid-time-off do not exist, the time displaced is actually a cost associated with income that could've been generated through labour. An inclusive system, thus, must account for user-oriented requirements that cause time displacement.

4.2.2 Technological Inclusivity

Technological Inclusivity is the concept that stakeholders with differing technological resources and technical literacy are able to engage, service, and support co-dependent processes.

4.2.2.1 Availability

Availability reflects a given technological product or service's presence within the socioecological system of the stakeholder. Availability is determined through the view of five aspects of typical technological layers: physical device, energy, network, platform, and application. It is important to note that there may be availability ratings may range dramatically across these layers, as well as Accessibility, another factor of technological inclusivity.

4.2.2.1.1 Physical Device

Physical device availability is defined by the physical presence of the technological product or service. While the physical presence of product such as a car or phone is self-explanatory, a service may be tougher to imagine. An example of physical service accessibility is that of a taxi service or a community health worker that may come through the area.

4.2.2.1.2 Energy

Energy availability focuses on the opportunity that stakeholders have to charge, fuel, or make function a technology product or service. Availability does not guarantee that the stakeholders will actually take advantage of the resource.

4.2.2.1.3 Network

Network availability describes whether the underlying infrastructure of a technological product or service, such as a telecommunication, road, clinical or support network, is available in the stakeholder's location. Whereas physical device focuses on a single component, like a car, this attribute considers whether that single component may achieve its intended function through a larger infrastructure, like a road network.

4.2.2.1.4 Platform

Platform availability accounts for the presence of an operating system, therein equipping stakeholders to a digital infrastructure. Unlike the other factors, platform and application focuses on specifically digital technology. However, it can still be broadened to include a non-foundational infrastructural system. For example, the digital platform for a computer may be a version of Windows or Apple OS. Similarly, the platform for a transportation system may be the companies that operate on the broader network, like Greyhound buses that take advantage of the open road network.

4.2.2.1.5 Application

Application availability is defined by the existence of applications - defined as modules designed to function and resolve specific use cases on a given operating platform - to stakeholders. Unlike the other factors, platform and application focuses on a specific type of technology. Understandably, platform and application are correlated. However, it may also be possible to have a single application system. While applications have a digital tinge, the category may be broadened with the idea of a specific solution. Building off the previous example, a single bus that goes from Charlottesville, VA to Washington, D.C., which serves a fairly specific need, can be comparable.

4.2.2.2 Accessibility

Accessibility of a technological product or service is defined by whether a stakeholder actually functions or uses the product or service. An assumption of including this factor in the broader technological inclusivity condition is that there is a difference between availability and accessibility in that an available resource may not be (or may not be easily) accessible by a stakeholder.

4.2.2.2.1 Physical Device

Physical device accessibility is defined by whether the stakeholder in question is in possession of or has a physical means to access the technological product or service. An interesting aspect here is that the stakeholder does not necessarily need to have ownership of the said technology, simply access. An example is that of a cell phone that is in the hands of the home's grandmother, but is also accessible by her broader family.

4.2.2.2.2 Energy

Similar to Physical Device accessibility, Energy accessibility depends on whether a stakeholder or group may access the means to charge or fuel the technology product or service. In this particular case, the accessibility of said energy may be inhibited due to physical, cultural, economic, and knowledge boundaries. For example, even if a village may have access to transient electricity, they may not be able to access simply because they either lack the resources or perhaps even fear its access.

4.2.2.2.3 Network

Network accessibility describes the extent to which a single person can access a broader network or infrastructure. While a precondition may be that the network be locally available, workarounds may exist where one can access a network that is not necessarily available, like one who takes advantage of an alternative network, instead, to access the given network of interest. Transportation is again a convenient example. While someone may not live next to a railroad station, the person may easily access it through driving self, cabbing, carpooling, busing, or biking.

4.2.2.2.4 Platform

Platform accessibility captures the extent to which one engages with an available platform. Unlike network accessibility, which may have work-arounds, platform accessibility will most likely require the presence of the underlying platform. Cases of an inaccessible platform with the availability of the respective platform are few, and may include restrictive use by authority and lack of knowledge of access.

4.2.2.2.5 Application

Application accessibility, unlike platform accessibility, varies irrespective of underlying application availability. An application that is available can be one that is either pre-loaded or downloaded on a respective platform. However, even if that application is available, it may not be accessible due to pre-requisite user attributes, security control, and access block from without. Thus, even a broadly available application, such as Facebook, may not be accessible to a rural farmer because of the pre-requisite requirement of email or alternate ID. As a side note, such applications have shifted the use case preconditions to allow for a broader set of IDs, including a person's phone number.

4.2.2.3 Interface Operability

Interface Operability summarizes the human factors aspect of the underlying technology or process. The major distinction is on how a user interacts the with the underlying platform and application set of solutions. Though it is difficult to front-end test design elements other than through iteration, comparables may be used to judge how a given populace approaches similar solutions.

4.2.2.3.1 First Use User Error Rate

First Use User Error Rate is a post-build measure that reflects how intuitive a technology or process may be. The measure can be used in iterations of builds. While specific underlying functional requirements ought to be tested individually, the First Use User Error Rate provides an indication of the human-solution operability, essentially resting on whether an individual was unable to perform the use case at the end of the day. Note also that the emphasis is on the first set of attempts, not just the very first attempt. Failure at this level is often rectified through use case delineation, design thinking, product iteration, pre-use user instruction, and stepwise exposure (e.g., starting with a simple operation before building to a more complicated one).

4.2.2.3.2 Sustained Use User Error Rate

Sustained Use User Error Rate captures how a user handles a solution or process over multiple uses. A higher sustained error rate indicates that the underlying solution or process is broken and ought to be reconsidered. On the other hand, interaction effects from an individual's exposure to other existing solutions or processes may change his or her expectations, and thus, this measure may change over time due to interaction effects from the user's overall environment.

4.2.2.4 Signal Reliability

Signal Reliability describes the success of sending and receiving a signal, which may simply be thought of as some form of information, over a channel. In addition, this factor also considers storage of a signal for future reference and usage. Note that this factor focuses on verification rather than validation, which is to say that while the requirements

of sending, receiving, or storing signals may have been meet, the intended use case may not still come to fruition due to other external factors.

4.2.2.4.1 Signal Originating Delivery

Signal Originating Delivery describes whether a signal, which is intended to be sent from node A to another node or set of nodes, has actually been verifiably sent.

4.2.2.4.2 Signal Terminating Delivery

Signal Terminating Delivery describes whether a signal that is sent from a node to another node or set of nodes has been received by the sender's intended set of recipients. The factor also captures whether the signal itself has been received correctly; for example, a verified sent signal of "123" is not received as “456."

4.2.2.4.3 Signal Storage

Signal Storage reflects the extent to which a signal can be stored on a chosen platform available to the user. While some devices or platforms or solutions have unlimited storage, others limit storage to a single signal itself or a set number of signals. The storage thus enables or disables a user's ability to record and respond to messages over longer longitudes of time.

4.2.2.5 Service Management

Service Management covers the process and support aspect of the overall technological process. Crucial to the starting, sustaining, and sunsetting of any technological or otherwise solution is the availability of resources that serve as guides, backup, and troubleshoots for arising cases.

4.2.2.5.1 Onboard and Offboard

Onboard and Offboard reflect the first and last stage of service management, effectively. Onboarding initiates a user to a specific use case and thus requires the completion of underlying attributes from the user, use case, and process. Offboarding enables transition of the solution or process to other necessary use cases, effectively freeing up underlying resources that may had been hitherto supporting an existing use case. While

both are distinct processes of the overall service management module, these two factors are typically designed in unison and as such held together as one.

4.2.2.5.2 Use Case Training

Use Case Training is the natural extension of onboarding that enables greater success of a use case. Training may be provided to the user through multiple media, including simple guides, references with graphics, in-person training, and other variants. The presence of use case training is intended to achieve higher success, though that may always not be the case due to quality of training itself.

4.2.2.5.3 Maintenance

Maintenance describes the backend system support that provides fixes, clarifications, and other adjustments to an ongoing service with an intention to improve the overall service for users.

4.2.2.5.4 Technology Literacy Adjustment

Technology Literacy Adjustment captures the technology-side adjustment during service management for users that may be less familiar with the provided technology or the technology itself. While this component may fall into the Participatory Inclusivity condition due to possible demographic factors, the idea is that the service management module is able to adjust to varying user attributes to deliver requisite amount of service regardless of user background.

4.2.3 Participatory Inclusivity

Participatory Inclusivity describes the state of how multiple stakeholder groups across different demographics are engaged on a given platform or process to achieve an aggregate goal. In an inclusivity approach, the manifestation of stakeholders arises through an initial participation process of different groups. In tune with their feedback, a primary group drives the formation and execution of collaboratively envisioned solution. The Participatory Inclusivity condition differs slightly in that it envisions a continued participation of all stakeholders through the process, including implementation and execution.

Herein is captured Richard Heeks' sentiment shift of "pro," describing solutions that are developed with a certain stakeholder group such as the poor in mind, to "para" and "per," where solutions are developed in collaboration with or according to the respective stakeholder group of interest. Lacking from this general structure, however, was a general set of factors for consideration of how such participatory elements rise to the top during systems design and implementation. Here, Participatory Inclusivity is summarized through Governance, Participatory Equity, and Demographic Inclusion.

4.2.3.1 Governance

Governance defines the structure and alignment of how a stakeholder group organizes. It contributes to the outcome of decision-making by process of its structure, formal organization, and stakeholder make-up.

4.2.3.1.1 Governance Structure

Governance Structure describes how multiple stakeholders arranged to form a decision-making entity. That entity then defines technological and economic boundaries that in turn contribute to the fruition of a pre-defined use case. Governance Structure can take many forms, though most community development theories encourage a process that's focused on less-hierarchical, more-democratic in nature.

4.2.3.1.2 Economic Alignment

Economic Alignment captures the extent to which the governing entity considers economic conditions of the stakeholder groups. While these factors were outlined in the Economic Inclusivity condition, the concept here is based around the decision-making process of the governing entity versus the state or pre-requisite state of the underlying stakeholder base.

4.2.3.1.3 Technology Alignment

Technology Alignment captures the extent to which the governing entity considers technology factors associated with the stakeholder group, similar to Economic Alignment.

4.2.3.2 Participatory Equity

Participatory Equity describes how stakeholders actually interact with each through the sending and receiving of signals to other stakeholders. The purpose of this factor is to understand whether the intended inclusion of multiple variants of stakeholders is actually being recognized through active and passive participation.

4.2.3.2.1 Participatory Equity – Originating

Participatory Equity - Originating is a lagging indicator on how individuals initiate active participation in an overall group, adjusted for the group size and frequency of signals. The focus here is on "initiated" signalling, which indicates that a user intentionally decided to send a signal. An example is a user sending a text message to a group of people, which then may initiate a group conversation. If all group members were sending an equal number of texts, the measure would be deemed to be equal and close to zero. However, with greater variance, the measure inches up to one, which would be the maximum possibility and reflecting that only a single user is sending messages in that group. Unlike the attribute under the Technology Inclusivity condition, this signal does not necessarily need to have been sent successfully, but rather just be sent with the intention to have done so. The measure is inspired by the Gini coefficient, which is a measure of economic inequality, and it is calculated in with similar methodology. Consider the origination of Gini coefficient, which approximates the Lorenz Curve, shown in Figure 7.

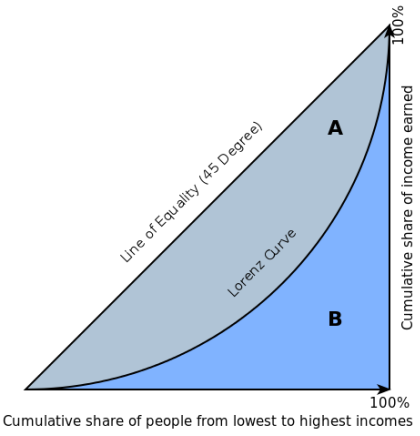

Figure 7: Gini Coefficient is based on the Lorenz Curve. Source: https://en.wikipedia.org/wiki/File:Economics_Gini_coefficient.svg

The Lorenz Curve is based on a curve that is drawn on two axes. The X axis is the cumulative share of resource holders ordered based on number of resources that they hold from lowest to highest. The Y axis is the cumulative share of resources. In effect, the Lorenz curve shows the cumulative distribution of the case of resources held by resource holders. The Gini coefficient is defined as the following:

$$Gini\ Coefficient = \frac{A}{A + B}$$

For the case of small batches, one can approximate the Gini coefficient through discrete math. Consider the same Lorenz Curve modified for the case of small discrete batches, in this case the number of finite messages sent by a finite set of individuals. Figure 8 below shows what the cumulative distribution ordered similar to Figure 7.

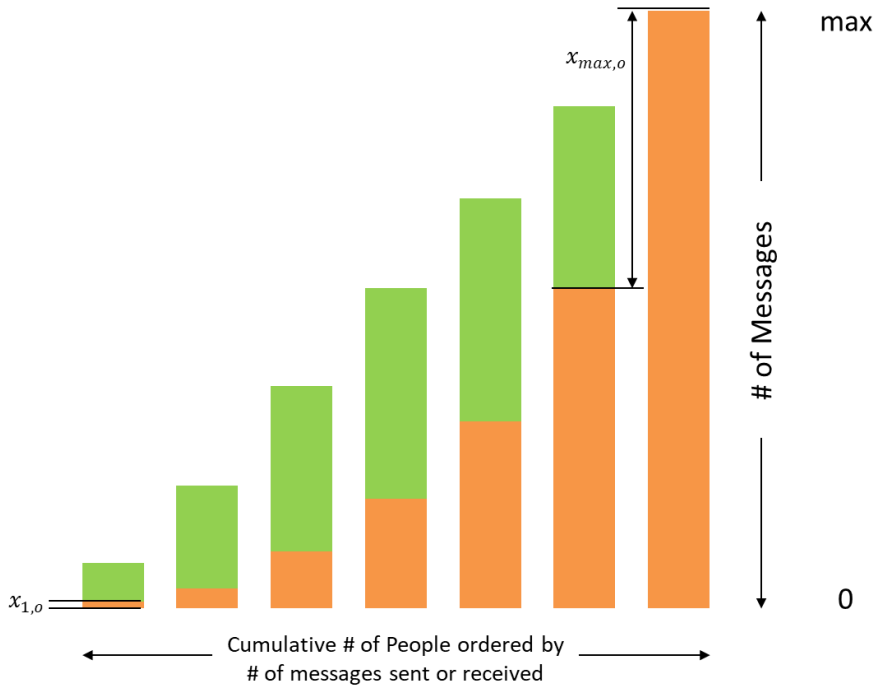

Figure 8: Lorenz Curve modified for the use case of a finite set of messages sent or received by a finite number of people.

There are two colors in Figure 8 above. The green bars denote a perfect distribution, or the case of the Line of Equality. In this case, you will notice that the jump from each green bar to the next is roughly equal. In that sense, each incremental person sends or receives the same incremental percentage of messages. Thus, the proportion of the person with the most activity to the person with the least activity is simply 1, since they are equal. A normalization relative to the most active person would thus also yield 1. Using the Gini coefficient = A/A+B, we are also able to see that A is 0, so the coefficient in turn will be zero. Note that A in the graph is the difference between Green and Orange, and A+B is the area of both colors.

Take into consideration now the orange portion, which yields a different cumulative distribution. In this case, some people are less active than others. Let $x_{i,o}$ for example denote the number of messages sent by any given individual i. If we were to rank order each person based on the number of messages sent, then the first orange bar will represent the number of messages sent by the least active person. Then the incremental portion to the next orange bar represents the number of the messages sent by the next least active person, and so on. Working backwards, we can calculate the number of messages sent by the most active person by subtracting from the right-most orange bar, which represents the total number of messages sent by all people, the orange bar to its left, which represents the messages sent by all people except for the most active person (remember, this is an ordered set). In order to calculate the proportions, then, the most active person's number of messages, denoted by x_{max} , becomes the key. To approximate the same Gini coefficient then, two discrete area calculations may be done. First, to calculate the area under the curve, one can add all of the green bars minus the orange bars. To do that, we start with just calculating the overall bar area first, which will be A+B in terms of the Gini Coefficient. Visually, it looks as in Figure 9.

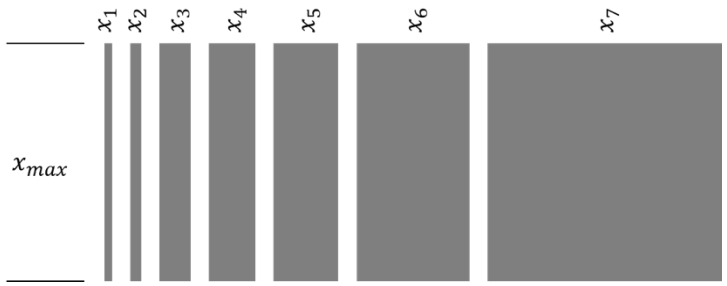

Figure 9: Visual approximation of area under the curve by using the respective discrete terms.

You can multiply the maximum number of messages sent by a single person by each respective other person's contribution. That will be as follows.

$$A + B = x_{max} * x_1 + x_{max} * x_2 + \cdots + x_{max} * x_n = x_{max} * \sum_{i=1}^{n} (x_i)$$

How then can one approximate just the A portion? One way is to normalize it by the overall maximum, which is x_{max}, so by dividing each individual's contribution by the maximum person's contribution. Given that we are working with absolute number of messages rather than proportional, A can also be approximated by subtracting each individual's contribution from the most active individual's contribution.

$$A = (x_{max} - x_1) + (x_{max} - x_2) + \cdots + (x_{max} - x_n) = \sum_{i=1}^{n} (x_{max} - x_i)$$

With the above, the last step is to simply divide A by A + B to yield the Gini Coefficient approximation.

$$Gini\ Coefficient\ Approxmiation = \frac{\sum_{i=1}^{n} (x_{max} - x_i)}{n - 1}$$

For the purposes of the framework, additional steps are taken to differentiate between messages that are sent and messages that are received. The following is the method for calculating participatory equity origination. Let $x_{i,o}$ be the number of times that individual i originates a signal. In the context of messaging, think of $x_{i,o}$ as the number of times the individual sends a message to a given group over a given period. Let $x_{max,o}$ be the maximum number of signal originations by a single individual in a given group over a given period. Let $\varepsilon_{i,o}$ be defined as the Relative Participation Coefficient (**RPC**) for signal origination, which is calculated as:

$$\varepsilon_{i,0} = \frac{x_{i,o}}{x_{max,o}}$$

Logically, we can think about the RPC as a simple proportion of an individual's signal origination tendencies relative to the most active individual in the community. Using this RPC, we can define the Participatory Index (PI) for signal origination as:

$$\rho_0 = \frac{\sum_{i=1}^{n}\left(1 - \varepsilon_{i,0}\right)}{n-1}$$

Essentially, the formula considers an individual's participation in a given group relative to the most active and takes into account the overall number of signal originations. By aggregating across all individuals in a group, we have a better understanding of how signal origination happened in the group. The single number ends up providing a perspective of the individual, even though it's an aggregate measure.

To illustrate the above examples numerically, consider the use cases below. Imagine a text conversation between ten individuals, who exchange 250 messages in total. In the first case, all individuals exchange the same number of messages equally. In other words, each individual sends 25 messages. In the second case, there is some variability in the number of messages sent. The cases are shown in table format below.

Table 1: Cases of Individuals Sending Messages. Case 1 focuses on completely equal distribution of messages. Case 2 has a greater mix.

User #	*Case 1: Equal*	*Case 2: Mixed*
1	25	2
2	25	5
3	25	8
4	25	10
5	25	15
6	25	30
7	25	35
8	25	40
9	25	50
10	25	55
Total	***250***	***250***

From the discussion above, Case 1 should produce a PI of 0 and Case 2 should produce a value between 0 and 1. See below for the calculations showing how the PI is calculated to produce the respective figures.

Table 2: Calculations of RPC for Case 1, which is the case of perfect equality

User #	*# of Texts per User*	*Cumulative Texts*	*Cumulative %*	*RPC rel to max)*	*1 - RPC*
1	25	25	10%	1	0
2	25	50	20%	1	0
3	25	75	30%	1	0
4	25	100	40%	1	0
5	25	125	50%	1	0
6	25	150	60%	1	0
7	25	175	70%	1	0
8	25	200	80%	1	0
9	25	225	90%	1	0
10	25	250	100%	1	0

Participatory Index Calculation	***0***

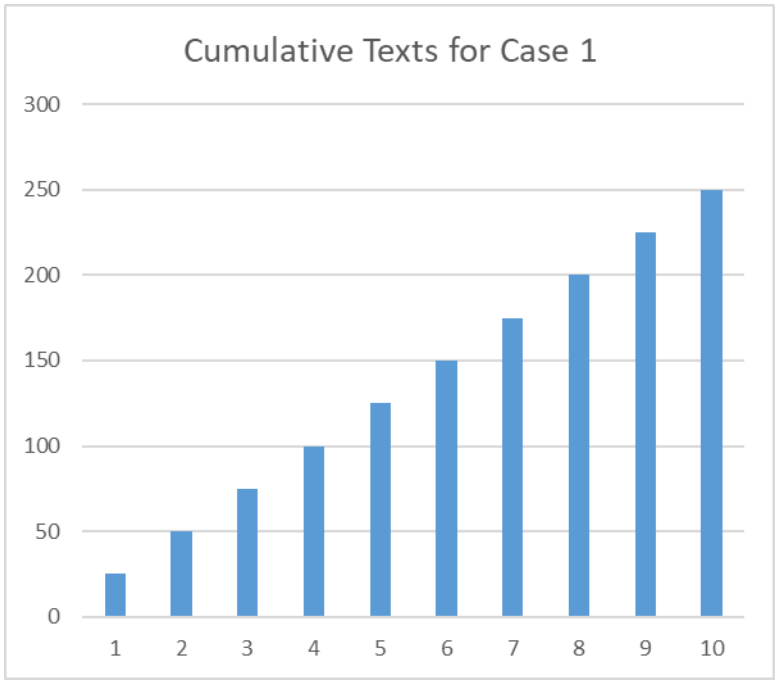

Figure 10: Cumulative distribution of messages in case 1. Note that this follows the same distribution as the green bars in Figure 8.

As seen above, in the case of the perfect equality, the PI index yields 0. This is because the maximum number of messages sent by any given user is 25, which is the same as all other users'. The RPC is 100% for all users, which effectively means that the numerator in the final calculation, which is 1 minus the RPC for each user, ends up being zero, which in turn generates 0 for the PI.

In the next case, the number of text messages per user are not equal. One user sends only two messages. In general, the bottom half of the users in terms of number of texts only make up 16% of the total number of messages sent. The top three users, on the other hand, attribute to close to three-fifths of the overall messages sent. This case thus replicates a more unequal spread of signal origination.

Table 3: Case 2, where number of text messages are not equal.

User #	# of Texts per User	Cumulative Texts	Cumulative %	RPC (rel to max)	1 - RPC
1	2	2	1%	0.04	0.96
2	5	7	3%	0.09	0.91
3	8	15	6%	0.15	0.85
4	10	25	10%	0.18	0.82
5	15	40	16%	0.27	0.73
6	30	70	28%	0.55	0.45
7	35	105	42%	0.64	0.36
8	40	145	58%	0.73	0.27
9	50	195	78%	0.91	0.09
10	55	250	100%	1.00	0.00

Participatory Index Calculation ***0.6***

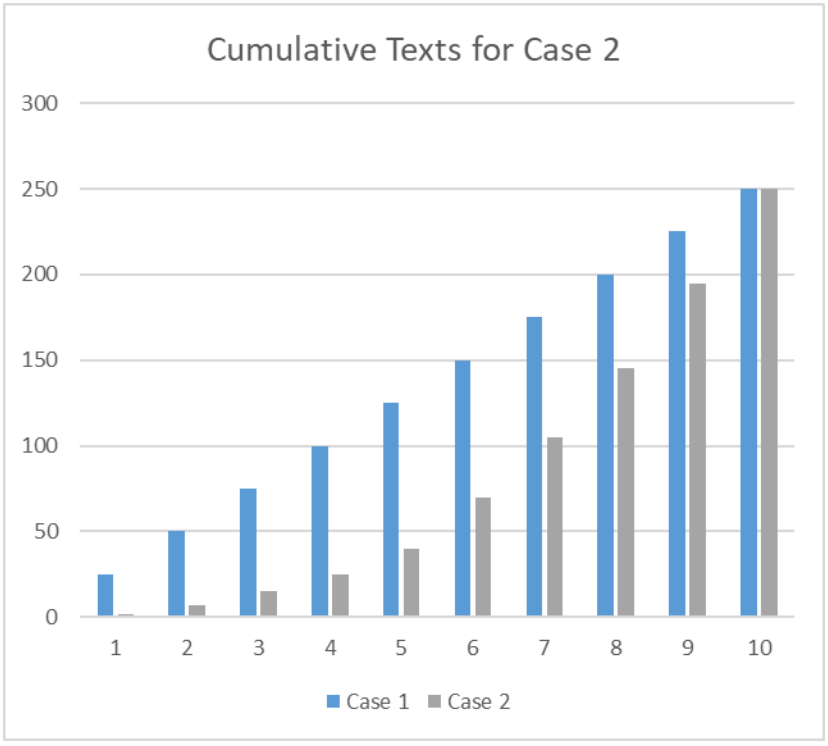

Figure 11: In the figure above, the second case is mapped in comparison to the first case. The unequal distribution is thus more clearly emphasized in Case 2.

The participatory index in the second case is much higher at 0.6. Remember that the range of PI is between zero and 1. So in this case, we are able to see that some individuals are not participating as actively as others. A few things can be done with this reflection. First, the users in general can be prompted to participate more – it could be simply that some are not aware that they have the *ability* to do so. Second, the less active users can be given a separate conversation or chain such that they do not feel overwhelmed by the superusers. Third, if the use case behind the conversation is that of a dispatch anyways, then they could be left alone as is. Regardless, the metric provides insight into how active individuals are within a group.

4.2.3.2.2 Participatory Equity – Terminating

Participatory Equity - Terminating is a lagging indicator that captures how individuals participate passively through the intentional reception of signals. The example here, as supposed the "Originating" example above, is that of a user that intentionally opens a set of messages but does not reply with his or her own. The focus is that the intended signal is not just received by the terminating node - or where the signal was intended to have been delivered - but also opened for the purpose of signal consumption. This variation thus allows for control of passive participation (reception only, with no response). Similar to "Originating" calculation, the factor here also ranges from zero to one. If all signals are consumed by all users, then the terminating equity is zero. However, if no other nodes than the sender consume the signal, the terminating equity becomes one.

The following is the method for calculating participatory equity for signal termination. Let $x_{i,t}$ be the number of times that individual i receives and captures a signal that has been sent to him or her. In the context of messaging, think of $x_{i,t}$ as the number of times the individual receives and opens a message that he or she receives as part of a given group over a given period. Let $x_{max,t}$ be the maximum number of signal terminations for a single individual in a given group over a given period. Let $\varepsilon_{i,t}$ be defined as the Relative Participation Coefficient (RPC) for signal termination, which is calculated as:

$$\varepsilon_{i,t} = \frac{x_{i,t}}{x_{max,t}}$$

Logically, we can think about the RPC as a simple proportion of an individual's signal termination tendencies relative to the most active to the individual. Using this RPC, we can redefine the PI Index for signal termination as:

$$\rho_t = \frac{\sum_{i=1}^{n}(1 - \varepsilon_{i,t})}{n - 1}$$

4.2.3.3 Demographic Factors

Demographic Inclusion accounts for how stakeholders are included or excluded due to social-cultural, economic, and location demographic attributes.

4.2.3.3.1 Social-Cultural Demographics

Social-Cultural Demographics comprise of gender, age, sexual orientation, religious, caste, and health-associative attributes marked upon a stakeholder or stakeholder group by broader culture, which in turn impacts the interaction between that individual or group and others.

4.2.3.3.2 Economic Demographics

Economic Demographics comprise of wealth inequality, income inequality, and opportunity inequality arising from inability to use resources based limited economic means.

4.2.3.3.3 Location Demographics

Location Demographics captures communities that are isolated out of geographic context. An example includes two communities that are divided by a river, and where one may thrive as it is closer a larger city and the other does not due to the additional geographic barrier. This factor plays a larger role in rural and developing communities, especially where automotive transportation may be limited.

4.3 Using ISF as a Capability Assessment

Given the definitions of the different conditions, factors, and attributes in the prior section, let's now turn to see how we can use the framework as a capability assessment with a focus on the individual's capabilities in a broader ecosystem. Why would such a capability assessment be necessary? As covered in prior chapters, the current design frameworks rarely take the individual perspective in consideration of provision of essential human services. What are often captured are institutional or organizational capabilities, such as capability around delivery of a specific service, management of information, strategy and architecture. By capturing the current capability at an individual perspective, functional and technical constraints and needs are better included in the subsequent solution design process.

The assessment can be conducted through a series of interviews with a mix of stakeholders. Importantly, the stakeholder group should include the individuals that will be driving the underlying use case. For example, if the focus is on improving communications in the delivery and maintenance of essential human services such as healthcare, the interviews would include perspectives from the patients, healthcare workers, volunteers, and any managing professionals that are overseeing the service. The assessment is recommended to be done alongside partners that are active service practitioners such that follow-up questions or explanations are relevant. After conducting said interviews, the interviewers can then use the stakeholder's input to choose the respective scoring for each attribute. The subsequent table presents the questions associated with each attribute as well as the description of what a specific score may mean for that respective question. Take for instance the first question focused on the "Activity Unit Cost – Originating," which as the reader may remember speaks to what the individual has to pay in order to send a signal. The respective scoring presents multiple ways the individual may see this as a barrier, with the most favourable being that the individual does not pay anything to the least favourable being that the individual has to pay a substantial portion, causing the underlying signal origination activity to be prohibited.

Table 4: ISF Capability Assessment Questions and Scoring Answers

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Economic Inclusivity	Variable Costs	Activity Unit Cost - Originating	As a portion of individual income, how much do individuals have to pay on a per unit basis to originate the activity or signal in question?	Prohibitive, very few people can afford to do so on an ongoing basis.	Significant, but a large minority can pay on an ongoing basis.	Mixed, majority can pay, but significant minority cannot.	Affordable, most people can pay on an ongoing basis.	Free, no per unit cost for originating activity.
Economic Inclusivity	Variable Costs	Activity Unit Cost - Terminating	As a portion of individual income, how much do individuals have to pay on a per unit basis to be the recipient of the activity or signal in question?	Prohibitive, very few people can afford to do so on an ongoing basis.	Significant, but a large minority can pay on an ongoing basis.	Mixed, majority can pay, but significant minority cannot.	Affordable, most people can pay on an ongoing basis.	Free, no per unit cost for receiving activity or signal.
Economic Inclusivity	Variable Costs	Energy (variable) Cost	As a portion of individual income, how much do individuals have to pay to receive the energy for each instance of	Prohibitive, very few people can afford to do so on an ongoing basis.	Significant, but a large minority can pay on an ongoing basis.	Mixed, majority can pay, but significant minority cannot.	Affordable, most people can pay on an ongoing basis.	Free, no per unit cost for receiving activity or signal.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
			activity? (can be generalized to daily use, if needed).					
Economic Inclusivity	Transaction Costs	Search (and Non-Immediate Connection) Costs	How much does it cost for an individual to perform a search for another individual or entity, or to reach that person without specific knowledge of identifying information (such as phone number)?	Costs must be paid by the individual at the time of search and are significant for almost all individuals.	Costs must be paid by the individual at the time of search; though not significant, they lower search activity by the individual.	Costs are included as part of a platform, and are passed on to individuals as part of an overall fee.	Costs are included as part of a platform, and are passed on to only frequent usage individuals.	Costs are included as part of a platform, and are not passed on to individuals.
Economic Inclusivity	Transaction Costs	Restricted Activity Enforcement Costs	How are costs associated with reducing restricted activity passed on to the individual?	Costs must be paid by the individual on an ongoing basis as a fee, and is a significant amount.	Costs must be paid by the individual on an ongoing basis as a fee; though not significant, they reduce individual activity.	Costs are included as part of a platform, and are passed on to individuals as part of an overall fee.	Costs are included as part of a platform, and are passed on individuals that break the eco-system rules or an alternative party.	Costs are included as part of a platform, and are not passed on to individuals.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Economic Inclusivity	Fixed Costs	Infrastructure Access Cost	How much does an individual have to pay to access the infrastructure?	Prohibitive, very few people can afford to do so on an ongoing basis.	Significant, but a large minority can pay on an ongoing basis.	Mixed, majority can pay, but significant minority cannot.	Affordable, most people can pay on an ongoing basis.	Free, another party (govt. or NGO, e.g.) covers the cost typically.
Economic Inclusivity	Fixed Costs	Solution Access Cost	How much does an individual have to pay to access the solution in question?	Prohibitive, cost represents a significant investment that is not revisited for several years.	Significant, but a large minority may afford to explore alternatives on a yearly basis.	Mixed, some can consider alternatives on a periodic basis, others hold on to their existing solution much longer due to cost.	Affordable, most people do not have to worry about cost as consideration for solution alternatives.	Very affordable, all people do not consider cost as a variable for exploring solution alternatives.
Economic Inclusivity	Fixed Costs	Process Support Cost	How much does an individual have to pay to receive effective maintenance and support?	Prohibitive, cost is faced each time support is needed and dissuades individual engagement.	Significant, cost is a one-time fee but represents a barrier that a majority cannot afford.	Cost is a one-time fee and a majority can afford payment; however, some may face a barrier to payment still.	Affordable, most people do not have to worry about process support cost or do not face it individually.	Free to the individual, another party (govt. or NGO, e.g.) covers the cost typically.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Economic Inclusivity	Fixed Costs	Administration Cost	How much does an individual have to pay to support the administration of the solution in question?	Prohibitive, cost is faced periodically by the individual, and the value of administration is not clearly communicated.	Significant, cost is a one-time fee but represents a barrier that a majority cannot afford.	Cost is a one-time fee and a majority can afford payment; however, some may face a barrier to payment still.	Affordable, most people do not have to worry about the administration cost or do not face it individually.	Free to the individual, another party (govt. or NGO, e.g.) covers the cost typically.
Economic Inclusivity	Opportunity Costs	Holding Cost	How much does an individual have to set aside as an informal asset (a minimum balance) for the ability to act on a yet-to-occur event? Note: there may be a knock-on effect from outside stakeholders that may charge against the balance kept as part of a fee.	Prohibitive, the minimum balance represents a large portion of income, and is rarely maintained under fear of losing it.	Significant, individuals often cannot set aside a minimum balance, but try to do when income and conditions are favorable.	Individuals follow a regular pattern of a minimum balance that's refreshed only when there's cash inflow.	Individuals are able to keep a minimum balance irrespective of income conditions, and are not under threat of outside forces.	Individuals do not require a minimum balance as the activity does not charge against an individual's informal asset (or charges to an outside entity's asset).

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Economic Inclusivity	Opportunity Costs	Time Displacement Cost	How much time does an individual typically dedicate to accomplishing an activity, and what is the resulting income or value displacement?	Prohibitive, individuals rarely take the time away from daily activities except for emergencies.	Significant, individuals often find alternative ways to pool time and act individually during emergencies.	Majority of individuals are able to take time away, and some efforts are made to adjust for their lost value of time.	Individuals' time is uninterrupted as they are reimbursed for some of their lost time through something of tangible value.	Individuals' time is uninterrupted they are fully supplemented for lost time through other clearly-defined and tangible value.
Technological Inclusivity	Availability	Physical Device	Is the resource or solution in question physically available to the individual?	No, and no intermediaries known to the individual have the resource either.	Rarely, and the resource is not directly available to the individual.	Sometimes, as the resource itself may be shared.	Most of the time.	All of the time.
Technological Inclusivity	Availability	Energy	Is there an energy resource that is available to the resource to power the solution or service in question?	No, and no intermediaries known to the individual have the resource either.	Rarely, and the resource is not directly available to the individual or is not reliable.	Sometimes, and the resource is often shared or intermittent.	Most of the time, the individual occasionally faces issues with availability of energy.	Yes, and the individual faces virtually no issues with availability of energy.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Availability	Network	Is there an underlying physical network that supports the solution or service in question that is available to the individual?	No, and few intermediaries known to the individual have the network either.	Rarely, the physical network is routinely available due to the individual because of his/her movement in the broader system.	Sometimes, the network may be directly available, though not always reliably so.	Most of the time, the network is directly present in the individual's area and is usually reliable.	Yes, the network is directly present in the individual's area and rarely fails.
Technological Inclusivity	Availability	Platform	What level of digital platforms that support the solution or service in question are available to the individual?	None, and few intermediaries known to the individual do not know of any digital platforms either.	Generic at arm's length, the individual may know someone that has some level of generic digital platform, such as J2ME.	Generic at individual level, has a generic digital platform directly available.	Connected, the digital platform available to the individual is occasionally refreshed with latest solutions.	Contemporary, the digital platform available to the individual has a vast array of solutions that are routinely refreshed, with security.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Availability	Application	What level of digital applications that act as a solution or service are available to the individual?	None, and few intermediaries known to the individual do not know of any digital applications.	Generic at arm's length, the individual may know someone that has some digital applications that could be useful.	Generic at individual level, has default, platform-provided digital applications with a limited capability to expand.	Connected, the individual has the capability to expand available applications through individual discovery.	Contemporary, the individual's digital platform automatically updates and suggests new, relevant applications.
Technological Inclusivity	Accessibility	Physical Device	Does the individual have access to the resource in question?	No, and the individual is not able to have access through immediate intermediaries.	Rarely, and the individual can access the resource with the help of an intermediary.	Sometimes, as the individual is able to access the resource, though faces some barriers.	Most of the time, the individual accesses the resource regularly, though may face reliability issues.	All of the time, the individual accesses the resource regularly with few or no barriers.
Technological Inclusivity	Accessibility	Energy	How does the individual access energy resources?	No, and the individual cannot access through immediate intermediaries either.	Rarely, the individual often accesses the energy resource via an intermediary, or by self unfrequently due to barriers.	Sometimes, the individual may access the energy resource, with mixed reliability.	Most of the time, the individual accesses the energy resource regularly with few reliability issues.	Yes, and the individual faces virtually no issues with accessing the energy resource.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Accessibility	Network	How does the individual access the respective network in question?	No, and the individual cannot access the network themselves or through an intermediary.	Rarely, the individual often accesses the network via an intermediary, or by self unfrequently due to barriers.	Sometimes, the individual accesses the network by themselves, but the network has mixed reliability.	Most of the time, the individual accesses the network regularly with few reliability issues.	Yes, and the individual faces virtually no issues with accessing the network.
Technological Inclusivity	Accessibility	Platform	How does the individual access the respective digital platform in question?	No, the individual does not have access to a digital platform, including through an immediate intermediary.	Generic at arm's length, the individual access a digital platform occasionally, and only through an intermediary.	Generic at individual level, accesses the digital platform, which in itself only carries a limited set of applications.	Connected, the individual access a digital platform with a broader array of use cases, with some limitations.	Contemporary, the individual access modern, updated, and secure digital platforms with a vast array of solutions that are routinely refreshed.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Accessibility	Application	How does the individual access digital applications that may represent solutions or services that are of need?	None, and the individual cannot access any digital applications through an immediate intermediary.	Generic at arm's length, the individual can access and maintain basic application connectivity through an intermediary.	Generic at individual level, can access digital applications natively, however, the use cases of the application are limited to the individual.	Connected, the individual accesses applications and can discover, acquire, and access a broader array of applications.	Contemporary, the individual can access other applications through interconnected modules, or other tech. enhancements that lessen barriers to expansion.
Technological Inclusivity	Interface Operability	First Use User Error Rate	Imagining a solution or service that an individual has never engaged with prior, what types of errors does the individual make during the first engagement?	Errors occur almost always, and the errors are significant to dissuade future use, even with intervention.	Errors occur at least 50% of the time, and the errors are significant to dissuade future use without intervention.	Errors occur at least 50% of the time, and the errors do not dissuade the user from trying again.	Errors occur less than 50% of the time, and the errors do not dissuade the user from trying again.	Errors are infrequent, and the errors do not dissuade the user from trying again.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Interface Operability	Sustained Use User Error Rate	Imagining a solution or service that has been exposed to the individual over a longer period of time, what types of errors does the individual continue to make?	Errors continue to occur regularly, and the individual typically stops using the solution or service, even if there's intervening assistance.	Errors continue to occur regularly, and the individual typically works with intervening assistance to debug errors.	Errors continue to occur regularly, and varies in types. The individual typically debugs simpler errors by self, and consults assistance otherwise.	Errors continue to occur occasionally, and are in simpler in nature. The individual typically debugs errors by self.	Errors occur rarely, and are in simpler in nature. The individual typically debugs errors by self.
Technological Inclusivity	Signal Reliability	Signal Originating Delivery	When an individual sends a signal (in the form of a message, a call, or whatever it may be), how certain is it that the signal reaches the intended actor or system?	Very uncertain, most sent signals are never received.	Somewhat uncertain, over 50% of sent signals are delivered, and they may be delayed in delivery frequently.	Somewhat certain, over 80% of sent signals are delivered, and they may be delayed in delivery sometimes.	Certain, over 95% of sent signals are delivered, and they may be delayed in delivery sometimes.	Almost all sent signals are delivered, and delays are minimal.
Technological Inclusivity	Signal Reliability	Signal Terminating Delivery	When a system sends a signal to the individual(in the form of a message, a call, or whatever it may be), how certain is it that the signal reaches the individual?	Very uncertain, signals are rarely received or are corrupted when opened.	Somewhat uncertain, over 50% of signals are received, and they may be delayed or sometimes corrupted.	Somewhat uncertain, over 80% of signals are received, and they may be delayed or sometimes corrupted.	Somewhat uncertain, over 95% of signals are received, and they may be delayed or rarely corrupted.	Almost all signals are received, and delays are minimal and with rare corruption issues.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Signal Reliability	Signal Storage	How does the individual store signals that are sent to them?	The individual does not have the ability to store signals.	The individual can store signals, but has a very limited capacity. Incoming signals are not received as a result.	The individual can store signals, and has to routinely clear capacity for new signals. However, incoming signals are not hurt stopped as a result.	The individual has a large capacity for storing signals, and can reliably rely on transfer of signal from one storage system to another.	The individual leverages cloud storage and has an effectively unlimited capacity as a result.
Technological Inclusivity	Service Management	Onboard and Offboard	What type of onboarding and offboarding process does the individual participate in?	No onboarding / offboarding process exists.	The individual receives an initial walkthrough or nominal documentation. Detailed documentation or Q&A opportunities do not exist. No offboarding exists.	The individual receives an initial walkthrough and documentation, outside assistance is available with Q&A. Offboarding may exist, though not clearly defined.	Outside assistance provides a detailed walkthrough with supporting documentation, answering any questions. The offboarding process is clear and succinct.	Outside assistance stays engaged on a routine basis, as the individual requires, from the onboarding to offboarding process.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Service Management	Use Case Training	Beyond initial interaction, is the individual provided with use case training to successfully become an actor in a given use case?	No specific use case training or documentation is provided.	The individual has access to some documentation that captures most of the use case. No outside assistance is provided.	Clear documentation of the given use case exists, with appropriate visuals. Ongoing assistance for Q&A is not provided.	Clear documentation of the given use case exists with appropriate visuals. Outside assistance is available as the individual requires.	Clear documentation exists, and outside assistance is readily available. Individual's feedback is actively taken to continue to improve the use case experience.
Technological Inclusivity	Service Management	Maintenance	How often does the solution or service provided to the individual undergo maintenance?	Maintenance is needed frequently; however, is unsuccessfully delivered.	Maintenance is needed frequently; is delivered upon the individual's request.	Maintenance is needed sometimes; it is delivered at the individual's request.	Maintenance is needed sometimes; it is delivered periodically and proactively.	Maintenance is rarely needed as the solution or service exists in a state of continuous improvement.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Technological Inclusivity	Service Management	Technology Literacy Adjustment	How does the solution or service support or adjust for the technology literacy of the individual?	No support is provided and no adjustments are made for the technology literacy for the individual.	For individuals new to the given technology, some efforts are made during the initial engagement, though not on an ongoing basis.	For individuals new to the given technology, individuals are supported throughout the engagement, often with clear documentation.	The technology and accompanying documentation are designed to enable the success of use case for a broad range of technology literacy levels.	Different interfaces exist for different individual bases to account for their literacy, and thus minimizing barriers to engagement.
Participatory Inclusivity	Governance	Governance Structure	What role does the individual have in influencing the primary governance structure that oversees and has decision-making authority over the solution or service in question?	None, the individual does not have an active or a passive role. Decisions are made without specific consideration for the individual, but rather the whole.	Passive uncoordinated. No formal processes exist for individuals to submit input to governance. However, individual's input is received informally.	Passive coordinated. Formal processes exist for individuals to submit input on any given issues to the governance.	Active coordinated. Formal processes exist for individuals to submit input to and participate in governance. Participation approval is needed from a non-democratically selected leader.	Active democratic. Formal processes exist for individuals to submit input to and participate in governance. If desired, the individual can choose to be considered by peers for leading the governance structure.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Participatory Inclusivity	Governance	Economic Alignment	What governance structures exist to support or consider the underlying economic conditions of the individuals involved?	None, the individual's economic condition is not considered as a part of governance.	Limited, the individual's economic condition is considered after execution of a decision that would impact the individual.	Limited, the individual's economic condition is considered during the execution of a decision that would impact the individual.	Intertwined, the individual's economic condition is an input to the decision that would impact the individual	Active design, the individual's economic condition is considered actively through a design committee or group before the decision, and is actively managed through the decision-making process, execution, and post-execution activities

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Participatory Inclusivity	Governance	Technology Alignment	What governance structures exist to support of consider the underlying technologies, such as infrastructure, platform, and solutions, that the individual may use or interact with?	None, the individual's technology capability is not considered as a part of governance.	Limited, the individual's technology capability is considered after execution of a decision that would impact the individual.	Limited, the individual's technology capability is considered during the execution of a decision that would impact the individual.	Intertwined, the individual's technology capability is an input to the decision that would impact the individual	Active design, the individual's technology capability is considered actively through a design committee or group before the decision, and is actively managed through the decision-making process, execution, and post-execution activities
Participatory Inclusivity	Participatory Equity	Participatory Equity - Originating	On a scale of 0 to 1, where 0 is perfectly equal and 1 is perfectly unequal, what is the likely originating participation of individuals within a group? That is, in a given group, how often does	1. A single individual tends to dominate the overall group that he or she is in by being the only person sending signals in the respective group.	0.75. Only a few individuals in the overall group send signals to their respective group.	0.5. Some individuals participate by sending more signals than the rest of the group.	0.25. Aside from a few individuals that do not participate as actively, a majority of the group sends signals just as often.	0. All individuals send signals just as much as any other individual in the group.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
			the individual proactively send signals to peers, relative to the rest of the group?					
Participatory Inclusivity	Participatory Equity	Participatory Equity - Terminating	On a scale of 0 to 1, where 0 is perfectly equal and 1 is perfectly unequal, what is the likely terminating participation of individuals within a group? That is, in a given group, how often does the individual proactively "open and read" signals from peers, relative to the rest of the group?	1. Given a set of signals that are sent to a group, only a single individual actively opens the signal.	0.75. Only a few individuals in the overall group open signals that are sent to their respective group.	0.5. Some individuals participate more actively by opening more signals than the rest of the group.	0.25. Aside from a few individuals that do not open messages as actively, a majority of the group sends signals just as often.	0. All individuals open signals just as frequently as any other individual in the group.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Participatory Inclusivity	Demographic Inclusion	Social-cultural Demographics	How does an individual's inclusion look like in a group that has a large subset of people that share the same social-cultural attributes, that is different from the individual's?	All individuals that share similar attributes in a group intentionally exclude an individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, some intentionally exclude another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, some may unintentionally exclude another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, no one unintentionally excludes another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, many intentionally work to include the person into their group irrespective of different attributes.
Participatory Inclusivity	Demographic Inclusion	Economic Demographics	How does an individual's inclusion look like in a group that has a large subset of people that share the same economic statuses, that is different from the individual's?	All individuals that share the same economic status in a group intentionally exclude an individual that does not share the same economic status.	Of a set of individuals that share the same economic status in a group, some intentionally exclude another individual that does not share the same status.	Of a set of individuals that share the same economic status in a group, some may unintentionally exclude another individual that does not share the same status.	Of a set of individuals that share the same economic status in a group, no one unintentionally excludes another individual that does not share the same status.	Of a set of individuals that share the same economic status in a group, many intentionally work to include the person into their group irrespective of different statuses.

Condition	Factor	Attribute	Analysis Consideration	1 - Most Unfavorable	2	3 - In the Middle	4	5 - Most Favorable
Participatory Inclusivity	Demographic Inclusion	Location Demographics	How does an individual's inclusion look like in a group that has a large subset of people that share the same geographic home, that is different from the individual's?	All individuals that share similar attributes in a group intentionally exclude an individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, some intentionally exclude another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, some may unintentionally exclude another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, no one unintentionally excludes another individual that does not share the same attributes.	Of a set of individuals that share similar attributes in a group, many intentionally work to include the person into their group irrespective of different attributes.

4.4 ISF Capability Assessment of Communications in Essential Human Services Delivery in South Africa

The author worked with several service practitioners to understand what's causing the underlying difficulties in simple communication between service delivery professionals and their intended beneficiaries. The process involved interviewing representative stakeholders from formal NGOs, community groups, and university organizations. The services that these organizations delivered included water, nutrition, individual capability development (like education), healthcare, and health awareness. Through multiple such interviews and by working alongside these stakeholders to define and design what an inclusive communication system could look like, an understanding of the individuals' economic, technological, and participatory conditions became clearer. With the help of Karen Venter, Director of Service Learning in the School of Nursing at the University of the Free State, and other students and colleagues, including Ella Shoup, Vijay Edupuganti, Andrew Ton, Humbalani Serule "Styles," Khwathiso Netshifhefhe, and Mboneni Elly, the author was able to assess and capture the capability of communications in essential human services delivery in South Africa.

To provide an example of how the process went, the score behind Variable Costs attributes Activity Unit Cost – Originating and Activity Unit Cost – Terminating is discussed. The conversations with stakeholders from different NGOs and community partners provided the evaluation team with a background on what types of costs their specific users face. We dove deep into their respective use cases, and asked questions similar to those illustrated in Table 4. When a user is trying to contact you, what happens specifically? Do they have to pay upfront? What happens when you are trying to reach them, do they have to pay to receive those calls or messages? From interviewing across organizations and conducting research on the telecommunications access in South Africa, it became clear that any pay-as-you-go subscriber did not need to pay to receive messages, regardless of their specific telecom provider (e.g., MTN or Vodacom) (GSMA 2018). Stakeholders reflected that this mechanism actually gave way to a cultural standard on people being able to receive calls even during meetings. On the contrary, subscribers did

have to pay to send calls or text messages, and these rates varied based on time of day, carrier, and type of message. Multiple variations of such pricing gave way to interesting arbitrage plays in using ICT in development, such as creating power groups (Aker and Mbiti 2010, Clarke et al 2013) or simply handing out SIM cards that were all with the same carrier (Jamison et al 2013). The evaluation team thus decided to score the Activity Unit Cost – Originating as a 2, which notes that the cost is significant to influence behaviour or sending calls or messages. The Activity Unit Cost – Terminating scored a 5, which notes that the cost is free to the end user. Using the same approach, each of the factors were scored. The results are shown below.

4.4.1 Summary of South Africa Assessment Results

Table 5: Assessment of communications capability in essential human service delivery in South Africa.

Condition	Factor	Attribute
Economic Inclusivity	Variable Costs	Activity Unit Cost - Originating
Economic Inclusivity	Variable Costs	Activity Unit Cost - Terminating
Economic Inclusivity	Variable Costs	Energy (variable) Cost
Economic Inclusivity	Transaction Costs	Search (and Non-Immediate Connection) Costs
Economic Inclusivity	Transaction Costs	Restricted Activity Enforcement Costs
Economic Inclusivity	Fixed Costs	Infrastructure Access Cost
Economic Inclusivity	Fixed Costs	Solution Access Cost
Economic Inclusivity	Fixed Costs	Process Support Cost
Economic Inclusivity	Fixed Costs	Administration Cost
Economic Inclusivity	Opportunity Costs	Holding Cost
Economic Inclusivity	Opportunity Costs	Time Displacement Cost
Technological Inclusivity	Availability	Physical Device
Technological Inclusivity	Availability	Energy
Technological Inclusivity	Availability	Network
Technological Inclusivity	Availability	Platform
Technological Inclusivity	Availability	Application
Technological Inclusivity	Accessibility	Physical Device
Technological Inclusivity	Accessibility	Energy

Technological Inclusivity	Accessibility	Network
Technological Inclusivity	Accessibility	Platform
Technological Inclusivity	Accessibility	Application
Technological Inclusivity	Interface Operability	First Use User Error Rate
Technological Inclusivity	Interface Operability	Sustained Use User Error Rate
Technological Inclusivity	Signal Reliability	Signal Originating Delivery
Technological Inclusivity	Signal Reliability	Signal Terminating Delivery
Technological Inclusivity	Signal Reliability	Signal Storage
Technological Inclusivity	Service Management	Onboard and Offboard
Technological Inclusivity	Service Management	Use Case Training
Technological Inclusivity	Service Management	Maintenance
Technological Inclusivity	Service Management	Technology Literacy Adjustment
Participatory Inclusivity	Governance	Governance Structure
Participatory Inclusivity	Governance	Economic Alignment
Participatory Inclusivity	Governance	Technology Alignment
Participatory Inclusivity	Participatory Equity	Participatory Equity - Originating
Participatory Inclusivity	Participatory Equity	Participatory Equity - Terminating
Participatory Inclusivity	Demographic Inclusion	Social-cultural Demographics
Participatory Inclusivity	Demographic Inclusion	Economic Demographics
Participatory Inclusivity	Demographic Inclusion	Location Demographics

Table 6: Summary of South Africa ISF Assessment

Row Labels	Capability Summary (Average)
Economic Inclusivity	2.5
Fixed Costs	2.5
Opportunity Costs	2.0
Transaction Costs	2.0
Variable Costs	3.3
Technological Inclusivity	2.5
Accessibility	3.0
Availability	2.8
Interface Operability	1.5
Service Management	1.8
Signal Reliability	2.7
Participatory Inclusivity	2.9
Demographic Inclusion	2.3
Governance	3.3
Participatory Equity	3.0
Grand Total	**2.6**

Additional views of the assessment results in graphic form are provided in the appendix.

4.4.2 Discussion of Assessment

The assessment provides a holistic view of the types of barriers that an individual faces as they try to communicate with peers, colleagues, community members, and service practitioners. Some items stand out over others. To start with, we see that the strengths lie in some aspects of the participatory inclusivity conditions. For example, Governance stands out as a positive. Since the end of the Apartheid and with growing intervention by community-based, faith-based, and university-based organizations, there's an increased effort to increase how individuals participate as a part of committees of change. Though tendencies to defer to existing Chiefdom structures remain, individuals have been elevated in participation through periodic community meetings, individual-focused presentations for specific services such as water and electricity, and encouragement of community-based services such as community-based health workers. The shift has also been encouraged, as has been discussed in prior chapters, by organizations such as UNICEF that formalized community-based health worker entities through regional support models.

Another area of strength is the availability and accessibility of technology. Over the last decade, proliferation of mobile coverage and mobile phones have also in turn increased network and physical device availability and accessibility. For example, most recent CIA factbook estimate of number of cell phones per capita in South Africa stands at 150. Network coverage as reported by varying GSMA-aligned operators shows a near 90% coverage of the populace. Anecdotally, we saw this with our interviewees that carried personal cell phones seemingly irrespective of their sex, age, or location. However, what we did notice is a split of the type of technology that they interacted with on those phones. The most universal use is the receiving of calls and sending of "callbacks," or an automated page to ask another user to call back. When we considered the broader statistics, we found

through the Mobile Marketing Association of South Africa Survey of 2014 that nearly 40% of people rely exclusively on SMS- and basic calling features, not additional digital applications and platforms like Facebook and Whatsapp. We found this to be especially true in rural areas and older demographics, as is reflected in the scoring.

When we peeled the onion of what drove the use of technology a certain way even though availability and accessibility is broadly acceptable, we found three main observations. Individuals had a tendency to shy away from proactively engaging, or originating, content or messages because of the upfront cost that they faced. To better understand this, it's necessary to review the economic model of mobile communications in South Africa. The market in South Africa is "MO," or mobile-originating, which means that charges for usage are against the originating entity. As with other areas of the world, there are "post-paid" plans and "pre-paid" plans. A post-paid plan is a monthly payment that typically includes a higher base payment with overage and additional charges based on what's happened in the prior month. Variances of these plans exist for different usage levels, but almost all are geared towards frequent user customers and mobile data-heavy customers.

Over two-thirds of the population still works with pre-paid plans, which are upfront payments that act as credits against activity. The credits are described as "minutes," though in actuality several minute credits may be necessary to have an actual minute of conversation, based on time of day. From experience and interview anecdotes, we would observe the following quite often: an individual puts in 55R on their SIM card, which is a fairly typical amount, they're promised 55 "minutes." Imagine now that the individual makes a call during the middle of the day for five minutes. The mobile network operator actually ends up charging 3-5 "minutes" per minute of conversation, and so the individual may soon see their credit deplete to half. For comparison of the impact, some individuals in rural areas may see an income of 100R / day, or about $8-12 per day, depending on exchange rate. The charges extend to other parts of the use case of communication, including SMS messages. A single SMS may cost as much as 0.5R or 0.5 minutes. Most

recently the pre-paid plan created a separate credit account for mobile data. For example, an individual can buy 10MB of data, which can be used for Whatsapp (the favourite for people with feature and smartphones due to simple data messaging taking up less money than SMS).

Because of the combination of a majority of people, especially in rural areas and semi-rural areas, relying on the pre-paid plans and because of the broad variety of mobile technology usage, we found the behaviour of hesitancy in initiating or sending signals. On the contrary, because receiving messages is free in a MO market, individuals happily received calls and SMSs. A quick anecdote on how this impacted cultural differences: the US has been a MT, or a mobile terminating, market though greater variances have entered the market recently. In other words, the MT market charges for the activity are placed against the person that's receiving the call or activity. As a result, people in the US have been culturally OK with letting a call ring through, especially with the advent of voicemail. In fact, it had become rude to interrupt in-person conversations with incoming calls. However, in South Africa, the reverse ended up being true. Given that incoming calls are free and that an incoming call implies an "investment" from the originator, the receiver would frequently pick up any and all incoming calls. As such, interviews with incoming call interruptions required cultural adjustments from the US-stakeholder side.

Another aspect of the economic condition that plagued the South Africans was the burden of additional fees and charges, especially as individuals tried to transfer to data-side plans. Individuals shouldered significant transaction costs and fixed costs in terms of fees, which further push them towards the pre-paid model. With the advent of mobile data, the mobile network operators saw the revenue from their mobile telephony drop, and as such tried to recover through higher rates and fees on a broader base of open pre-paid subscriptions. A combination of promotions and the simple need for communication kept individuals engaged with non-data pre-paid plans, though younger populations with broader use case needs shifted to increasingly data-only plans. As a result, a divergence started happening between those facing economic barriers with a simpler means of

communication and those that did not want to communicate at the mobile telephony level due to reliance on data-only plans.

The other aspects of technological conditions also played large roles especially in use cases. Often, solutions that are developed for communications for essential human services did not account for things like service management and interface operability. Solutions were ad hoc and simple applications in nature, rather than an end-to-end service that integrated with the broader essential human service use case. For example, the application used by UNICEF for community-health workers simply received and reported information, and additional use cases around ease of use, working through errors, providing service for those that faced errors, and adjusting for technological illiteracy all fell by the way side. The lack of money on the organization side to build out the full end-to-end service is an obvious barrier. However, as we observed from prior chapters, the lack of thinking about these additional items as a fundamental capability necessary to the broader functionality also led to failure of the solution over a longer period of time. As a result, we again observed a divergence between those that had access to data or internet and can effectively self-service, and those that defaulted onto basic functionality like telephony and SMS simply due to the lack of knowledge or service to acquire additional options.

In summary, we found three main observations of the individual's interactions with others in communications for essential human services in South Africa. First, individuals face an economic barrier especially in originating activity. The flip-side of this is that a future solution or platform should answer the question: in a mobile originating market, how does one remove the initial barrier faced by individuals as they seek to send or originate messages to someone or some group? Second, individuals exist on a diverging plane of technological options. Some are focused around basic functionality such as mobile telephony and SMS, while some have shifted to a mix of telephony and data or simply data. The design question stemming from this is: how do we connect individuals with divergent preferences for channels of communications? Lastly, communities are starting to improve their participatory condition through improved governance. The question here is: how do

we continue to encourage the participation *and* inclusion of different types of individuals in groups? These are the fundamental design questions to answer for any system that tries to solve the communications issues in the world of development. As observed in prior chapters, it's likely that South Africa is not alone in these observations. Answering these design questions, as such, represents a real opportunity for capability improvement in multiple domains and locations.

5 CASE STUDY: HICOMM AS AN INCO SYSTEM FOR RURAL HEALTH SERVICES IN SOUTH AFRICA

In the last chapter, we understood that stakeholders in South Africa faced issues in sustained delivery of essential human services due to barriers in inclusive communication. We understood that, in general, three items drove the erection of said barriers: first was the economic gate that each and every individual faced when proactively sending a message to another person or entity, second was the divergence of technological options that inhibited cross-solution channels, and third was the inability to take advantage of a growing communal need for participatory decision making and delivery. In this chapter, we consider the same ISF from a different angle: one of a design framework that provides inputs to functional and technical requirements for a communication platform that overcomes the aforementioned barriers.

5.1 History and Context of HiComm

Before diving directly into what HiComm is, the history and context may serve to provide a base case study, in line with the examples covered in the first two chapters. The history starts with a continued set of observations from research trips in provision of clean, domestic water supply to stakeholders in rural areas, including India and South Africa. In 2010, the author conducted field research of Nalgonda's domestic water supply system. The context of this research was an assessment of the district's communal capacity by employing Capacity Factors Analysis, and recommending paths forward based on alternative water supply schemes. In addition to the assessment, the author discussed in the thesis and subsequent papers that one item that stood was the inability of stakeholders in rural areas to adequately connect with "upstream" water providers and maintenance personnel, causing several days of inaccessibility. What stood out here, specifically, was that these people literally could not send basic messages, unless it was by physical journey and even then, having to align with the schedule of regional water-related governance personnel.

In a separate field research trip in the subsequent years, the author worked with a team of undergraduate students to design a gravity-based water delivery system and a Slow Sand Filter for centralized water purification. While many other challenges ultimately impacted the eventual failure of the SSF system, yet again it was observed that the end user struggled in sending signals to responsible and responsive parties with the ability to sustain the system. At this junction, the author worked with a team from the School of Nursing to employ Appreciative Inquiry (AI) as a method of learning from the community of what our team can do in the future to better enable the community's desired future. We discovered during this time that the individuals in the AI groups struggled to connect and communicate with us on a regular basis due to the seasonal nature of our research trips, and any system hereon would need to be purely community-driven. However, individuals in the AI groups also noted the challenge of connecting with partners that are thirty miles away, had better access to knowledge and resources, and had the ability to serve as enablers even if not drivers of change. This last insight was also reflected in subsequent groups in the understanding interviews conducted by the author, Karen Venter, Serule Humbalani Styles, Khwathiso Netshifhefhe, Elly Mboneni, and others that assisted along the way. Some notable quotes from formal entities, include:

> "I feel there is a communication gap between the beneficiaries and NGOs, and it is high. But it is not reflected due to the lack of feedback." – Representative in Hyderabad from Dr. Reddy's Foundation

> "There is a data network problem, papers tend to be used because of the network problem" – Representative (Community Health Worker) from Mothers2Mothers

> ""Smaller chapters are easier, but communication is a problem with large groups." – Representative from Enablis

A broader picture of essential human services started to form that illustrated the dramatic gap in the critical capability of communications between beneficiary and service practitioner, one that was reminiscent of the hypotheses of Easterly, Aker, and Mbiti. How does one think about addressing this problem? How does such a problem get solved? What is the design process? Those questions were answered through the birth of the conditions and some of the factors defined in the Inclusivity Systems Framework. However, two more remained: can such a problem be solved? Would the solution be sustainable? To answer these questions, the author set out to create a technological platform with the goal of enabling communication with the individual stakeholders in the community in mind first, yet providing for the service beneficiary to continue to play the role of an enabling entity.

5.2 Description of HiComm

Service-focused projects, such as water supply and HIV education, in South Africa face economic and technological barriers in day-to-day operations. HiComm strives to improve the operational efficiency by improving the communication process between and amongst the primary stakeholders involved in these projects – servicers (for example, Sally the Servicer) and community partners (for example, Cathy the Community Leader). HiComm has a three-pronged approach. First, HiComm is built as a system such that the economic barrier to the person that would feel it the most – Cathy – is reduced down to zero. In effect, the intention is for the system to be free to the end user – the individual. Instead, the servicing organization that Sally represents would cover the cost. The technological and process innovation to deliver such a feature will be covered in a subsequent subsection.

Second, HiComm is designed and developed as an SMS+web-based platform that increases access via SMS to Cathy while retaining flexibility and lowering costs via internet and PC for Sally. In effect, this address different elements of the technological

inclusivity condition as well as the demographic component of the participatory condition. The multi-channel access now means that the divergent signal delivery can be aggregated and delivered to intended individuals or groups seamlessly. The technological innovation here will also be discussed later. Last but not least, an analytical layer of ongoing activity that constantly calculates participatory, and in this case messaging, equity continues to provide means for service practitioners to ensure that the groups continue to be inclusive, or at least identify behaviours of silo-ism that can either be separated or tweaked. In addition, other word-based analytics such as word clouds and frequency serve as feedback and continuous assessment tools.

5.2.1 Underlying Technology and Process Innovation

HiComm's mission is to enable Sallys and Cathys to connect and collaborate easily and cheaply, and thus overcome barriers in community development. HiComm's unique approach, a combination of web-based platform, SMS APIs, and aggregator-based sourcing, addresses the economic and socio-technological challenges highlighted in the previous section. Instead of a haphazard communication process, Sally pays for a monthly service that includes the ability to send, receive, retain, and organize messages from Cathys and other Sallys over both basic mobile telephony and mobile internet channels. HiComm removes the economic barrier for Cathy by transferring it Sally – Cathy's project-related SMSs will be paid by Sally as a part of her monthly payment. Though HiComm is not intended to be a full replacement for all communication with partners, benefits include projected cost savings of 20-50% for Sally, a streamlined process for both Sally and Cathy, and a bigger voice for Cathy.

HiComm users can access the system via the web-based application or SMS. When accessing the system through the web-based application, more functionality such as user registration, group and project setup, and conventional administrative rights are available. The intention for web functionality is to align with the desired needs of service practitioners and "superusers." When accessing the system through SMS, the user has limited

functionality that includes: sending and receiving group messages for free, irrespective of the device or type of network available (as long as there's some level of network available). After an initial registration on the web-based application, the user may continue to interact with the system via SMS.

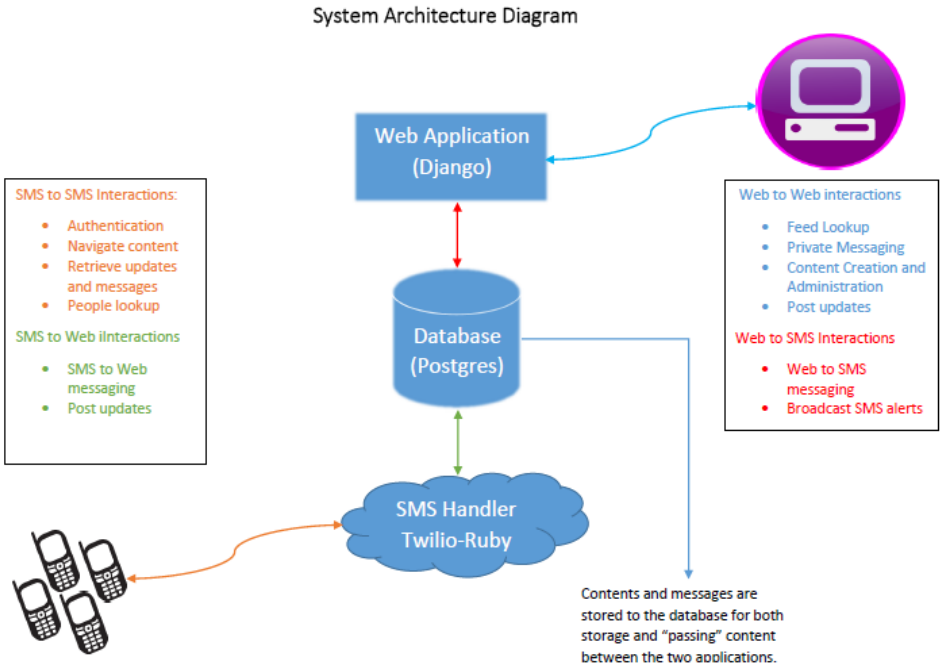

Figure 12: HiComm High-Level System Architecture

The technology works as follows. A manager creates a "Project" on an online web portal and the system assigns them an identification tag, such as "@b3a". After identifying all stakeholders that would participate in the respective service project, the manager then creates accounts with the stakeholders' existing cell phone numbers. If the manager so wishes, he or she may also create subgroups of these stakeholders by creating color-based identification tags, such as "#green" or "#red." Note that this idea was actually shared with us by UFS stakeholders, as they noted that it was easier to memorize colors for subgroups. Any time a user wants to send a message to their project peers, that user may send a message to the HiComm's designated 5-digit number with their project tag (e.g., "@b3a") and respective subgroup's tag (e.g., "#all" or "#green"). The HiComm system connects

with a third-party telco-provider to send and receive these messages. As a result, users may send and receive messages from any cell phone in South Africa to the web or any other cell phone in South Africa. Currently, our development team has also connected the American mobile telco network such that text messages from the US may be sent to South African mobile subscribers, and vice versa.

If the above platform serves as highway that connects many stakeholders, then tolls on the highway are still an issue. Unlike US mobile subscribers, South African mobile subscribers are still charged for all SMS messages sent. Though the amount may seem negligible, from a community member's viewpoint that may be living in extreme poverty of 25R – 40R per day, the extra 0.20R – 0.30R per SMS is still significant. Currently, HiComm circumvents this toll by working with its partners to suggest proactive cash grants, which are topped off based on the users' system activity. In a sense, the tolls are not paid by the community member, but rather the service project, and thus the donor or grantor who has already cleared sums of money for communication and logistics purposes. Last but not least, the system also meets the dialogue condition by the creation of multi-user communication groups. With the assistance of a dashboard, the manager is able to see each user's activity, promoted both individual and group activity by creating smaller clusters of the overall group.

Let's work through a scenario of Sally and Cathy can benefit with HiComm. A pipe just burst in Cathy's community and she needs Sally's resources and knowledge to fix it. Typically, Cathy makes a rudimentary fix to the problem while relying on anyone going into the city to get the word to Sally. That process unfortunately can take up to a week and could cost the entire community poorer water pressure or no supply. With HiComm, Cathy does not have to worry about paying for the SMS since it is a project-related communication. Sally gets the word in a matter of minutes than weeks, and can schedule a trip down over SMS. From Cathy's perspective, HiComm improves decreases cycle time, streamlines communication, and crowdsources responses to shocks. From Sally's perspective, HiComm lowers transportation costs, increases communication rate and

reliability, and improves communication interface. In short, the effect of HiComm is improved operational efficiency.

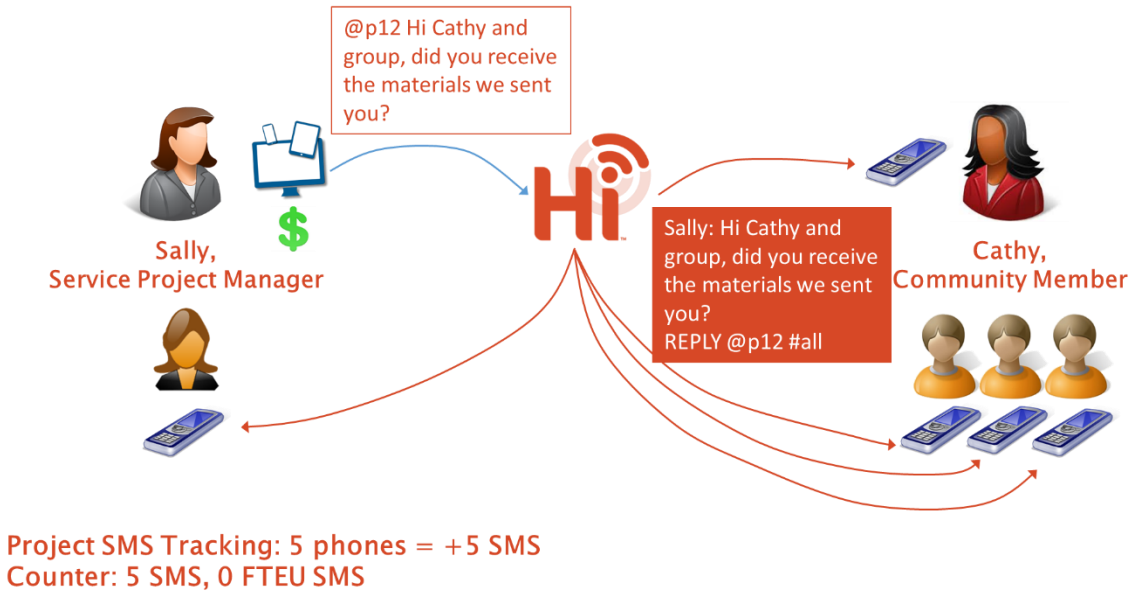

Figure 13: Sally the service practitioner engages Cathy in a conversation on a community project-related material delivery.

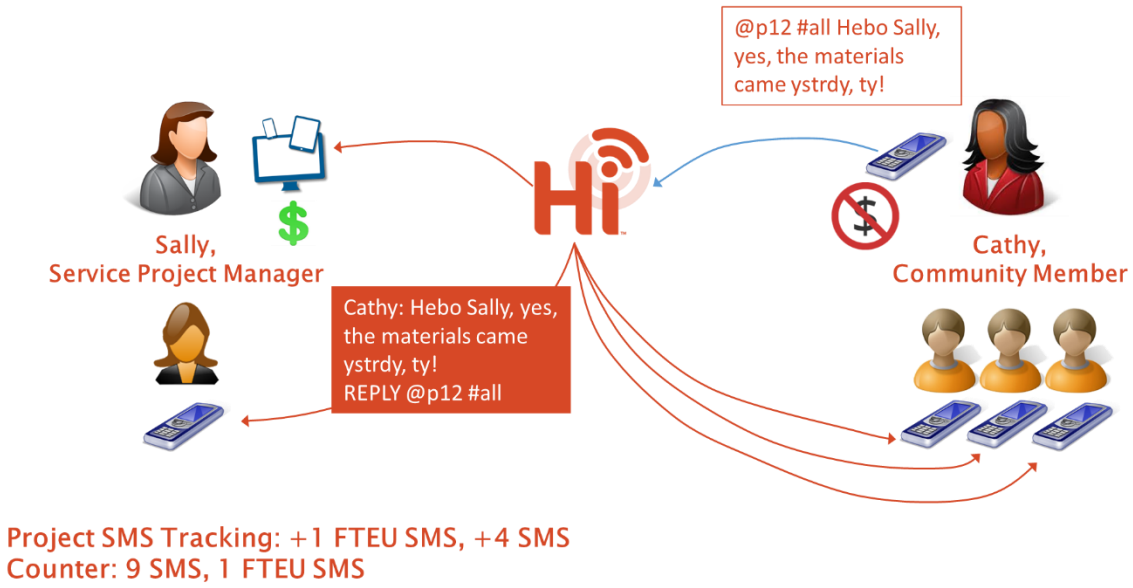

Figure 14: Cathy responds from a mobile phone without any cost to herself.

A common question – why can't Sallys and Cathys just group-text? Why not avoid the web-interface altogether? While group texting applications have made their rounds in South Africa, the primary users have been younger generations and those with 3G+ phones. Whatsapp is an example of such an application. Group texting applications do not additionally allow for more than just messaging – for example, Sallys and Cathys cannot retain messages for analytics, setup of different groups, and variations of subgroup texting. HiComm gets around that by combining the ease and low-cost benefits of SMS with query and functional capabilities of server-side languages. The product strategy is asset-based, institution-supported, and capacity recognized. HiComm employs an asset-based approach. Rather than advancing an unknown technology unsustainably, the author and team have researched ways to deliver messages from "dumb" phone to web applications and vice versa. In the case of South Africa, as shown in Appendix B, the mobile profile shows the prevalence of mobile phones (86% of population) and the remarkable usage of SMS (50% of users) compared to mobile internet (6.2%). With trailblazer ICT4D apps such as Mobile Medic and M-Pesa as noted in Chapters 1 and 2, the popularity has risen while the learning curve has flattened.

Second, as noted in the previous section, the ICT4D sector has made significant gains in the past few years by harnessing the versatility of SMS in the developing world with some examples in Exhibit 3. The WB, IFC, infoDev, and other macro-institutional entities are working hard to expand the bandwidth for ICT4D applications. An example of this collaboration is the renewed relationship with South Africa's Department of Science and Technology to create the mLab Southern Africa – a mobile app focused accelerator in Pretoria. This investment has been followed by Google with 88mph in Cape Town. In short, South Africa is taking an institutional lead on ICT4D. HiComm's own partnership with the Service Learning Centre at the University of the Free State in Bloemfontein, South Africa is another example of a growing ecosystem for M4D and ICT4D.

5.2.2 Considering the Business Model

HiComm is a B2B service that provides a streamlined communication process for stakeholders in service and community development. HiComm is technically classified under the new Information and Communication Technology for Development (ICT4D) industry as it is a web+mobile-tech that is trying to help service practitioners achieve the Sustainable Development Goals (SDG). By leveraging SMS, which is a cheaper technology, and increasing that technology's effectiveness by creating a decentralized network system, HiComm brings tremendous value to stakeholders involved in community development. The vision is to create a societal network that encourages service organizations and disenfranchised communities to collaborate and overcome development challenges. To achieve this mission, HiComm would follow the design components of ISF by reducing economic barriers (cost savings for operations for NGOs and free for communities), technological barriers (no internet requirement for communities and faster cycle time), and improving multi-stakeholder participation.

The B2B model works as follows: a service practitioner's organization, whether it's a formal NGO, governmental entity, or a granting organization, pays for a "project," which is the tag is the "@xyz" symbol referred to during the technical walkthrough, on a monthly basis for a series of 6-, 12-, and 24-month subscriptions. A step-based method is used to determine the cost to the organization. Given that most community groups are smaller in nature to encourage cross-conversation and because the management of excessive number of users is difficult for service organizations, there's currently a limit to a maximum of 50 users in a project and a limit of 10-subgroups. That said, HiComm is exploring a "dispatch" feature where certain users in an area will be able to receive automated alerts, to which they can respond one time for free. It is important to note that the user's response free-response feature is currently not active as it requires the signing of a longer-term contract with the supplier.

On the cost side, HiComm negotiated a long-term per-SMS contract for web-enabled multi-user text messaging with an API connectivity. The per-SMS price is a small fraction that individuals would be paying, if they were paying themselves. By working

economies of scale and bringing in social impact to highlight what HiComm could deliver, and a bit of luck during negotiations with multiple different mobile network operator aggregators, HiComm was able to create a reasonable margin while providing attractive prices to the customer. As expressed in Chapters 1 and 2, solving this problem would be a double benefit for the service beneficiary. Ika, Diallo, and Thullier (2011) sought to isolate the critical success factors behind statistics such as a 61% success rate in World Bank projects in 2010. They identified five project management critical success factors: design, monitoring, training, coordination, and institutional environment; and they concluded that these attributes correlated positively with the success of projects. The takeaway message is that service practioners do best when communication barriers are removed so that each of the critical success factors can be optimized. For the World Bank, reducing these failures would equate to opportunity cost savings of nearly $20B. But this isn't just a billion-dollar problem; it is a billion-person problem.

One of the biggest success stories has been the combination of ICT4D and agribusiness. In Global Information Technology Report 2013 by the World Economic Forum, Rwanda is highlighted for its E-Soko project. E-soko connects farmers to an agricultural database via mobile phones to better inform daily farming decisions, such as planting, selling, and holding. The removal of information asymmetry in agribusiness has increased total welfare, and as a result, Rwanda achieved an average annual growth rate of 8% despite of the 2008 financial crisis and takes top rank for start-ups. The agribusiness application itself spurred other ICT4D start-ups that have collectively attracted nearly $540M in foreign direct investment.

In conclusion, the innovations advanced by HiComm help answer the questions at the end of Chapter 4 by reducing economic and technologic barriers while enabling participatory behaviour of individuals in the community. The business side shows potential, though significant capital may be necessary to prove out at a larger scale.

6 CASE STUDIES OF HICOMM IN SOUTH AFRICA

In this Chapter, two sets of case studies are presented to present the theory of HiComm in action. The first covers a series of mini-projects conducted with ISF design partner and HiComm contributor – the Service Learning Centre and the School of Nursing at the University of Free State (UFS) in Bloemfontein, South Africa. The second is a project where HiComm was employed as a private virtual support network to enable conversations between at-risk young men. Learnings from both sets will be discussed at the end of the chapter.

6.1 Projects with UFS

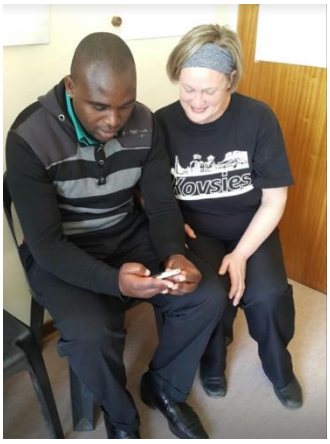

Figure 15: Karen Venter, key partner from UFS, training community partner and member on the use of HiComm

The authors brought the design of an inclusive communication system, HiComm, to three live SL engagements in which the Service Learning Centre and the School of Nursing at the University of Free State participate. The community partners include Bloem Shelter, REACH for Community Foundation (ROC), and Interprofessional Learning Engagement (IPE). Bloem Shelter is a faith-based organization that provides food, health, and shelter services for the homeless, women, and elderly. REACH for Community (ROC) Foundation, which inspires orphans and vulnerable children in an at-risk neighbourhood in Bloemfontein to learn and become motivated beyond daily challenges that surround them,

such as poverty, consequences of HIV/AIDS, familial problems, and abuse. IPE is an interdisciplinary group of university students that together participate in SL engagements.

UFS and UVa. partners engaged with stakeholders from these three groups to understand how their idea of an inclusive communication system may be used or be useful. The technical service was provided by students and researchers in USA and in South Africa for this research project. As noted during a prior section, the free-to-end-user technological feature was disabled due to the immense capital cost. However, it was replicated through frequent reimbursements for messages sent, which were counted as a part of the HiComm analytics. For this set of projects, the primary student support came from Ella Shoup, Andrew Ton, and Vijay Edupuganti from the University of Virginia, and Geoff Seale from the University of the Free State. The work was funded as part of a Community Engagement Programme Grant by the National Research Foundation won by the partnership of University of the Free State, which received South African IRB approval, and HiComm. Because of the nature of the award, the focus of the study was on service learning and participatory action. As such, two new concepts are introduced: Interprofessional Service-Learning Project (ISLP), which refers to service learning projects that combines multiple disciplines such as nursing, community engagement, and education; and Participatory Action Learning Action Project (PALAR), which focuses on collaborative intervention by both external and internal stakeholders, with an aim to both learn something new and improve an outcome, such as health. Venter served as the champion of these new concepts as they were paired with the more technical focused ISF framework and HiComm system.

6.1.1 Quantitative Assessment

The three groups had forty-six total users, including two to three silent observers per group. The number of communications varied dramatically per group. The use case across all three groups was that of reflection after service received or service provided. Given that the focus was on even being able to deliver and receive messages, the number of messages was not considered as a major requirement for analysis. However, it should

be noted that future research will include a longer time horizon with moderated messaging to encourage continuous participation.

6.1.1.1 Error Rate and Time Between Messages

Figure 11 shows the percentage of errors in attempts of sending a message via the HiComm system mapped against the interarrival time between messages, which can also be construed as response time. Since this was a new system in a new environment, the errors were studied in detail. Almost all errors were caused by incorrect usage of the tagging technique by users in the Bloem Shelter Group and ROC. Interestingly, IPE had no errors, but this can be attributed to the fact that IPE mostly had university students that were familiar with smartphone applications like WhatsApp and Twitter. Moreover, the lower interarrival time in Bloem Shelter Group and ROC indicate a greater eagerness in responding to fellow members.

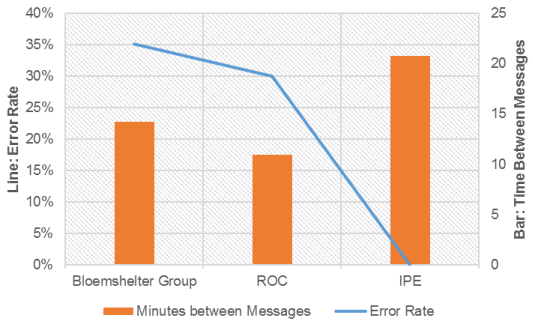

Figure 16: Error rate of users across different groups, in accordance with the respective attribute from ISF

6.1.1.2 Messaging Equity

Another interesting aspect to consider is "messaging equity," which is the metric provided by HiComm to understand the relative participation of an individual with respect to the rest of the group. The metric defined earlier in the Inclusivity Systems Framework borrows from the Gini Index, which measures income or wealth distribution where "0" indicates a perfectly equal world and "1" indicates a world where only one person holds all of the resources. Similarly, an index that was lower indicated a group that was more

inclusive in the participatory equity – originating. In this case, it was great to see that, while there were some individuals that participated more, the overall participation was fairly equivalent across the members in each group. This may be influenced by the heavy emphasis on mutuality and reciprocity during service learning engagements.

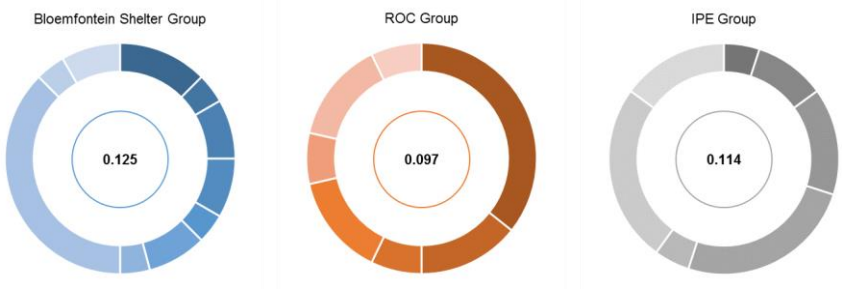

Figure 17: Messaging Equity across the Bloem Shelter, ROC Group, and IPE Group

6.1.2 Qualitative Assessment

After qualitative inductive and deductive coding of the reflection from the participants, the data was organized (see Table 1). Relevant themes were identified after data was categorized. In the table quotes are included to provide meaning to the findings. In short, the results indicate a combination of excitement and opportunity for new ways to communicate and a learning curve for shifting to the new. The themes will be discussed at greater length in the discussion section.

Table 7: Themes, Categories, and Quotes from Engagements

Identified Themes	Categories under Themes	[Translated] Quotes to honour the text used by participants
Effective system	Communication, Cost, Community of practice, Learning, Service, Cell phones	*"Clear communication helps the grease the wheels of a sustainable relationship"* *"Champions in academia, business and community – a Community of Practice"*
Benefits	Access, Bridge the gap, Connection, Communication, Collaboration, Research, Learning, Development, Positive change	*"Positive action which was embedded by all role-players in this project"* *"Improve their lives with seamless communication"*

Challenges	Culture, Diversity, Distance, Finances, Language, Learning, System, Time, Technology	*"Highlight and connect with an individual in the group each week"* *"Don't you think messages are enough for one day, I do not have space"*
Partners	Aspirations, Characters, Feelings, Skills	*"Understand the unspoken code of conduct and power hierarchies"* *"Own leaders were invited to be the first to send a message"*

6.1.3 Discussion

The objectives of this research as highlighted in Chapter 3 were to investigate the current capability of stakeholders in South Africa with respect to ICT, design an ICT4D that pushes that capability higher, and then deploy that respective ICT4D in cases of essential human service deliveries. The impact of whether the ICT4D actually improved service delivery was a question that remains to be explored and was outside the scope of this work. Thus, the focus of this work is to understand if the introduced technology can increase inclusivity in the respective case studies. The quantitative results and the themes arising from the qualitative analysis indicate that certain aspects of the system were well-received, while others required improvement. In short, all stakeholders appreciated being on a common communication platform where they felt they were all included. However, the novelty of being on the platform combined with technological challenges warranted further reflection.

6.1.3.1 Reflection on the Design and Implementation of the System

Considering the aforementioned ISLP framework, the essence of shared of integration and inclusivity have been mentioned. Thus, in PALAR it is important to do research with and not on the participants. It is of interest to listen to and acknowledge the suggestions from participants. According to the participants of the three engagements, the

following effective components were suggested for the design of an effective and inclusive system: communication, cost, community of Practice (CoP), learning and service. In summary, the system should be easy and simple to use, be administered by experts, managed and monitored continuously.

Given the feedback, it was clear that communication should occur daily on the system. However, several system issues could be improved to enable daily usage. Given that the system was used in a new manner across different cell phone models, troubleshooting was necessary. When under construction or troubleshooting, users should be notified to manage their impression of the system. Moreover, given that several users are joining an "networked" system for the first time, "netiquette" – a standard of communication dos and don'ts – may protect users' privacy while clarify messaging. In response, a service engagement was created (see Appendix C).

On the cost front, the system should be cost-effective, because stakeholders, including community members, partners, and universities, have limited access to funding. While the system was built on the premise of achieving Condition 2: Economic Inclusivity, it was clear that there were shortcomings. First, the reimbursement model was not yet automated and required much of the managers in tracking people's airtimes. Second, while those that did receive airtime use some of it for dialogue, it was clear that the balance was used personally. While limiting personal access may not be the objective, there perhaps should be an element that restricts provided airtime for the use of the system only. Last but not least, the cost management on the organizer front can also be improved through proper procedure documentation.

Community of Practice (CoP) describes the participants' interpretation of the purpose behind the common communication platform. A CoP builds on a sense of shared beliefs and passions to drive an action. Within Venter's PALAR paradigm, and in a CoP, participants wish for a partnership to reach a deeper level of relationship. In this level,

reflection and recognition are needed for effective functioning. The process with which the reflection and recognition occurs remains with champions in academia, business and community, who can and should assist members. One form of assistance can be the clear delineation of roles, goals and responsibilities such that the interaction between stakeholders inside of the HiComm network is seamless. In a way, this is no different from any group adopting a new tool to an existing process – the champions can create a responsibility assignment matrix for all of the respective stakeholders. However, such a matrix must still ensure the central tenant of inclusivity, where discussion and decision making should occur between many diverse viewpoints and from the perspectives of different partners' experiences. It is important that partners should specialise and keep developing their skill, within their unique background.

Participants advised that knowledge and information should be shared, for a good understanding of how the system works and the content on the system itself. While the "experts" should guide others on how to use the system, the "novices" can provide active feedback in improving both interface and function. Critical reflection in a collaborative learning context is of essence for effective learning, and that learning should be recognized by the service learning champions. Moreover, individuals can also be recognized for their learning of the systems itself. Such recognition can enhance the users' appreciation of the overall network. Lastly, participants noted that training should be proper, persistent, visual and oral, and provided in a language and accent that is clearly understood. The trainer must focus beyond themselves. An interesting method can be to both recognize an active community member on the system and enable them to become a trainer, which would achieve both of the above objectives.

The participants reflected that the technology enhanced information for all partners, including non-traditional learners. Here alone, it can be argued that a digital divide gap has been bridged. All partners can connect, communicate and collaborate on this network to share information, even for research. Having access to research can assist NGO's with funding when they compile proposals. The three community partners noted that the

research communication enhanced their learning and holistic development. Positive change thus occurred on a personal and professional level.

On reflection of the project itself, several components challenged the project from success, including the design and implementation of the system, cultural diversity, distance between administrators in terms of time zones, inadequate funding, language barriers, different levels of learning, systems failure, and time for administration of the system technology failure. An ideal service would be a one-stop shop that provides the network, training, setup, and other administrative duties accompanied by a delegate. While such a shop may not appear overnight, an inclusive communication system should do all it can to be the grease behind the engine of service learning and community development. Regardless, this project served as in important step in interdisciplinary and international learning.

6.1.3.2 Participants' Voices

At the heart of a Community Health Engagement Partnership are the people who interact. From the reflections of the participants it appeared that aspects such as aspirations, character, feelings and skills, are essential to drive communication systems and networks. Social responsibility clearly remained at the heart of all partners. They cared and wished to contribute positive action towards a common good of society. The voices of the participants are honoured here by including some of their quotes. A community partner at the start of the project introduced the technology and exclaimed, "we plan to own and develop this system from our side to improve our relationship with the university and increase our level of academic operations"

The character of those who serve towards the common good, emerged as that of motivators, passion for making a difference in people's lives, commitment, and emotional intelligence. One participant embraced the worth of a community member, when providing

her as leader of the volunteers at one of the sites to "…enable one of the community champions to send the first SMS to the community. All of her co-workers instantly received a text and knew where to meet. That's a really powerful information technology!" The feelings that were evoked by collaborating in the network, had dimensions of appreciation, excitement, gratitude, inspiration, reward, and completeness. One of the students that served as a technical expert for the system reflected simply, "I could finally see how the community members use this tool in person."

During the process it was clear that the intrinsic skills of each person emerged in their own way. Some of the partners designed the system and project from the beginning, like the authors. Others with computer science and engineering knowledge contributed effectively to the development and maintenance, as needed, of the system. Some of the partners were very comfortable with technology and could troubleshoot quickly. Some of the community members could troubleshoot even better than the student partners because of their own working knowledge of their cell phones.

6.1.4 Conclusion and next steps

Inclusivity systems focus on bridging stakeholders, that are otherwise divided geographically, digitally, and culturally, via a common platform. This research project presented the introduction of an iteration of inclusive communication system, by provision of a student-developed networked system that worked over SMS, in the field of service learning. Participants appreciated the ability to be on a common communication platform and suggested several improvements that will be carried on to future projects. The initial deployment was successful in gaining hitherto unheard voices, and thus engaging multiple different stakeholders in a more inclusive environment than in the past. The next steps include longer-term engagements and developing additional features onto the system as per the suggestion of participants.

6.2 Case Study: HiComm as a Virtual Support Network in South Africa

In collaboration with the Center for Global Health at the University of Virginia, PinPoint, LoveLife Community Centre, and CHAPS Mobile Clinic, a student team delivered a unique HiComm-based service that created a safe, private environment for young men in South Africa that were at-risk for HIV in South Africa. The underlying service provided by the community partners is unique and incredibly relevant in a country that has one of the highest HIV rates in the world. There's currently a stigma against free conversation around HIV, sexual health, and proper healthcare. Such conversations are hypothesized to increase education in the arena. lessen misconceptions, and create camaraderie against risky behaviour. A student team composed of Sasheenie Moodley, Ella Shoup, and Vijay Edupuganti from the University of Virginia were advised by Professor Rebecca Dillingham from the School of Medicine and Professor Garrick Louis from Systems and Civil Engineering. Primary contributors to the study included Mervin Govender and Ntswaki-Tsoni from PinPoint, the lead community partner in the engagement. The work was funded in part by a Public Health Research Grant from the Center for Global Health at the University of Virginia. The work and results are covered in a submitted article to *South African Journal of Health*, entitled "How Do Men Support Each Other? Investigating Virtual Peer Support with Men at Risk for HIV in Botshabelo, South Africa." However, since the South African community partners had not received South African IRB approval (note, US IRB approval was received), the specific results will not be able to be published. This section, thus, captures general learnings from the employment of the HiComm system, particularly the learnings around service management.

6.2.1 Overview of Study

The basic premise of the study was to create a virtual environment where young men can have conversations with privacy and anonymity. The individuals that ran this research were investigating whether individuals that used a common communication

platform with anonymity would be willing to openly discuss personal and sexual health. Note that for the purpose of the discussion here, I focused specifically on whether individuals from poorer demographics would be willing to even engage over a common platform. Thus, the scope of the next level question of the impact on health-related discussion is not considered.

The onboarding process included recruitment of the individuals to a clinic that focuses on increasing awareness of self-care in sexual health. The anonymity and camaraderie were intertwined by introducing each participating individual as Brother X (where X corresponds to a specific number associated with a specific individual). Doing so also enabled the US Institutional Approval Board in approving the activities that required health-based socio-behavioural research involving humans. The process also included an introduction to the HiComm technology and how it could theoretically be used by individuals to ask questions, or simply chat behind a different name. Moderators, or counsellors as they were termed in the sessions, were allowed in certain groups to check in and keep conversation civil.

Similar to the other case study, the free-to-end-use technological feature was disabled; however, it was replicated via a credit-based system where users were provided with credit intended to serve as a monetary base to support message sending over the HiComm number and channel. The moderators conducted periodic checks, including reminders on how to use the tagging system for proper delivery of messages. Midway through the observation period, a re-training and another addition to the phone credit were provided to individuals. For the purpose of analysis, the first period before the re-training was called Period *A* and second period was called Period *B.*

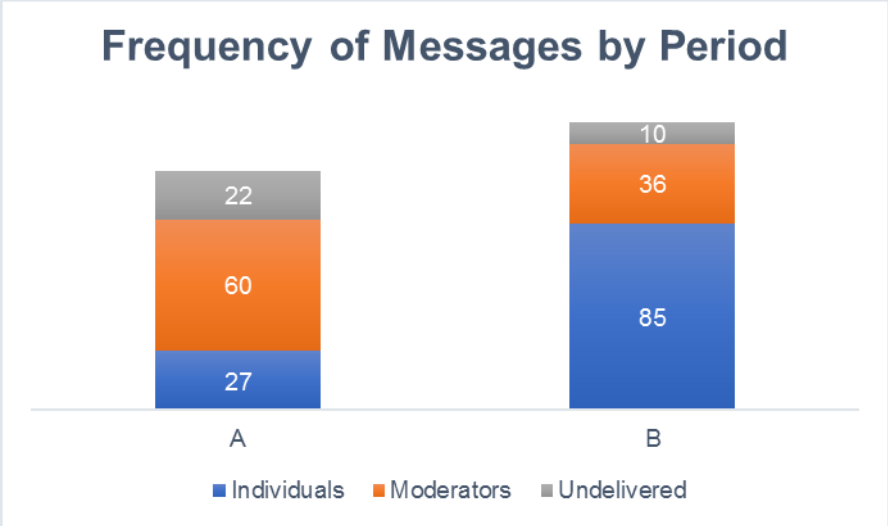

Figure 18: Frequency of messages sent before and after the re-training and additional credit

Additional data analyses, including sentiment analysis and messaging equity, that will not be able to be presented here showed that the participants expressed interest in co-engagement and that the moderator provided a critical role in continuing conversation amongst otherwise strangers. In general, the paper summarizes that the subject of the messages focused around peer support rather than specific health questions. One aspect of the paper that will be highlighted here is that of the factors of interface operability and service management.

6.2.2 Discussion and Resulting Changes

The two takeaways from the VSN case study pertain to the limitation of systems like HiComm as a double-blind peer support system and the importance of proper onboarding and service management. Core to the hypothesis that was tested by the VSN study is support networks can be created or fostered amongst strangers that face a common challenge, as long as there is adequate privacy. While there is a lot to unpack within that hypothesis itself, I focus on the common challenge and privacy items. Unlike the previous cases with UFS which focused on groups of stakeholders that were already familiar with each other, the VSN case brought together individuals from different neighbourhoods and

from a similar age group that has been proven to be susceptible to HIV. In essence, where the UFS studies started with at least a few relationships that had already been created and trusted, the VSN intentionally sought individuals amongst whom there's no relationship other than a statistical one. As such, when the moderators of the study were reflecting why participation may have been haphazard, it was clear to fall back on the simple fact that strangers may not have anything to say to each other. Of course, that statement is just as easily rejected because of thriving internet-based communities where individuals do engage without prior contact. What, then, was the difference?

There are two possible explanations. In the case of the VSN studies, as suggested by Jamison et al (2013), participants bring a bias of self-isolation while satisfying personal gains in the case of health-based assessments. HIV understandably carries a significant stigma in the community. However, participants still have something to gain by understanding the risks of HIV and earning some reward for participation. For young adults, the balance becomes a tricky one as they seek to protect their identity while topping up their mobile balance. In those cases, we can expect that the content of the messages focused on non-health related topics, which happened to be the case with the VSN study. Secondly, in the case of internet-based support networks and anonymous chat sites, content or theme tends to drive the traffic. However, health-based content seeding in the VSN study was forbidden as it could have negatively influenced future behaviour. See Appendix D for the pre-cautions taken to specifically address topics that were ***not*** to be covered. A VSN, especially through a new platform such as HiComm, is not a proven intervention to preventing HIV and thus understandably faces high barriers in terms of what it could address. No amount of privacy could overcome those legal barriers until there has been a formally approved longitudinal program with control groups to study the intervention.

Service management also played a critical role in the VSN study. During the first encounter with the participants, the moderators played a limited role in onboarding and guiding the participants through typical and intended use cases of the VSN. As shown in Figure 13, the number of messages in the first period (a longer period than the second) was

lower than in the second. The number of moderator messages and errors were also higher. As the team tried to uncover what was happening, the moderators' limited engagement during the kick-off was revealed. The team then adjusted and created a more user-friendly engagement sheet with specific diagrams of messages on two types of locally popular phones – a typical Nokia-style feature phone and a Blackberry (see Appendix D). The participants were re-invited for another onboarding session, with the promise of an additional reward of cell-phone time. During the session, specific use cases were covered and trial runs were conducted with each participant individually. After the second onboarding, the second period started. Whether driven socially by the re-engagement, economically by the added reward, or simply a better understanding of the system, the participation rate went up amongst most individuals. The topics of conversations also varied, including general peer support to more male-specific health questions. While a follow-up survey was not possible due to the time constraints on the study, it was understood through the community partners that the clarifications on the system generated the incremental participation.

6.3 Comparative Analysis of Use Cases through ISF Lens

The lessons learned from each use case were discussed in the prior sections of the chapter. One question remains – how does the deployment of HiComm in each of these respective use cases compare with each other? Where was there a positive or perhaps negative influence due to the introduction of HiComm in each of the communities? I answer that question by re-using the same lens as established in Chapter 4 – the ISF. Note Figure 17 below, which is recalled from Chapter 4 when ISF was introduced. The framework was used to first assess the capability of the community to form the general ICT4D strategy for HiComm, and then re-used as a part of the design process of HiComm. As shown below, it can also be used to summarize capability shifts after the system has been deployed.

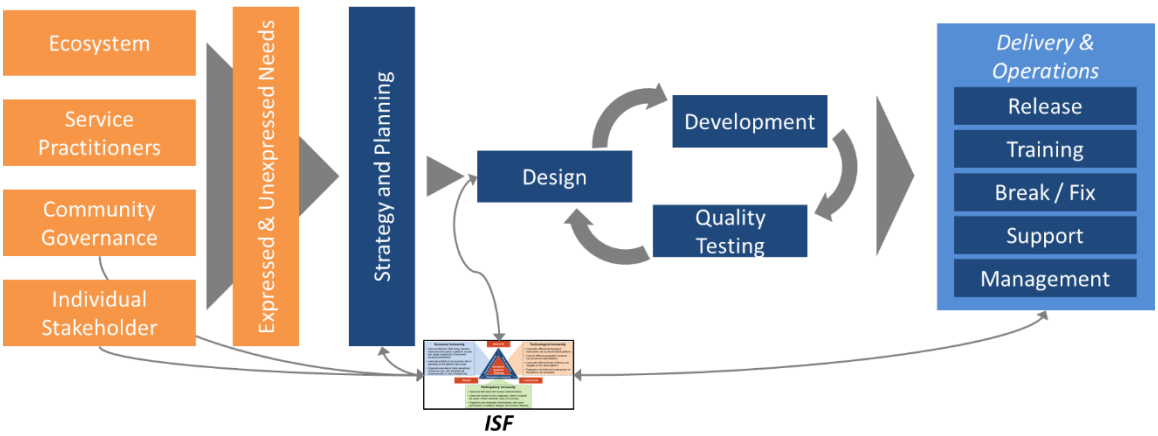

Figure 19: ISF in action across multiple areas of a typical essential human service delivery process.

The table below shows the summary of a subjective comparative analysis as it relates to capability uplift across the different use cases: Bloem Shelter (BS), Inter-Professional Experiential (IPE) learning group, Reach Out Community (ROC), and Virtual Support Network (VSN). As noted earlier, all the use cases occurred in the general area of Bloemfontein.

Table 8: Subjective Comparative Analysis of Capability Uplift for Stakeholders in Use Cases

Inclusivity	Factor	Attribute	BS	IPE	ROC	VSN
Economic	Variable Costs	Activity Unit Cost - Originating	↑	↓	↑	↑
Economic	Variable Costs	Activity Unit Cost - Terminating	-	-	-	-
Economic	Variable Costs	Energy (variable) Cost	-	-	-	-
Economic	Transaction Costs	Search (and Non-Immediate Connection) Costs	↑	↑	↑	↑
Economic	Transaction Costs	Restricted Activity Enforcement Costs	-	-	-	↑
Economic	Fixed Costs	Infrastructure Access Cost	-	-	-	-
Economic	Fixed Costs	Solution Access Cost	↑	-	↑	↑
Economic	Fixed Costs	Process Support Cost	-	-	-	-
Economic	Fixed Costs	Administration Cost	↑	↑	↑	-
Economic	Opportunity Costs	Holding Cost	↓	↓	↓	↓
Economic	Opportunity Costs	Time Displacement Cost	↑	↑	↑	-
Technological	Availability	Physical Device	-	-	-	-
Technological	Availability	Energy	-	-	-	-
Technological	Availability	Network	-	-	-	-

Technological	Availability	Platform	↑	↑	↑	↑
Technological	Availability	Application	↑	↑	↑	↑
Technological	Accessibility	Physical Device	-	-	-	-
Technological	Accessibility	Energy	-	-	-	-
Technological	Accessibility	Network	↑	-	↑	↑
Technological	Accessibility	Platform	↑	↓	↑	↑
Technological	Accessibility	Application	↑	↓	↑	↑
Technological	Interface Operability	First Use User Error Rate	↓	-	-	↓
Technological	Interface Operability	Sustained Use User Error Rate	↓	-	↑	↑
Technological	Signal Reliability	Signal Originating Delivery	↑	-	↑	↑
Technological	Signal Reliability	Signal Terminating Delivery	↑	-	↑	↑
Technological	Signal Reliability	Signal Storage	-	↓	-	-
Technological	Service Management	Onboard and Offboard	↑	↑	↑	↑
Technological	Service Management	Use Case Training	↑	↓	↑	-
Technological	Service Management	Maintenance	-	↓	-	↑
Technological	Service Management	Technology Literacy Adjustment	↑	-	↑	↑
Participatory	Governance	Governance Structure	-	↑	-	-
Participatory	Governance	Economic Alignment	↑	↑	↑	↑
Participatory	Governance	Technology Alignment	↑	↓	↑	↑
Participatory	Participatory Equity	Participatory Equity - Originating	-	↑	↑	-
Participatory	Participatory Equity	Participatory Equity - Terminating	↑	↑	↑	↑
Participatory	Demographic Inclusion	Social-cultural Demographics	↑	-	↑	↑
Participatory	Demographic Inclusion	Economic Demographics	↑	↓	-	↑
Participatory	Demographic Inclusion	Location Demographics	-	↑	-	-

Table 5 summarizes a subjective view of the capability uplift or decrease provided to stakeholders based on each use case. It is important to note that a full ISF capability reassessment was not conducted at the end of the period of each use case observational period due to funding and timing constraints. However, it is still valuable to reflect on the use cases through the lens of ISF to understand what attributes may have seen improvement, and where there may have been divergence.

Most of the improvements and challenges have already been discussed in the prior sections. To briefly summarize, stakeholders that participated in the Bloemshelter (BS), Reach Out Community (ROC), and Virtual Support Network (VSN) use cases saw the most improvement in terms of capability uplift, particularly in areas of economic and

technological inclusivity. To expand on this, consider first the current condition. Most of the stakeholders in the groups were in poorer, more rural areas. The type of phones they owned are basic mobile phones that did not have access to data-based networks, which allowed for applications such as WhatsApp. They had to pay to send messages, something they still did with HiComm, but at a significant discount since they were sending messages to several people on different carriers at different times of day. What HiComm brought to these users was a capability to replicate the type of connectivity that they saw in their intervening stakeholders, the non-profit leaders. Basically, the capability improved because the capability previously was very low. The underlying reason here may be that the predominant users of these groups did not previously have access to advanced messaging capabilities, such as those available in over-the-top internet-based applications, such as Whatsapp, iMessenger, or Mxit.

However, users in the Inter-Professional Experiential (IPE) learning group broadly faced a capability downshift, likely due to there being a greater number of users in these groups that did have access. While appreciative of being able to connect with individuals without such access, the more privileged IPE stakeholders reflected loosely that there may be alternative ways to achieve the same goal. What some users saw as a boon was in turn an unnecessary burden on the others. Individuals that had higher capability phones and more resources could more easily achieve the same task of sending group messages via email or Whatsapp, or a multitude of other applications that exist over mobile data. Making these users that were used to more streamlined applications instead use simple text messaging with coding requirements actually made them go backwards in capability. Furthermore, some users had data-only phone plans that caused them to incur charges for sending text messages.

One way to address this multi requirement nature of economically diverse stakeholder groups is to add an internet-enabled application for smart devices. From the perspective of someone that has had a smartphone and has used internet-enabled applications, the interface with texting could be interpreted as a step backwards. However,

what if such users could work with a front-end not unlike Whatsapp or iMessenger? That could not only change perceptions, but it could also streamline the continued use of the platform as even BoP stakeholders gain sustainable access to smartphone technology. The HiComm platform was designed such that it could be used over mobile web, but even that experience can be troublesome at times. For future engagements with deeply economically and technologically mixed groups, it may be worthwhile to create an iOS and Android mobile application.

Some areas that broadly saw a downshift included items such as Holding Costs and First Use Error Rate. The later was covered in the previous sections, so I will focus more on the Holding Costs. Given the way that mobile network operators charge their subscribers to send messages on a pay-as-you-go plan, one necessary requirement to send messages is to have a minimum balance. Moreover, a user cannot dip into a negative balance in order to send messages. What this effectively means is that at all times, the user needed to weigh if he or she wanted to use a portion of the balance to send messages or not, which in turn meant that even if a user *intended* to send a message, he or she may have not been able to do so due to a lack of balance. We found this to be particularly egregious in the initial round of the VSN and the Bloemshelter groups. Ideally, the mobile network operators allow their subscribers to keep a negative balance for a brief period of time, at which point either a service administrator or an automated system from HiComm can "push" or reimburse credit for messages sent through the system. However, from conversations with Vodafone and MTN, it seems such a feature is unlikely. The issue also crosscuts those that use internet-enabled applications as well. For instance, if the SIM card runs out credit for "Data" services, then applications such as Whatsapp do not work. One item that is slightly worse for data-enabled applications is that their users do not even receive messages for free, unlike SMS-enabled services such as the one provided by HiComm.

It is also noteworthy to talk about areas where there was not a significant capability uplift or downshift. Particularly, availability of physical devices, network, or energy points

did not change in the use cases. The HiComm solution simply provided an over-the-top solution on devices and network that already exists for everyone, which is a part of its innovation. Regardless, conventional challenges associated with availability and access of such items still persisted. For example, given that the IPE use occurred in tandem with users in rural Springfontein, network and energy availability both were issues at times. At the least, future deployments should consider small, affordable battery packs capable of charging older-model phones.

In this chapter, two sets of implementation studies were covered. One provided a view of how HiComm was leveraged as community engagement enhancement tool by encouraging participant reflection, a critical component of service learning. Another shared the potential and limitations of HiComm as a virtual support network tool for HIV-susceptible populaces. In both cases, the use case itself presented interesting interactions with the concepts of inclusivity as well as technical and operational considerations during implementation. The next chapter expands on these considerations by discussing future work.

7 CONCLUSION AND FUTURE WORK

This dissertation sought to understand barriers for proliferation of information and communication technology at the Base of the Pyramid and present a new framework that focused on addressing challenges in essential human service design, development, and engagement. Specifically, the dissertation introduces an Inclusivity Systems Framework to focus on individuals, their role in their respective community, their interaction with technology and vice versa, and their interactions with economic factors. The ISF framework builds on the importance of trust, community, and individual capability at the BoP. For the purposes of scope, the ISF was chiselled to focus on communication systems. The framework was deployed to consider capability maturity of communication systems in South Africa from a community stakeholder perspective. It was conversely used to inspire the design, development, and delivery of HiComm – a messaging platform that enabled individuals with basic cell phones and no data access to still be able to message others as if they were on the internet. Two sets of studies of HiComm in action were presented, and HiComm's potential and limitations were discussed. Over the course of the dissertation, several additional items of individual merit were also introduced, such as the Participatory Inclusivity Index, the underlying conditions of inclusivity, the HiComm technological system, and the concepts behind the UFS and VSN studies themselves. Future work remains in expanding the ISF framework within the ICT4D domain, beyond into other domains, and in general building upon the other work presented in this dissertation.

The work presented to date unpacked lower-level attributes of ISF conditions and factors based on the domain focus on ICT4D. These were constructed in collaboration with research partners such as University of Free State in South Africa. As the framework is tested in different geographies and markets, it may be the case that both the attributes and the scoring components will need to be adjusted. For example, the United States relies on a fundamentally different telecommunications protocol than South Africa. Messages are charged for when they are received rather than when they are sent. Hence, the set of weighting and descriptions will need to be modified. Given that some form of normalizing

the framework to a geography or market will be needed, the fundamental question is whether the ISF framework proves to be just as useful in that next geography or market as it was in South Africa. One way to study the translatability of ISF is to employ a similar approach as was taken in this dissertation in a new country. Specifically, a similar capability assessment with select stakeholders can be conducted in India, and then HiComm's platform capability can be expanded to replicate the type of experience that was generated in South Africa. The expansion can be further motivated for countries with more disparate access to technology, such as others in the Sub-Saharan Africa, Asia-Pacific (not inclusive of Russia), and Middle-Eastern and Norther Africa regions as highlighted by the GSMA 2018 Mobile Economy report.

In addition to expanding across different areas, the study could continue in different parts of South Africa as well. Both case studies were predominantly conducted in the Free State province of South Africa, which is neither the richest nor poorest. Additionally, partnerships with community partner organizations and universities across Limpopo, Mpumalanga, Gauteng, and Western Province were already cultivated during the capability assessment phase of the research. Using the UFS research partnership agreement as a template, similar engagements could be started. It is advised that the initial engagements also focus on the domain of service learning and community health workers as these were the primary focus areas when working with UFS. By expanding to additional groups within the same country, a network of ISF practitioners and HiComm users can be created. Therein, an opportunity rises for new investigation of the network effects.

Additional domains of practice should also be considered for future work. While the current work has been limited to service learning, community health workers, and male sexual health, the initial domain inspiration came from water services. Use cases within water have already been investigated for research grant applications, such as the US-India Science and Technology Endowment Fund. The connections to Birla Institute of Science and Technology in Pilani and Jawaharlal Nehru Technological University in Hyderabad, and the regional relations available, represent starting points for investigating the

application of inclusive communication systems such as HiComm on top of water infrastructural solutions and services. An example for such an investigation includes using HiComm as water quality dispatch and response system that's paired with a point-of-use water quality tester. The combination could yield a powerful outcome in the periodic collection of water quality data, immediate advice relay to individuals, and networking capability for individuals to borrow water from others on the network in case of local contamination. Of course, the same type of work could also be done within South Africa as well.

Last but not least, there's still a need to improve the framework itself for ICT4D. Given the rapid pace of technological change, additional factors and attributes will likely need to be considered, even if the BoP's current accessibility remains limited. An example is the transition of the above case of signals from simple text to image and video, as the same transition has already occurred in the US. In such cases, modifications would include a new set of capacity and reliability metrics. Additionally, the economic framework could also change with evolving market and political conditions. While the basic elements of the framework will likely remain the same, the attribute layer will certainly require continuous improvement and re-deployment.

Understanding how Inclusivity would work with domains other than ICT4D is another area of future work. The translation to a new domain would require a full adjustment of the attributes layer of the framework. However, new factors may also rise up. For example, transportation, water, and energy seem like natural extensions given the similarity of broad-based infrastructural service. However, how would ISF work in softer arenas such as racial or sexual justice? In the modern world, these are becoming the new considerations for essential human services as well. While the theoretical elements should be the same per the argument of Sen (1979), it is doubtful that the framework can so easily adapt. It will be an interesting academic exercise to see if such a translation is feasible. Regardless, even expansion to similar domains will require rework and re-establishment of usefulness. A great place to start may be with existing partners.

Additional areas of future work can be done with the mathematical and development-side innovations brought forward in this dissertation. Specifically, the approximation of the GINI co-efficient for small-scale calculations can be explored for alternative uses. Proofs can also be conducted to trace the nature of the equations back to the fundamental nature of equality-based distributions. Furthermore, the PI index can also be put to the test for larger-scale calculations and simulations to understand its efficiency relative to other approximations. Such an innovation may prove useful for iterative calculations necessary during the census or annual reports. The PI index could also be studied on its own across different implementations of HiComm as new geographies and markets are explored. Overlay of the concept on HiComm and perhaps other social networking tools may yield interesting results in understanding the relative strength of certain participants to others, or relative inclusivity of certain groups to others. In an environment where transfer of communication has become quite important, such results could help companies identify security risks within naturally formed groups.

The development of HiComm itself represents an area of future work. The platform was constructed through an innovative stitching of mobile network operators, aggregators, and end devices – all over API. Whether the API can be extended to additional devices or interconnected with other domains such as payment API is the big question. Furthermore, it was revealed that the current HiComm platform fell short of its economic promise of free-to-end-user capability. While it is design ready for such functionality, it remains practically untested. A significant capital investment, perhaps to align with a future grant for expansion in geography, would be required to understand what the platform's true interactive capability. Additionally, the HiComm platform currently runs over a web-based service that is mobile-friendly. Expanding the interface functionality to mobile native by building an application for Andriod and iOS would further streamline interconnectivity between legacy devices and newer, more advanced devices. Similarly, a feature phone native version could also help improve the human factors component for individuals that are currently reading messages one at a time rather than in a thread. What this would mean

practically is the construction and installing of native applications on feature and smartphones that rely on a different band of service (non 3G) altogether. Network operators may not allow such a solution.

In summary, there is great opportunity for expanding upon the work started in this dissertation. The research over the last five years has been substantial, and it has helped establish seeds through theories, practical systems, and partnerships, all from which new roots of opportunity will grow.

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9 APPENDIX

9.1 Appendix A: Data Summary

9.1.1 NGOs Met in First Phase of Research Survey

Name	***Date***
Riyakule Motivational Programme	2-Jul-13
M-Gee Teens	3-Jul-13
Centre for Positive Care	5-Jul-13
Zwoitwa Community Centre	5-Jul-13
Zwoitwa Creche	5-Jul-13
Khanimamba Training and Development Centre	8-Jul-13
Ntshuxeko Health Development Organization	8-Jul-13
Get Ready Information Services	8-Jul-13
Mvuhla Trust	10-Jul-13
African Eagles	10-Jul-13
South Africa NGO Network (SANGONeT)	17-Jul-13
LifeLine	17-Jul-13
Soul City Initiative	17-Jul-13
African Health Placements	18-Jul-13
PEN	19-Jul-13
Foundation for Professional Development	19-Jul-13
United States Agency for International Development (USAID)	19-Jul-13
loveLife	19-Jul-13
Greater Good	22-Jul-13
Enablis	23-Jul-13
Mothers2Mothers (m2m)	23-Jul-13

Heart and Stroke Foundation	24-Jul-13
Community Development Resources Association (CDRA)	24-Jul-13
University of the Free State (UFS) Service Learning Centre	26-Jul-13
Reach (Heidedal)	26-Jul-13
Bloemshelter	26-Jul-13
Nelson Mandela Foundation	29-Jul-13

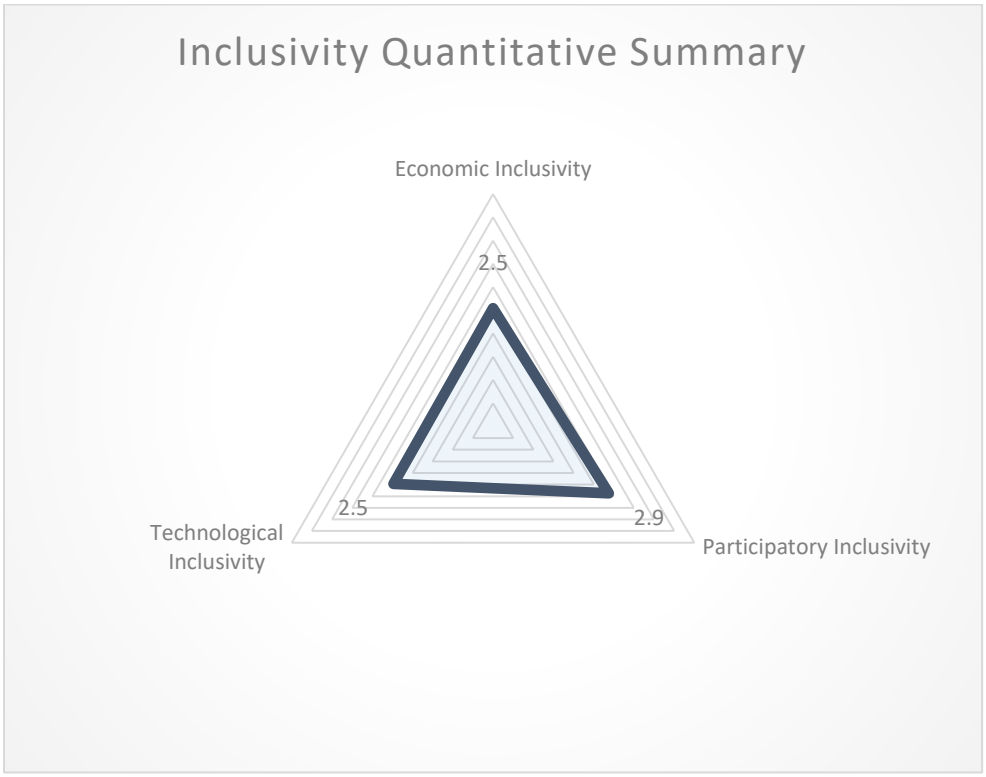
The above table summarizes the organizations whose stakeholders I met and interviewed in 2013. This initial trip laid the foundation for understanding the factors and attributes that influence inclusivity, and provided the inspiration for the Inclusivity Systems Framework. Additional organizations were interviewed in subsequent trips. However, initial capability assessment was based on the 2013 survey.

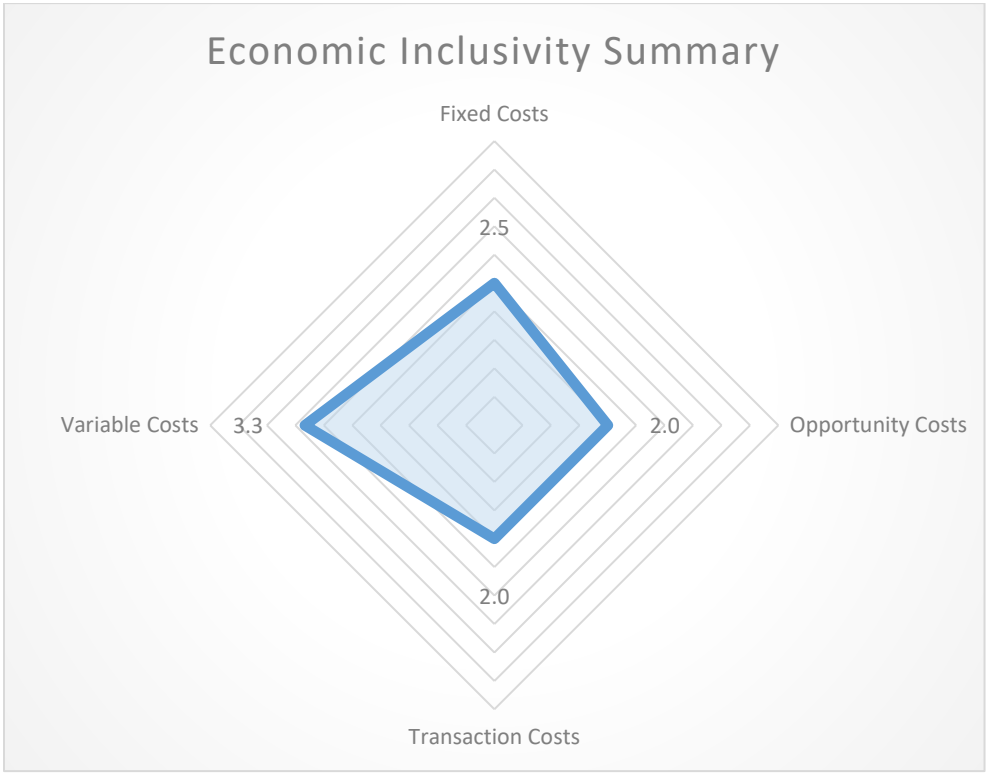
9.1.2 Participant Summary List for Projects

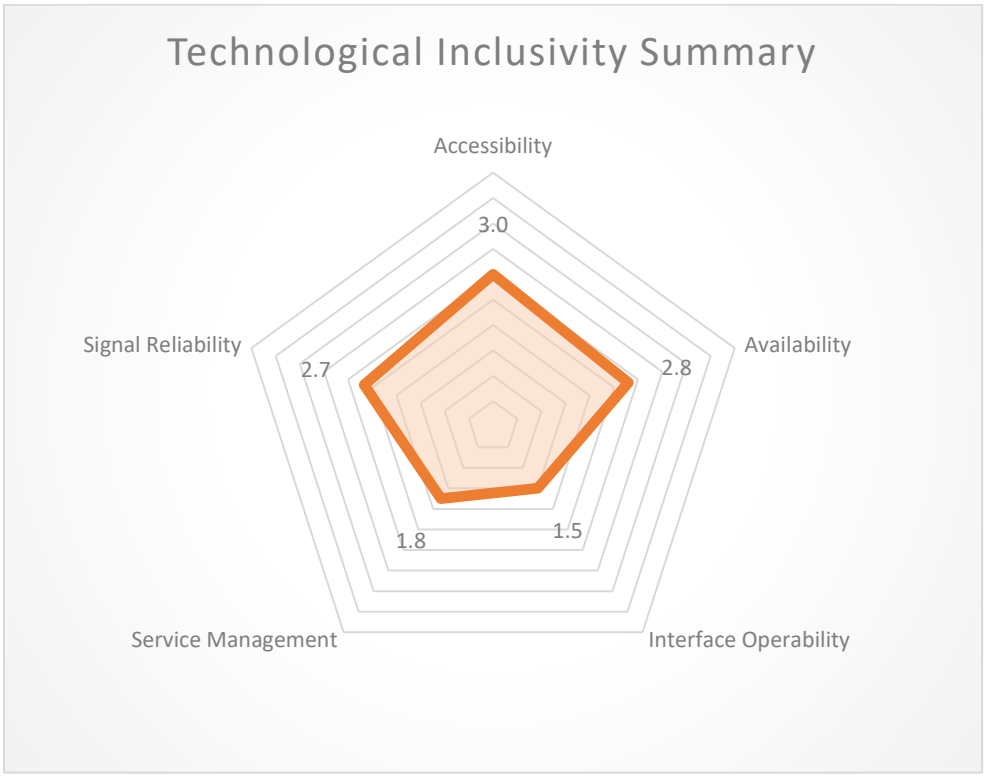
#	**Name of HiComm Project**	**Description**	**Project Size**
1	Bloem Shelter (BS) Group	Shelter for abused women/children	21
2	Inter-Professional Experiential (IPE) learning group	Medical students and Clinic in Springfontein	25
3	Reach Out Community (ROC)	Daycare & creche in colored township	14
4	Virtual Support Network (VSN)	VSN for young men in Bloemfontein and with two moderators	24

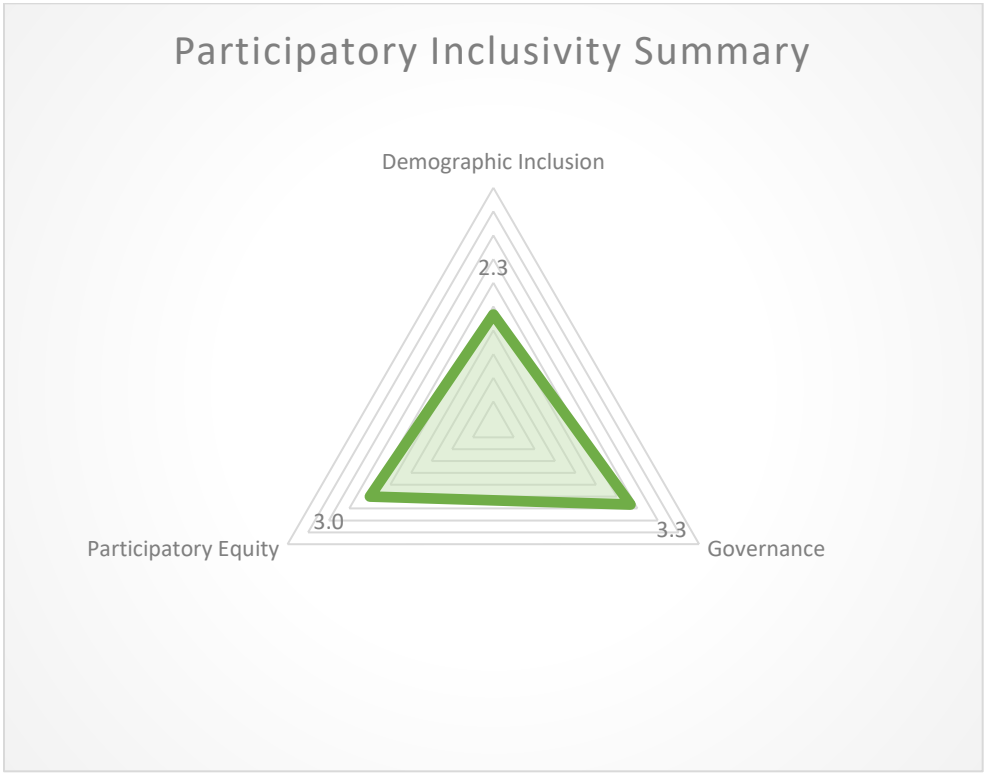
The above table provides a summary of the project sizes for each group. The project size includes stakeholders from the administrative team from the HiComm side, which were typically 2-3 people. The message data was excluded to honor the privacy agreements between HiComm, community partners, and the end-users. The aggregate level information is provided in Chapter 6.

9.2 Appendix A: Results of ISF Capability Assessment of South Africa





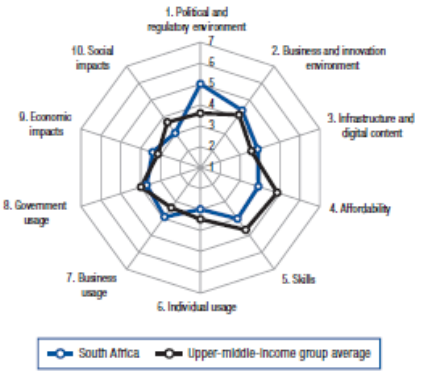

Technological Inclusivity Summary
Accessibility
3.0
Availability
2.8
Interface Operability
1.5
Service Management
1.8
Signal Reliability
2.7


Participatory Inclusivity Summary
Demographic Inclusion
2.3
Governance
3.3
Participatory Equity
3.0

9.3 Appendix B: Mobile Profile of South Africa

South Africa

	Rank (out of 144)	Score (1–7)
Networked Readiness Index 2013	**70**	**3.9**
Networked Readiness Index 2012 (out of 142)	72	3.9
A. Environment subindex	**33**	**4.7**
1st pillar: Political and regulatory environment	21	5.0
2nd pillar: Business and innovation environment	55	4.4
B. Readiness subindex	**95**	**4.0**
3rd pillar: Infrastructure and digital content	59	4.2
4th pillar: Affordability	104	3.9
5th pillar: Skills	102	4.0
C. Usage subindex	**72**	**3.5**
6th pillar: Individual usage	81	3.0
7th pillar: Business usage	33	3.9
8th pillar: Government usage	102	3.7
D. Impact subindex	**92**	**3.2**
9th pillar: Economic impacts	51	3.4
10th pillar: Social impacts	112	3.1



The Networked Readiness Index in detail

	INDICATOR	RANK /144	VALUE
	1st pillar: Political and regulatory environment		
1.01	Effectiveness of law-making bodies*	31	4.3
1.02	Laws relating to ICTs*	29	5.0
1.03	Judicial independence*	27	5.3
1.04	Efficiency of legal system in settling disputes*	17	5.0
1.05	Efficiency of legal system in challenging regs*	16	4.8
1.06	Intellectual property protection*	20	5.3
1.07	Software piracy rate, % software installed	20	35
1.08	No. procedures to enforce a contract	15	29
1.09	No. days to enforce a contract	92	600
	2nd pillar: Business and innovation environment		
2.01	Availability of latest technologies*	39	5.7
2.02	Venture capital availability*	37	3.1
2.03	Total tax rate, % profits	47	33.3
2.04	No. days to start a business	81	19
2.05	No. procedures to start a business	30	5
2.06	Intensity of local competition*	51	5.1
2.07	Tertiary education gross enrollment rate, %	100	15.4
2.08	Quality of management schools*	15	5.3
2.09	Gov't procurement of advanced tech*	105	3.1
	3rd pillar: Infrastructure and digital content		
3.01	Electricity production, kWh/capita	45	5,004.3
3.02	Mobile network coverage, % pop	40	99.8
3.03	Int'l Internet bandwidth, kb/s per user	66	18.9
3.04	Secure Internet servers/million pop	54	73.9
3.05	Accessibility of digital content*	85	4.8
	4th pillar: Affordability		
4.01	Mobile cellular tariffs, PPP $/min.	117	0.51
4.02	Fixed broadband Internet tariffs, PPP $/month	89	37.48
4.03	Internet & telephony competition, 0–2 (best)	118	1.13
	5th pillar: Skills		
5.01	Quality of educational system*	140	2.2
5.02	Quality of math & science education*	143	2.0
5.03	Secondary education gross enrollment rate, %	56	93.8
5.04	Adult literacy rate, %	93	88.7

	INDICATOR	RANK /144	VALUE
	6th pillar: Individual usage		
6.01	Mobile phone subscriptions/100 pop.	37	126.8
6.02	Individuals using Internet, %	96	21.0
6.03	Households w/ personal computer, %	90	18.3
6.04	Households w/ Internet access, %	94	9.8
6.05	Broadband Internet subscriptions/100 pop.	96	1.8
6.06	Mobile broadband subscriptions/100 pop.	55	19.8
6.07	Use of virtual social networks*	86	5.3
	7th pillar: Business usage		
7.01	Firm-level technology absorption*	38	5.4
7.02	Capacity for innovation*	41	3.5
7.03	PCT patents, applications/million pop.	42	6.0
7.04	Business-to-business Internet use*	36	5.6
7.05	Business-to-consumer Internet use*	52	4.8
7.06	Extent of staff training*	26	4.6
	8th pillar: Government usage		
8.01	Importance of ICTs to gov't vision*	105	3.4
8.02	Government Online Service Index, 0–1 (best)	79	0.46
8.03	Gov't success in ICT promotion*	100	3.9
	9th pillar: Economic impacts		
9.01	Impact of ICTs on new services and products*	44	4.8
9.02	ICT PCT patents, applications/million pop.	42	1.0
9.03	Impact of ICTs on new organizational models*	53	4.4
9.04	Knowledge-intensive jobs, % workforce	58	23.7
	10th pillar: Social impacts		
10.01	Impact of ICTs on access to basic services*	123	3.4
10.02	Internet access in schools*	111	3.1
10.03	ICT use & gov't efficiency*	97	3.8
10.04	E-Participation Index, 0–1 (best)	76	0.16

Note: Indicators followed by an asterisk (*) are measured on a 1-to-7 (best) scale. For further details and explanation, please refer to the section "How to Read the Country/Economy Profiles" on page 139.

World Economic Forum, 2013 Mobile Profile of South Africa (latest). Page 285.

http://www3.weforum.org/docs/WEF_GITR_Report_2013.pdf

9.4 Appendix C: Service Management – Engagement Manual Sample

Setting up HiComm in the Community

This document will describe the general steps for smoothly setting up HiComm in any community.

1. Setup internet connection via existing Wi-Fi or Mobile Hotspot

2. Explain the technology and the "magic" Clickatell. Also introduce to them the idea of key-codes. Sample script is below:

Script:

HiComm is a powerful communications platform that links SMS to Internet. HiComm was developed to meet your communication needs and help perform research on communication. You can mass-message at the cost of 1 message and that 1 message will be subsidized.

3. Distribute pre-surveys.

4. Collect the Names, Number, Carrier, and Group/Conversations for each participant.

5. Visit beta.hicomm.co and begin adding members to your Project.

6. Add Members to each conversation.

7. Send mass message.

Sample:

HiComm: Hi, welcome to the texting project! REPLY @123 #all
Hello HiComm, I received your message. @123 #all

8. Teach people to reply to the #all conversation

9. Teach them how to send messages to their specific conversation using the color hashtags #.

10. Remind them to write down there key codes for each conversation they are in! @____#____

PART 1: Receiving Airtime & Converting it to SMS

If you have already converted your airtime or have SMS bundles, go to step 3.

1. Receive Airtime

On your receipt, follow the instructions provided by your carrier (MTN, Vodacom, Cell C, etc.)

2. Convert Airtime to SMS bundles
   a. Vodacom

Enter ***111#**
Enter **2**
Enter **4**
Enter **1**

   b. MTN

Enter *141*7#
Choose the SMS bundle you want. And dial that number

To buy 50 SMS bundle:
Enter ***141*7*50#**

   c. Cell C

Enter ***147#**
Enter **4**
Enter **2**
Enter 1
Enter the number for the preferred SMS bundle

PART 2: Receiving HiComm SMS & Replying

3. Wait for SMS message from HiComm. It should resemble this message:

HiComm: Hi, welcome to HiComm! Did you receive this message? REPLY @123 #all

If you do not receive a message within 5 minutes, please talk to a HiComm representative

4. Save this phone number as a new contact called "HiComm" in your cellphone. All messages will be received and send to this number.

5. Memorize and write down the key codes from the welcome text. They are unique to your HiComm project. The first code starts with an @ and the second code starts with a #. Remember to add a space before the @ and before the #.

   Example: @123 #all

6. Respond to SMS message. REMEMBER: use the key code provided to you at the end of your message.

HiComm: Hi, welcome to the texting project! REPLY @123 #all **Hello HiComm, I received your message. @123 #all**

7. If you are in a subgroup which is called a "conversation," please remember your color. The example below uses #green. If you use #green, only members in the #green conversation can see your message.

HiComm: Hi, welcome to the texting project! REPLY @123 #all

Hello HiComm, I received your message. @123 #all

HiComm: Hi welcome to the conversation for leadership REPLY @123 #green

Hello, thank you for adding me to the leadership conversation. @123 #green

8. Finally, USE THIS SYSTEM. The more messages you send, the better the research results, the better communication, and it is free. Try to send at least one message a day.

9.5 Appendix D: Service Management – Directions for South Africa VSN Project

Texting Project - Directions of Use

1. We will ask for your name and phone number. This will be used to register you in the computer. Our system will not show your phone number or name in the group chat.
   Welcome text: "Welcome to the texting project "@123" & "#all"

2. You will receive a welcome message from us. After the message, there will be two codes: "@123" & "#all"

3. Each group will have a different number code ("@123" or "@458" or "@983"), but all groups will have the same code "#all"

4. The text message will be written like any other text but after **EVERY** message you send, you **MUST** write these two codes or else the message will not be sent. Remember your group codes.

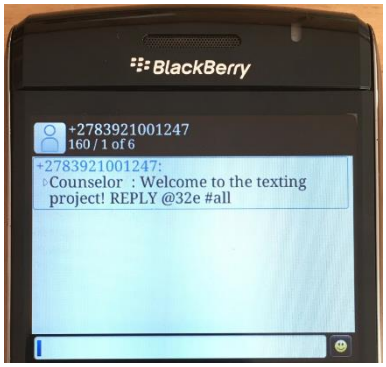
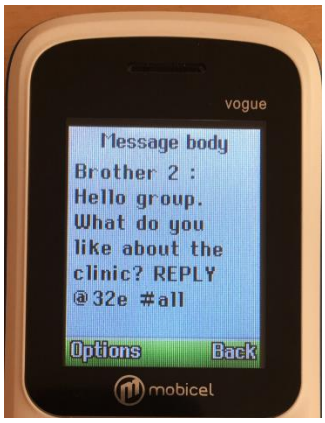
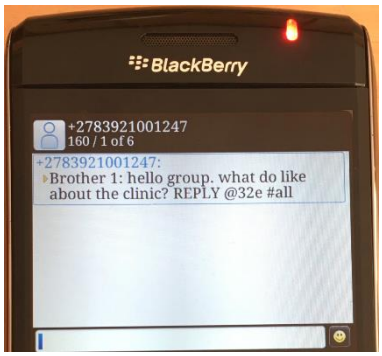
5. Here are some example questions. Feel free to use your own.

- DO text about
  - How you are feeling today?
  - What do you like about the mobile clinic? What do you NOT like about the clinic?
  - Tell us about your family/children. Do they go to the clinic?
  - How often do you go to the clinic? Have you always gone to the clinic, or only recently?
  - What can the clinic do better?
  - Do you have privacy in the clinic, as a man?
  - Would you recommend your friends for circumcision?
- do NOT text about
  - your HIV status, CD4 count.
  - do not ask anyone for their name, phone number, or personal details.
  - Do not give say your name
  - You can talk about your family/girlfriend/wife but without using names

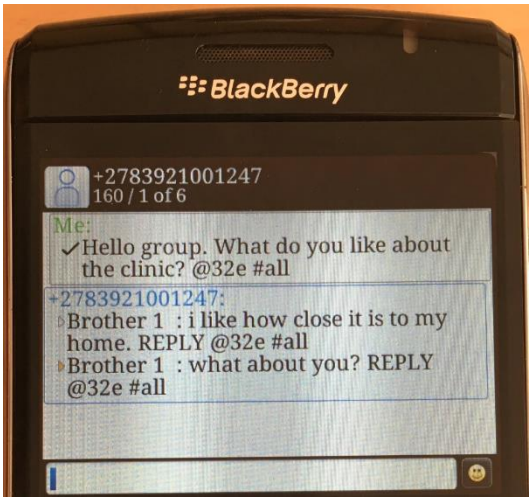
6. Please remember that we would like you to use your R50 airtime texting in this group. If you do this, after 10 days we will give you more airtime (R100).
7. Thank you for participating. **Please contact 061 615 3000 (clinic number) for questions or emergencies.**
8. Let's try the system.

***If you have any questions or concerns about the research, please feel free to contact**:
Sasheenie Moodley/Ella Shoup
Email: sm2zd@virginia.edu, Tel: 061 615 3000 Email: ems2fd@virginia.edu, Tel: 061 615 3000

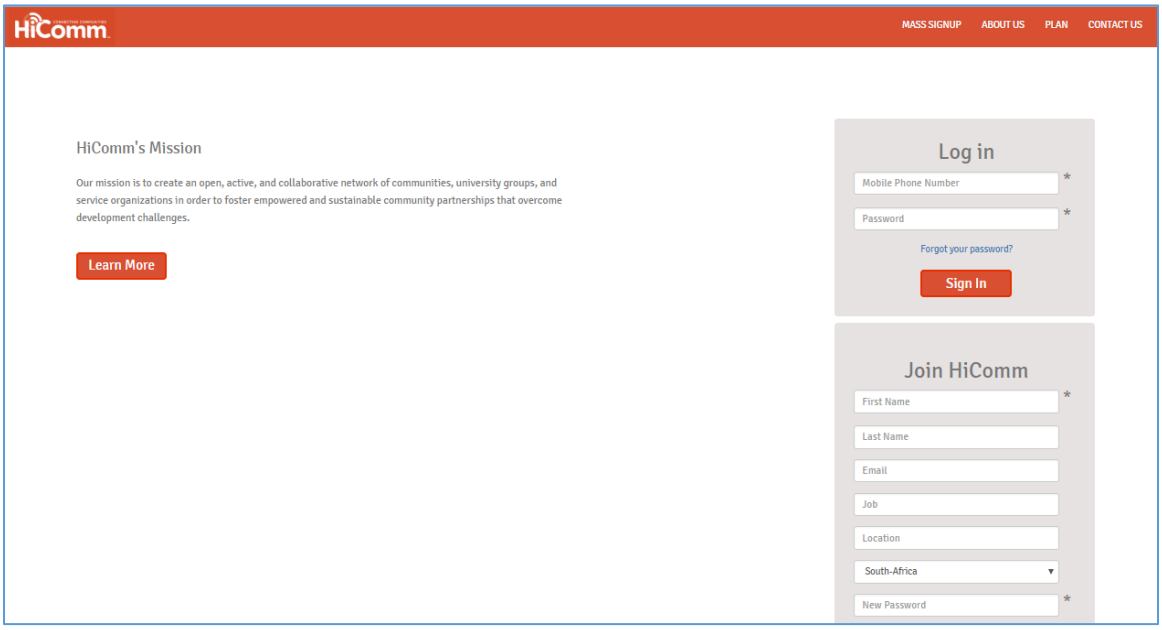
You can also **contact the IRB** at the University of Virginia directly: Phone: +1-434-924-5999, Email: irbsbshelp@virginia.edu

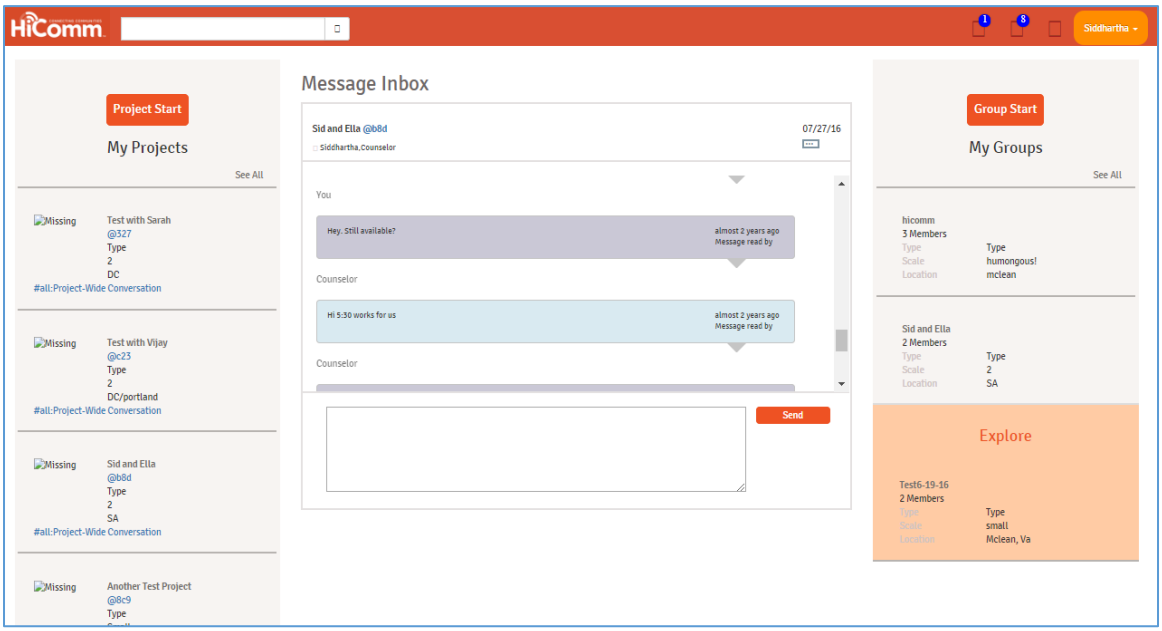
Message from Counselor:		Message from Counselor:	
Message from Brother 2:		Message from Brother 2:	

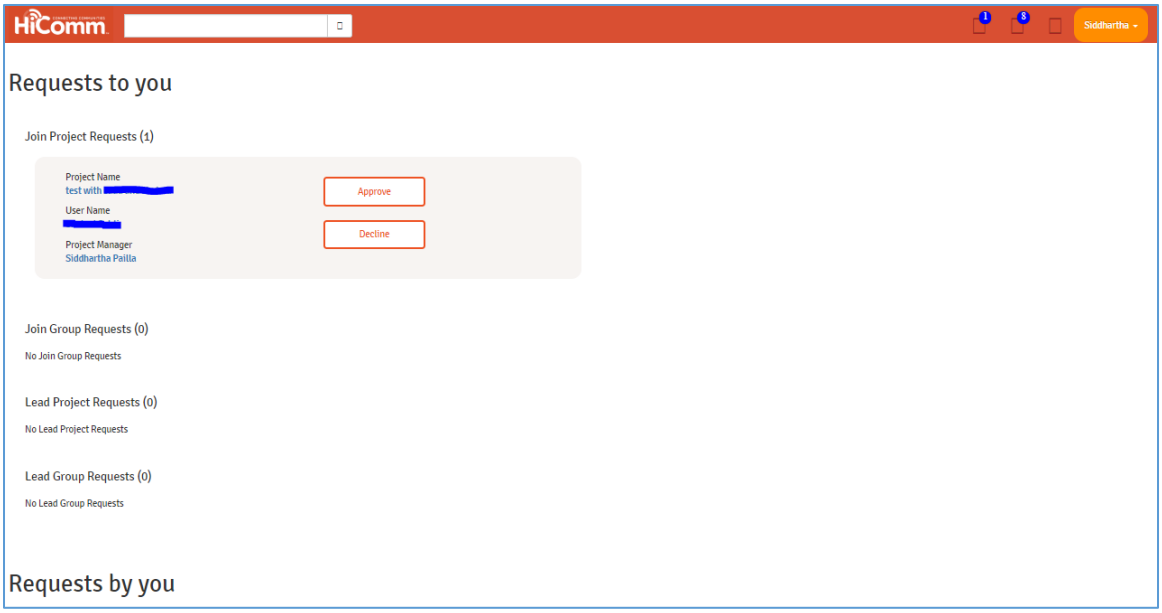
Full conversation:

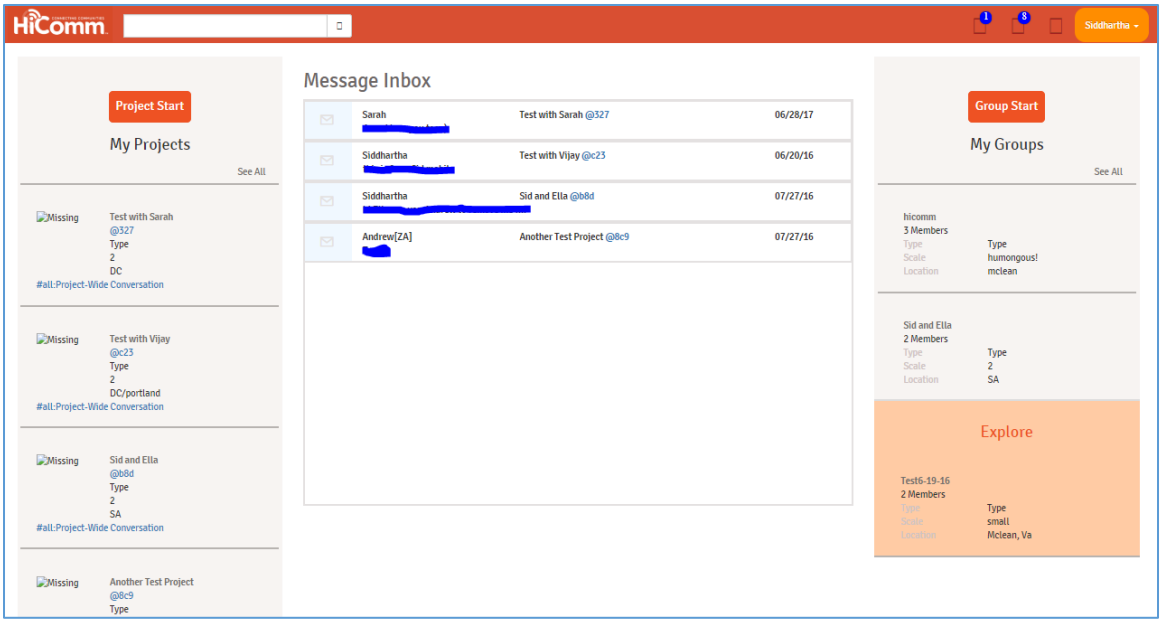


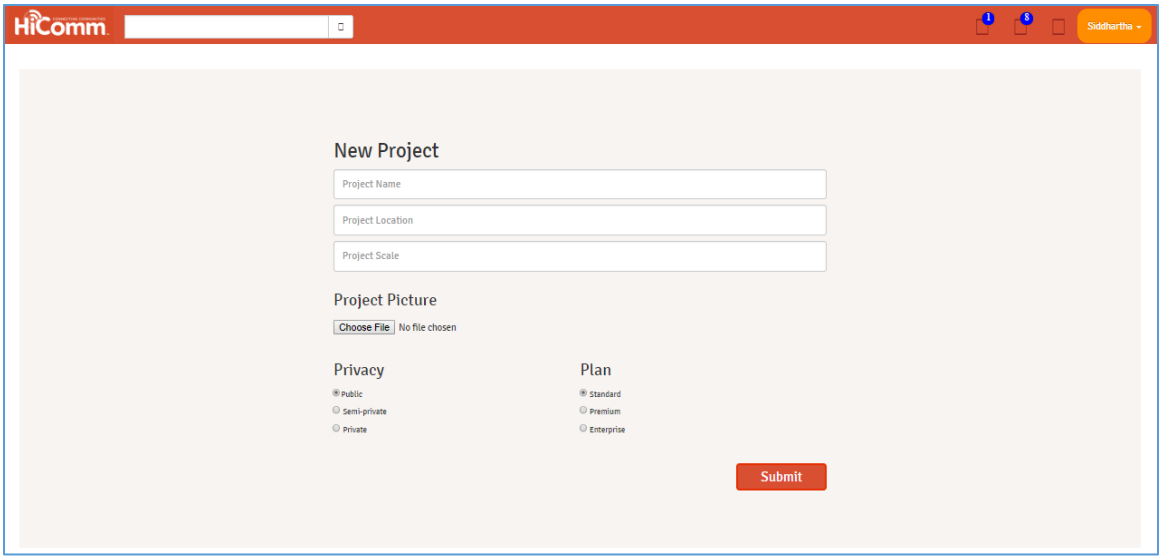
9.6 Appendix E: Select Screenshots of HiComm Online System

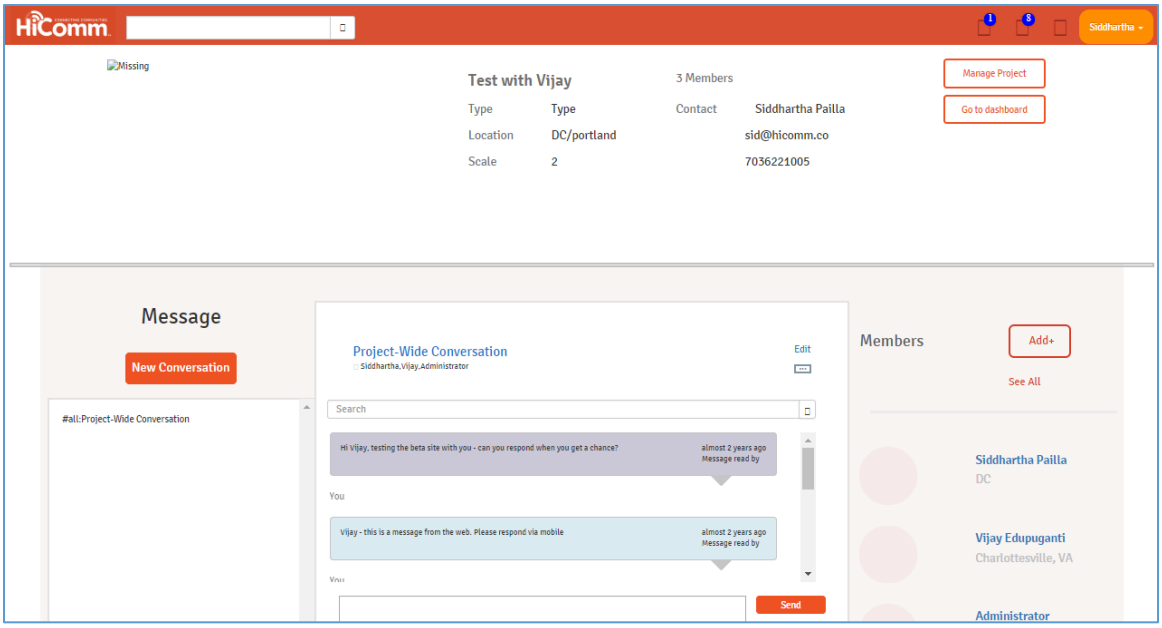


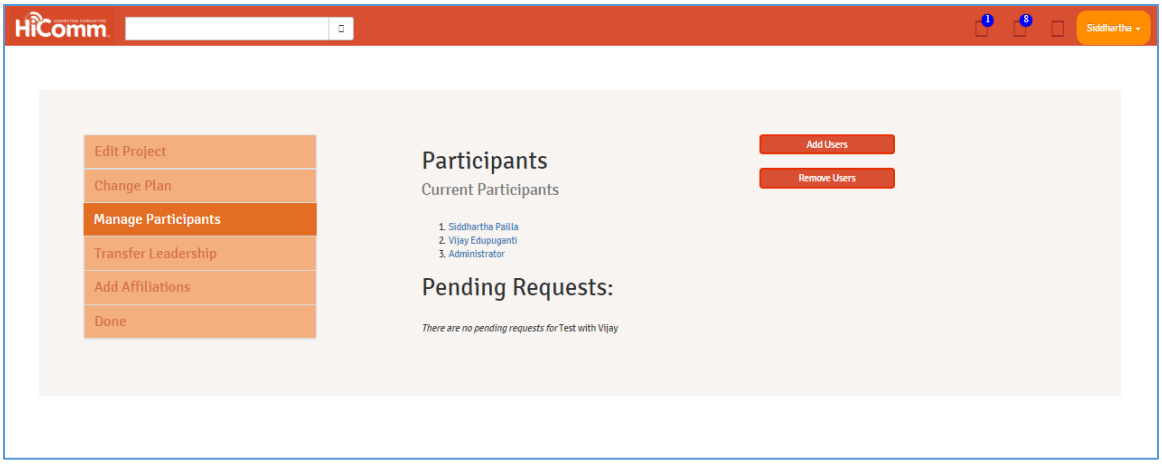



HiComm
Siddhartha
Requests to you
Join Project Requests (1)
Project Name
test with
User Name
Project Manager
Siddhartha Pailla
Approve
Decline
Join Group Requests (0)
No Join Group Requests
Lead Project Requests (0)
No Lead Project Requests
Lead Group Requests (0)
No Lead Group Requests
Requests by you


HiComm
Siddhartha
Project Start
My Projects
See All
Missing
Test with Sarah
@327
Type
2
DC
#all:Project-Wide Conversation
Missing
Test with Vijay
@c23
Type
2
DC/portland
#all:Project-Wide Conversation
Missing
Sid and Ella
@b8d
Type
2
SA
#all:Project-Wide Conversation
Missing
Another Test Project
@8c9
Type
Message Inbox
Sarah
Test with Sarah @327
06/28/17
Siddhartha
Test with Vijay @c23
06/20/16
Siddhartha
Sid and Ella @b8d
07/27/16
Andrew[ZA]
Another Test Project @8c9
07/27/16
Group Start
My Groups
See All
hicomm
3 Members
Type
Scale
Location
Type
humongous!
mclean
Sid and Ella
2 Members
Type
Scale
Location
Type
2
SA
Explore
Test6-19-16
2 Members
Type
Scale
Location
Type
small
Mclean, Va


HiComm
Siddhartha
New Project
Project Name
Project Location
Project Scale
Project Picture
Choose File
No file chosen
Privacy
Public
Semi-private
Private
Plan
Standard
Premium
Enterprise
Submit


HiComm
Siddhartha
Missing
Test with Vijay
3 Members
Type
Type
Location
DC/portland
Scale
2
Contact
Siddhartha Pailla
sid@hicomm.co
7036221005
Manage Project
Go to dashboard
Message
New Conversation
#all:Project-Wide Conversation
Project-Wide Conversation
Siddhartha,Vijay,Administrator
Edit
Search
Hi Vijay, testing the beta site with you - can you respond when you get a chance?
almost 2 years ago
Message read by
You
Vijay - this is a message from the web. Please respond via mobile
almost 2 years ago
Message read by
Send
Members
Add+
See All
Siddhartha Pailla
DC
Vijay Edupuganti
Charlottesville, VA
Administrator


HiComm
Siddhartha
Edit Project
Change Plan
Manage Participants
Transfer Leadership
Add Affiliations
Done
Participants
Current Participants
1. Siddhartha Pailla
2. Vijay Edupuganti
3. Administrator
Add Users
Remove Users
Pending Requests:
There are no pending requests for Test with Vijay