A FOGGY DESERT:

**EQUITABLE INFORMATION FLOW FOR A FOGWATER SYSTEM IN
SOUTHWEST MOROCCO**

by

LESLIE LYNN DODSON

B.A. PSYCHOLOGY, LAKE FOREST COLLEGE, 1982

M.S. JOURNALISM, NORTHWESTERN UNIVERSITY, 1986

A thesis submitted to the
Faculty of the Graduate School of the
University of Colorado Boulder in partial fulfillment
of the requirement for the degree of
Doctor of Philosophy
College of Engineering and Applied Science
ATLAS Institute
2014

This thesis entitled:
A Foggy Desert: Equitable Information Flow for a Fogwater System in Southwest
Morocco
Written by Leslie Lynn Dodson
has been approved for the ATLAS Institute

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John K. Bennett, Ph.D. (Chair)

_____

S. Revi Sterling, Ph.D. (Co-Chair)

Date _____

The final copy of this thesis has been examined by the signatories, and we
find that both the content and the form meet acceptable presentation standards
of scholarly work in the above mentioned discipline.

IRB protocol # 12-0664

ABSTRACT

Leslie Lynn Dodson
(Ph.D., Technology, Media, and Society; ATLAS Institute)

A Foggy Desert: Equitable Information Flow for a Fogwater System in Southwest Morocco

Directed by Professor John K. Bennett and Sarah Revi Sterling

This dissertation describes the design, implementation and evaluation of a gender-inclusive information system linking rural women in Agni Hiya, Morocco and water project managers from the Association Dar Si-Hmad. This research was motivated by an interest in exploring the linkages between information and communication technologies (ICT), climate change, natural resource management and women's participation in community development in the drought-ridden Aït Baamrane region of southwest Morocco. The research investigates the potential for mobile phones to help address communication constraints that rural Berber women face, including culture, religion, and lack of digital literacy. These issues are relevant to the study and design of a gender-inclusive information system (the "Fog Phone") intended to help manage a fogwater distribution system that will deliver water from the Anti-Atlas Mountains to Berber villages.

The research investigates two similar groups of low-literate, marginalized rural Berber women from the same geographic community who have mobile phones. Technology-focused ethnographic research methods were used to first investigate the social, cultural and technical factors involved in mobile phone use by women employed in an Argan oil Cooperative. Findings from the Argan oil Cooperative study were then applied and expanded in a study of Berber women involved in the operation of the

fogwater system. By virtue of their responsibilities as principal water gatherers and water users in the community, Berber women are key stakeholders in the fogwater system. Their continued involvement in water management was extended to the participatory design and development of the prototype Fog Phone.

Cultural conditions restricting communication between unrelated men and women led to an information system design that supported cultural, social, economic and technical constraints. The Fog Phone enabled women to report on the water system using a series of symbols that communicate water system status without violating cultural norms. In addition to an exploration of the relationship between gender and technology, this research explores related themes of climate change and environmental vulnerability as they pertain to women's lives and livelihoods, as well as the ability of rural Berber women to manage the environmental assets on which their livelihoods depend.

The contributions of this research include a prototype information system for the fogwater project; a better understanding of the mobile phone utility gap and its impact on the use of ICT by marginalized women in polyglot and oral-language dependent communities; and advances in the emerging practice of ICTs, Climate Change and Development (ICCD) by providing a case study of the linkages between mobile phones, water resources that are affected by climate change and women in rural communities involved in an environmentally sustainable development project in the Middle East and North Africa – a region that is largely missing from ICCD and overall ICT for Development research.

DEDICATION

For my mother Patricia Ungaro Dodson
and the women of Agni Hiya and the Tafyoucht Argan oil Cooperative

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CHAPTER 1

INTRODUCTION

"I'm illiterate. How could I text?"

Issues of natural resource management, climate change, gender and rural livelihoods intersect in this research, illustrating the inherent complexity of sustainable development projects. Scarcity is a constant theme, whether in reference to scarce natural resources, inadequate education, financial poverty or insufficient technical and functional literacy. These issues are magnified for rural Berber women and are compounded by vulnerability to a changing climate. These issues are also relevant to the study and design of a gender-inclusive information system (IS) to help manage a fogwater distribution system.

In rural southwest Morocco, Berber women and girls spend up to four hours per day hauling water from wells that are increasingly compromised in terms of quantity and quality. Water volume in this pre-Sahara Desert zone of the Anti-Atlas Mountains is decreasing due to climate change-induced droughts that are expected to worsen (Brown, 2009). Presently, only six to eleven inches (estimates) of rain falls per year (Berkat & Tazi, 2004). Many wells are contaminated due to poor sanitation and exposure to animal waste. These compound conditions create chronic water shortages for area residents. However, due to geography-induced meteorological conditions, nearby Mt. Boutmezguida is enshrouded in fog for nearly six months per year (Marzol & Sánchez Megia, 2011).

Fog has been identified as an important source of water in desert environments such as Aït Baamrane, the location of this research (Vavruska, 2012). The geography and topography of southwest Morocco are conducive to the formation of dense fog, leading to

the conclusion that there is "no doubt that in desert areas where rain is absent during many months or perhaps several years, fog must be seriously considered as a source of water" (Eugster, 2008, p. 5). In the largest project of its kind in North Africa (Bargach, 2011), fog is being harvested from the Anti-Atlas Mountains to provide supplemental drinking water to hundreds of downslope Berber residents who are struggling with drought and depleted water resources.

This research explores questions related to the appropriate and useful role of information and communication technologies, or ICT, in exploratory research at an Argan oil Cooperative and in primary research in the fogwater delivery system where Berber women, traditionally responsible for water collection, have been assigned water stewardship and management responsibilities by the Moroccan non-governmental organization responsible for developing the fog-water system, Association Dar Si-Hmad. Women in the participating communities have low literacy levels, but often have mobile phones. Thus, the focus of this research involves the use of ICT to help address some of the traditional constraints placed on these women by culture, conservative religious interpretations and lack of digital literacy. In this research, ICT refer to mobile phones such as basic feature phones in use by low-literate Berber women, more advanced mobile devices such as smartphones as well as hardware, GSM devices, software and the mobile network.

This research also addresses what Watson et al. (2010) characterize as the need for researchers "to show leadership in applying the transformative power of IS to create an environmentally sustainable society" (Watson, Boudreau, & Chen, 2010, p.23). The emerging practice of ICTs, Climate Change and Development (ICCD) provides a top-

level framework that can be used to study and plan development initiatives that involve the three linked domains of technology, climate change and development (Ospina & Heeks, 2010a). In the ICCD model, information and communication technologies include hardware, software and services such as telecenters, mobile phones, computers, monitoring equipment, broadband and smartphones. This research applies the ICCD model to explore, in this case, the linkages between mobile phones (the ICT tool), water resources (that are affected by climate change) and women in rural Berber communities (the focus of an environmentally sustainable development project).

The socio-cultural complexities explored in this research revolve around gender issues embedded in the conservative, rural Berber-Muslim communities where the fogwater project is located. Fogwater project managers from Dar Si-Hmad (DSH) envisioned a community-based structure to manage the water system in a way that offers opportunities to women and which has the potential to shift water beneficiaries' relationship with the environment from a labor-based relationship to one that entails communication. By virtue of their responsibilities as principal water gatherers and water users in the community, women are key stakeholders in the fogwater system. In collaboration with DSH, we determined that women's continued involvement in water delivery and water use needed to also be extended to the information system, which was developed using participatory design techniques.

As Donner (2008) notes, there is a need among ICTD scholars to "disaggregate" the mobile phone artifact in order to "yield a better understanding of the mobile as a complex technology" (p. 25). I disaggregated the mobile phone in various ways throughout this research into the social, cultural and technical barriers to mobile phone

use by rural Berber women. During my investigation of the technological barriers to mobile phone use, I focused on the technical features and services available on a mobile such as menus and SMS services, including issues related to the physical form of the device (the handset) and user interfaces that supported or constrained access to services by low-literate women. In the technology inventory, I discuss the mobile phone in terms of device and network availability. "Technology is not just a handset," though, so along with an analysis of technical and physical features of mobiles, I also investigated behaviors and cultural norms related to use of the device, such as constraints on communication between unrelated women and men (Donner, 2008, p. 25). When discussing communication patterns, the mobile phone represents both a set of behaviors and a tool that rural Berber women use to communicate with family members. Mobile phone affordances, behaviors, interfaces and technical features are pertinent to an investigation of the social, cultural and technical barriers to ICT use that rural Berber women face, barriers I identify as *utility gaps* (discussed in detail in Chapter 10).

1.1 Research Progression

As is often the case with field-based action research (Tacchi, Slater & Hearn, 2003), this research followed an unpredicted path and had unplanned outcomes for initial field visits although the research design solidified with the identification of the need for an information system that would support women's roles in the DSH water project. The research process was dynamic and evolved over the course of a year-and-a-half, progressing from immersive ethnographic fieldwork and on-the-ground ICT training in exploratory field visits with Berber women at an Argan oil Cooperative (the Coop) to my primary research on the ICT tools and processes involved in the development of a

prototype water IS, called the "Fog Phone," to help women manage their responsibilities around the fogwater harvesting system.

The Coop and the fogwater project share a number of common and unifying features. The Coop and the fogwater project are located in the same rural canton in the Aït Baamrane region of southwest Morocco, involve the same population of low-literate Berber women, and are both based on valuable natural resources (Argan trees and water). Further, in southwest Morocco, Argan oil and water are both largely managed by rural Berber women, and in Aït Baamrane, the local Argan oil Cooperative and the fogwater harvesting project are both part of DHS's portfolio of development projects. Thus, the relationship I had with DSH at the beginning of the project carried through and continues, creating continuity and rapport. DSH leaders and I shared an understanding of the importance of pursuing a community-centric approach throughout the research in the Coop and in communities involved in the water project (Dodson, Sterling, & Bennett, 2012). The progression of this research from oil to water is detailed in Chapter 2.

1.2 Research Questions

The goal of this research was to generate new and useful knowledge about the ICT tools and research processes involved in developing a culturally appropriate and gender-aware information system for natural resource management in rural, gender-segregated communities in Morocco. This action, or change-focused, research was guided by research questions that provided a path to understand complexities related to ICT use, information needs related to the water project and factors relevant to women's participation in management of the environmental project. The three primary research questions are:

1. What information and communication requirements are critical to the major stakeholders in the fogwater project?

2. What features are required to create a socially and culturally appropriate ICT system that allows unrelated women and men to communicate about the fogwater system?

3. How do ICT facilitate women's involvement in overall system management and communication of meaningful technical information regarding the fogwater system?

While a working, successful information system was clearly a desirable outcome, that objective was not a required outcome of the research reported in this dissertation.

1.3 Contributions

Contribution 1: A Prototype Water Information System for the Fog Project

This research contributes to the sustainability of the fogwater system by providing the Dar Si-Hmad organization and water users with a functional prototype Fog Phone that can help the organization achieve its mission to deliver potable water to rural households in an operationally sustainable way.

Contribution 2. Widening the Definition of the Utility Gap

This research contributes to practitioners' understanding of the mobile utility gap and its impact on the use of ICT by marginalized women in polyglot and oral-language dependent communities.

Contribution 3. An ICCD Case Study Focusing on Complex Vulnerabilities

This research advances the ICCD model by contributing a case study portraying the linkages between ICT, climate change and development in a project to deliver fogwater to rural Berber communities that are vulnerable to climate change.

Contribution 4. Research In A Geo-Strategically Important Region

This research contributes to an understanding of an under-resourced and marginalized population in the Middle East and North Africa, an understudied, politically important and environmentally fragile region of the world.

1.4 Chapter Overview

Chapter 1: Introduction

Chapter 1 has been an introduction to the study of an information system to support the fogwater system in rural Morocco. Chapter 1 includes the research questions and provides an outline of the thesis.

Chapter 2: Culture, Community, Language and Site Selection

Chapter 2 provides cultural and socioeconomic context on the Berber communities involved in the Argan oil Cooperative and the water project, including relevant development indicators and top-level observations from extensive field experience within these communities. This chapter also includes an explanation of how the two research sites (the Argan oil Cooperative and the water project) were chosen, and it explains the progression of the research from the Coop to the water project.

Chapter 3: Related Work

Several academic fields inform the research questions and research design. Chapter 3 summarizes related work in Information and Communication Technology for

Development (ICTD), gender and sustainable development literature. ICTD refers to the practice of incorporating information and communication technologies into development programs and initiatives, and it encompasses the study of the intersection of information and communication technologies in the context of international development and developing communities. In the ICTD literature review, attention is paid to studies from Human-Computer Interaction for Development (HCID), a subset of the ICTD field. Relevant HCID studies pertain to agriculture and natural resources in developing communities as well as Mobiles for Development (M4D) literature that focuses on technology use by low-literate populations in developing communities. The Related Work section on gender and ICTD considers barriers to ICT access that women in developing communities often face. It also discusses the benefits that women derive from ICT. Relevant literature on natural resource stewardship, desertification and water resource management in the Middle East and North Africa (MENA) is discussed in the sustainable development section of this chapter.

Chapter 4: Theories and Models

Chapter 4 explores theories and conceptual frameworks linking sustainable development, gender and technology that have helped frame the research questions. These theories and frameworks converge in the ICTs, Climate Change and Development (ICCD) model (Heeks and Ospina, 2012). The theoretical sections on gender and development focus on the intersections of gender and poverty and gender and environment. Gender and Development (GAD) theory provides a lens through which to study men's and women's roles and responsibilities in the context of developing communities. Gender, Environment and Development (GED) frameworks highlight

women's and men's differing roles and responsibilities in managing natural resources. These are important issues in this research on women and water stewardship in Morocco.

Chapter 5: Methods

Chapter 5 contains a description of how three methods – Ethnographic Action Research (EAR), the Sustainable Livelihoods Framework (SLF) and Stakeholder Analysis (SA) – were used to frame, collect and analyze research data. EAR provides a mechanism to understand how Berber women use their mobile phones in personal and instrumental contexts. The SLF approach integrates culture, gender, geography and climate vulnerabilities to create a baseline portrait of the communities involved in the fogwater project. Stakeholder Analysis (SA) offers a mechanism to analyze stakeholders in the water IS (female and male community members, the water manager, the project manager, the telecommunication authority and network providers) and the degree to which they influence the water IS and the benefits and risks they may experience.

Chapter 6: Exploratory Research

I conducted four months of Ethnographic Action Research (EAR) and ICT training sessions at the Tafyoucht women's Argan oil Cooperative in Mesti, Morocco. Data from this fieldwork illustrate the complex mobile utility gaps that rural Berber women face. This exploratory research at the Cooperative led to the formation of the research questions related to the investigation of the tools and processes involved in developing a culturally appropriate and gender-aware IS. Exploratory research set the foundation for the design of the primary research focusing on the prototype water IS for the fogwater project.

Chapter 7: Community Analysis

While I discuss methods in Chapter 5, this chapter demonstrates how I utilized the Sustainable Livelihoods Framework (SLF) to capture baseline top-level and community-level processes that affect the fogwater project and women's participation in the water IS. This chapter also details the results of the Stakeholder Analysis on six relevant stakeholders involved in the water IS. Chapter 7 also contains a Gender Analysis in which I used the "8 Tools of GAD" to analyze men's and women's roles and responsibilities in communities involved in the fogwater project. Additionally, I completed a Gender, Environment and Development Analysis that helped me identify women's and men's water-related roles and responsibilities.

Chapter 8: System Design

This chapter contains details of how I planned to examine the factors required to develop the prototype water IS as well as the design of the IS connecting female water users and project managers. I provide details on the two interview instruments that I used in nearly eight months of fieldwork. These are the ICT interview to establish ICT use and a water-related interview to determine information needs related to the new water system. Chapter 8 contains a description of data collection procedures and system design requirements. It also identifies data sampling and recruitment procedures as well as an explanation of how data is managed and checked for accuracy and adequacy.

Chapter 9: Technical Details

Technical details for the water information system are included in Chapter 9. The system incorporates a laptop computer, mobile phones and an SMS aggregation platform that was designed as part of a lab course. The prototype water IS, which I dubbed the

"Fog Phone," was deployed and tested in January 2014 with project managers and female water users when the new water system was launched in the rural community of Agni Hiya.

Chapter 10: Findings

Qualitative research and quantitative findings from both exploratory research at the Argan oil Cooperative and primary research in communities involved in the fogwater project are presented in Chapter 10. Findings from the Coop focus on the mobile utility gap and the technical, social and cultural barriers to mobile phone use by low-literate rural Berber women. Findings from the alpha and beta tests of the water IS show that an information system that used simple, uniform codes could enable the project manager and water users to communicate about issues pertaining to the new water system. This chapter presents data on the amount and types of SMS messages sent during the alpha and beta tests of the water IS.

Chapter 11: Implications

Chapter 11 presents additional analysis to support this investigation of the tools and research processes involved in developing a socially and culturally appropriate prototype water IS that can help enable rural Berber women manage a new water project. This section synthesizes and interprets the findings from the study with respect to the three research questions and puts the findings into wider context. Each of the three research questions is discussed and linked to themes identified in the related work. This chapter addresses both the benefits and limitations of ICCD, GAD, GED frameworks and HCID practices. Chapter 11 also contains an assessment of methods and personal reflections on the research process.

Chapter 12: Contributions and Conclusion

This chapter summarizes the contributions this research makes to the fields of sustainable development, ICCD, gender and ICTD. Chapter 12 also contains a discussion of the broad theoretical and practical consequences of the research and suggests ways to apply the research to practice and policy. Additionally, this chapter provides an outline for further research on an expanded IS for the fogwater project.

CHAPTER 2

CULTURE, COMMUNITY, LANGUAGE AND SITE SELECTION

The Argan oil Cooperative (the Coop) and the nearby fogwater project are located in rural Berber communities in the Aït Baamrane region of southwest Morocco (Figure 1). This chapter examines state and local cultural and socioeconomic contexts that are relevant to both the exploratory research at the Cooperative and the primary research related to the fogwater project. This chapter also discusses the myriad language constraints that factor into the use of ICT in a project of this nature.

Figure 1: Map of Morocco indicating region where research site is located.

2.1 Development Indices

Unemployment, inequality and poverty in the Kingdom of Morocco (the Kingdom) place it in the bottom third of human development and gender rankings. Morocco ranks 130th out of 187 counties in the UN Human Development Index's composite score of health, education and income, below regional and global averages (UNDP, 2013b). While Morocco's 2011 Gross National Income of $2,970 per capita (World Bank, 2013) places the country in the lower middle range of developing countries, almost half of Morocco's population is "economically vulnerable" and living at or below the poverty line (World Bank, 2001, 2011). In Morocco, poverty is largely a rural phenomenon: the World Bank estimates that 66% of Morocco's poor live in rural areas (World Bank, 2001).

2.2 Berbers in Southwest Morocco

The status of Berbers in Morocco "is highly complex" (Richards & Waterbury, 2008, p. 337). Berbers, or Amazigh (singular), Imazighen (plural), are considered a minority population in the Kingdom of Morocco. However, they are a sizeable minority. An estimated 40-60% of Morocco's population of 32 million is ethnically Berber. This indigenous ethnic group is linguistically and culturally distinct from Arabs, but centuries of Arab rule and pressure to assimilate have left their mark. The majority of Berbers are now practicing Muslims although they retain many traditional tribal cultural and religious customs. Scholars note, though, that Berber interests in Morocco are not entirely homogeneous. Some Berbers have joined the ranks of the political and business elite, others have left the country for education or jobs, while others remain in Morocco in traditional rural settings such as the communities in which this research is based

(Richards and Waterbury, 2008). The majority of the rural population in Morocco is Berber, as are most of the poor (IFAD, 2010; UNHCR, 2000). These facts are true for the community members involved in both the Coop and the fogwater project. The Aït Baamrane tribal region of southwest Morocco is rural, Berber and underdeveloped.

The Moroccan government has an uneasy relationship with the Berber population, subjecting them to decades of state-sanctioned legal, cultural and political marginalization (BBC World Service, 2001). Rural Berber communities, such as those in Aït Baamrane, suffer from a lack of basic public services such as running water, a lack of school facilities, a ban on the teaching of Berber dialects (only recently lifted) and a lack of jobs. A chronic lack of financial and educational opportunities, combined with social and political disenfranchisement, contributes to the marginalization of the rural Berber population, particularly women.

2.3 Marginalization of Rural Berber Women

For Moroccan women, inequities persist across the spectrum of health, education, welfare and income. These conditions are exacerbated for rural Berber women. The Kingdom is one of the least gender-equitable countries in the world, ranking low in global gender development indicators (ITU, 2011; Kingdom of Morocco, 2008; UNDP, 2003; World Bank Statistics). The 2012 Gender Inequality Index, which measures inequalities across access to reproductive health services, empowerment and economic activity, classifies Morocco 84th out of 148 countries, far below neighboring Tunisia and Libya (46th and 36th, respectively) (UNDP, 2013a). The World Economic Forum's (2013) Global Gender Gap Report 2013 ranks Morocco as one of the least equal countries in the world. Morocco is ranked 129th out of 136

countries with respect to gender gap. Morocco receives a similar low ranking in economic participation for women, ranking 111th out of 136 countries. These data reflect the low levels of female political empowerment in Morocco, further highlighted by a 109th place ranking in equal educational attainment for males and females (WEF, 2013). Furthermore, the ratio of male-to-female school enrollment in Morocco is one of the lowest in the world (NationMaster.com). Low levels of women in the labor force are a further manifestation of the lack of gender equality in Morocco (UNDP, 2013b; World Bank). The UN Human Development Index for Morocco reports that the female labor force participation rate in Morocco is 26.1%, compared to 80.1% for men (UNDP, 2013b).

The literacy rate for rural women in Morocco is half the national average, and in some rural areas, women's illiteracy rates are as high as 89.5% (U.S. State Department, 2012; UNDP, 2013b). Illiteracy is not just a problem for adult women. Fewer than 15% of rural girls are enrolled in secondary school, and 60% of Moroccan girls aged 15-24 are illiterate (Potter, 2011). Some females have not been able to participate in formal education due to the lack of public schools in rural areas. Madrasas (Islamic religious schools) are often the only schools available in rural areas, but they sometimes exclude girls' attendance. Additionally, cultural norms may preclude girls from traveling long distances for school. The lack of education for women and girls has led to a more than 20-point literacy gap between men and women in Morocco (UNESCO, 2012). The lack of literacy is often coupled with lack of numeracy (both of which affect the use of ICT).

2.4 Migration out of Berber Villages

Jobs for women and men in rural southwest Morocco are in short supply. The lack of jobs combined with increasingly degraded, low-yielding land, climate-induced desertification and water stress propel primarily able-bodied Berber men to leave in search of opportunities, either local or abroad. Job-related emigration from rural villages is now a common phenomenon among Berbers from Aït Baamrane, and many families in the region where this research was conducted rely on family remittances to make ends meet. Morocco is, in fact, the world's fourth largest recipient of labor remittances, valued at more than $3 billion in 2001 although the recent global slowdown has caused a substantial remittance squeeze, directly affecting families in rural Aït Baamrane (de Haas, 2006, p. 565). De Haas (2009) notes that in addition to being a tool for economic development, the Moroccan state has considered emigration to be a "safety valve to prevent political tensions in Berber areas" (p. 6). Currently, more than three million Moroccan nationals live outside of Morocco. More than 90% of them migrate to European countries (primarily France) as documented and un-documented workers. Moroccans are the second-largest group of non-EU immigrants in the European Union after Turkish immigrants (Bilgili & Weyel, 2009).

As Momsen (2004) notes, men's migration patterns in and out of rural villages can be "repeat, circular or return" (p. 42). Regardless of the pattern, the impact of male out-migration has cultural, financial, communal and personal implications. It should be noted that women also leave rural communities for cities or other villages, but the departures occur in lower numbers and are driven primarily by marriage.

The temporary and long-term departure of men from rural communities in Aït Baamrane creates a culture of female-headed households. When married men with families leave in search of work, women in the villages effectively become single mothers, and the absence of male family members increases the work burden on women who remain. The female population in rural villages in Aït Baamrane is also boosted by the presence of young unmarried women who are often removed from the educational system after primary school.

Women who remain in villages fulfill traditional roles such as raising children and performing domestic tasks. They also have intangible, more abstract roles as preservers of Berber tradition and culture. These roles can have a stabilizing effect across generations and can raise a woman's status. Conversely, traditional and domestic roles can also serve as additional burdens on women as they are imbued with norms that can suppress a woman's mobility out of the village and her choices and agency within the community.

Despite their absence, male family members often retain an influential role in rural Berber community and family life by exerting control over household finances and decision-making (Momsen, 2004). Decisions are communicated over ICT either directly or through family members, as well as from intermittent visits that men make to their homes in the countryside. Additionally, their absence can delay development projects. "Migrant husbands' decision-making authority in their household or native village leads to delays in the implementation of community projects" (Momsen, p. 41).

Village life also exerts an influence on men who have moved away. As Momsen (2004) notes, men stay attached to their natal village for retirement and as a place where

women and extended family members raise children. Interviews with both male and female community residents in Agni Hiya confirmed this allegiance to home villages in Aït Baamrane. Interviews also confirmed that mobile phone devices, which the majority of adults in the communities possess, make frequent contact possible between migrants and family members in their natal home.

Female-headed households in the Coop and in communities involved in the fogwater project were the result of circumstances such as widowhood, out-migration by men, the departure of the husband due to marital discord or a man's desire to pursue a lifestyle outside of the village. Consistent with Momsen's (2004) observations, female-headed households have both positive and negative effects on women at the research site. One detrimental effect is that female-headed households in rural Aït Baamrane are often among the poorest. Female-led households have fewer working adults. Women typically earn less than men, and poverty perpetuates due to the inability to pay school fees for children or the need to remove children from school to perform chores.

In communities participating in the new water system, and among women working at the Coop, women are often *temporary* single mothers or female-heads of households during the week, over the course of a month, or intermittently throughout the year. Their autonomy and power shifts depending on the family structure: women often lose power when their husbands or sons return. This 'liminal' zone between dependence and independence from male authority complicates women's participation in water management because they may make different decisions when male family members are present, or they may change their decisions when men are present.

2.5 Language Complexities

There is no formal agreement on the precise number of spoken and written languages in active use around the world, but scholars estimate that there are currently as many as 7,000 different spoken languages, two-thirds of which do not have a written form (BBC, 2013; NationMaster.com; O'Neil, 2011; UNESCO, 2006; University of Pennsylvania). Such is the case with Moroccan Arabic (Darija) and Berber dialects. Furthermore, spoken Darija and Berber dialects often differ markedly from the country's two official languages, Modern Standard Arabic and French. The multiple languages and language varieties in polyglot Morocco result in "bilingualism, multilingualism, pidginization, interference, diglossia, borrowing, and code-switching" that create substantial complexities that shape how residents of the Aït Baamrane region engage with their mobile phone devices and the features and services provided by phones and, hence, with any potential water IS (Weinreich, 1979).

Wagner (1993), Hoffman (2008), Hoffman and Miller (2010), Goodman (2005), Ilahiane (2006) and Sadiqi (2003) write cogently on the ways in which women's communication is framed by Arab culture, Berber traditions, Muslim edicts and political authority. Sadiqi (2003) remarks "language and gender interaction in Morocco is also closely related to the social status of women, namely their geographical origin (urban vs. rural), their class (rich vs. poor), their age, and their level of education" (p. 3). Sadiqi links gender, dialect and illiteracy, noting that Berber is spoken by more women than men, and women "are the ones who have perpetuated the language…and women are also the ones who have suffered more from illiteracy" (p. 6). Hoffman (2006) also remarks on the connection between gender and dialect in Morocco. While Berber women "have been

the linchpins of language maintenance in Morocco" (p. 146) and they play an important role in perpetuating an oral heritage in Morocco, Berber women's mono-lingualism can also limit their access to resources and livelihoods and contribute to their on-going marginalization. In Hoffman's (2008) study of monolingual and unschooled Ashelhi Berber in southwest Morocco, she investigated how the idea of Berber homeland manifests in language, gender roles and the relationship to land (Hoffman, 2008). Monolingual Berber-speaking women there personify the "the rugged homeland and embody the native language" (p. 151). That mono-lingualism assures "that wives will remain in their husbands' homelands, tend land, and preserve the husband's patrimony and reputation" (p. 150). The Berber dialect, Hoffman writes, "indexes rurality, which in turn indexes female gender" (p. 151).

My research explored the complex gender, culture, linguistic and socioeconomic contexts that contribute to lack of equality and lack of literacy among rural Berber women in Aït Baamrane. In Chapter 10, I discuss how multiple spoken and written languages complicate the use of ICT for rural Berber women, particularly when devices do not reflect common languages that a mobile user sees, hears or speaks. These language complexities contribute to the formation of the mobile utility gap where low-literate and illiterate women have mobiles but are unable to access many of the features on their phones due to complex social, cultural and technical factors.

I adopted and expanded the term "utility gap" from research on SMS use by women in developing countries conducted by the GSMA, the global mobile phone industry association representing mobile operators worldwide (GSMA 2012b). Neither the GSMA nor I employ the term to indicate a binary condition indicating the presence or

absence of ICT devices or the attainment or lack of a set of absolute skills that enables device owners to use their mobiles effectively. Instead, the mobile utility gap, as I employ it, is informed by an understanding that mobile use is a complex phenomenon involving technical, social and cultural factors. The GSMA definition of utility gap served as a foundation for an investigation into the myriad social, technical and cultural factors that affect use of many mobile features and services.

I incorporated GSMA's terminology into my research because the organization explicitly studies mobile use by low-literate and resource-poor women in (among other places) the Middle East and North Africa, thus providing me with data and insights that were directly applicable to the population I studied. I found that the utility gap terminology concisely framed top-level issues related to women's access to mobile phones and women's use of basic services. Furthermore, the GSMA provides data and resources that specifically identify gender issues related to mobile phone use in developing communities, which make findings and terminology from the industry group pertinent to my research. For example, the association's mWomen initiative develops programs to serve resource-poor women in the developing world by increasing the availability of "life-enhancing value-added" mobile phone services and by addressing barriers to mobile use among women who have limited access to education or who experience social isolation due to limited mobility or remote locations (GSMA mWomen, 2014). These goals are consistent with the change agenda embedded in my Ethnographic Action Research. Additionally, GSMA's mWomen programs and research acknowledge that women in the Middle East and North Africa historically experience more significant gaps in access to and use of mobile phones. The organization's research (along with other

industry research such as Intel's "Women on the Web" report (Intel, 2012) helps illuminate issues related to women's mobile phone use in a region of the world that has been largely ignored by ICTD scholars (Dodson et al., 2012; Gomez et al., 2012).

Below, I discuss the numerous spoken and written languages in use in my research sites.

2.5.1 Spoken Dialects

Darija, or Colloquial Moroccan Arabic, is the common vernacular spoken in both rural and urban Morocco. Darija is an amalgamation of Arabic, French and Spanish words and syntax that has no standardized written form. When written in SMS texts or social media, for example, Darija borrows either the Arabic or Latin alphabet, and users spell words phonetically.

Additionally, Berber dialects are widely spoken in rural areas. Approximately 30% of the Moroccan citizenry speak one of the three main Berber dialects in use in Morocco (Tamazight, Tarifit and Tachelhit)[1]. Tachelhit is the dialect of the Anti-Atlas mountain region of southern Morocco. Tachelhit is widely spoken in both research sites but does not have a commonly used written form. The majority of rural Berber women in the Coop and villages involved in the fogwater project rely on oral communication in Tachelhit, which can negatively affect their use of text-based mobile interfaces.

2.5.2 Official Languages

Distinct from the commonly spoken vernaculars of Berber and Darija, the Kingdom has two official written and spoken languages. Modern Standard Arabic (MSA) and French are used in official documents, speeches, newspapers, journals, education and

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[1] Tamazight is spoken in the Central to Mid-Atlas region. Tarifit, or the Riffian dialect, is spoken in the northern provinces (Hoffman, 2008; IRCAM). Saharouis and desert populations in the Moroccan Sahara speak Hassaniya which is unrelated to the Berber dialect (Ilahiane, 2006).

international commerce. Radio and television news broadcasts are also delivered primarily in MSA or French.

Arabic is a 'diglossic' language in which "two or more varieties of the same language are used by people in one speech community" (Ferguson, 1959; Salia, 2011). In Morocco, religious life is often conducted in Fuhsa (formal, classical Arabic), the language of the Quran, which differs slightly from Modern Standard Arabic and sometimes markedly from vernacular Moroccan spoken Arabic (Darija).

As the second official language of Morocco behind Arabic, French retains an important role in commercial and social life. French is a legacy of the colonial occupation of Morocco (1912-1956) and continues to be is used in official proceedings. The language is introduced in primary school and is widely spoken and understood by elites and Moroccans educated beyond primary school, particularly in the North.

Although no longer considered an official language, Spanish is a remnant language in southwestern Morocco, and it remains in use in and around Sidi Ifni where the fogwater project and DSH are based. Sidi Ifni was the provincial capitol of the regional Spanish protectorate from 1912 until Moroccan independence in 1956 although Spain retained administrative control of Sidi Ifni and parts of the south for more than a decade after independence (until 1969). During that time, Sidi Ifni was the capitol of the Spanish presence, and Spanish was the official language of commerce and government. Traces of the language persist as older residents of Sidi Ifni often speak or understand Spanish, some words have found their way into Darija (such as *simana/semana*, *cuzina/cocina* and *blassa/plaza*), and some Spanish-language street signs remain. Additionally, many residents of the Aït Baamrane relocate to Spain as emigrants or

seasonal workers where they acquire some facility in the Spanish language.

2.5.3 Alphabets

The profusion of spoken languages in Morocco is accompanied by an array of alphabets. There are currently three written scripts in use in Morocco. Arabic is a 28-letter cursive script written and read right-to-left. Letters in the Arabic alphabet have no distinct upper or lower case letter-forms, but letter-shape changes (often dramatically) depending on the position within the word. Most Arabic letters have an initial, medial, terminal and isolated form, and ligatures (letter combinations) and diacritics (distinguishing marks that function as phonetic guides) are important elements of Arabic script. Most low-end and older mobile handsets do not support Arabic script, but language preferences on many newer and more sophisticated mobile devices and smartphones can be set to support Arabic script. Sending SMS messages from an Arabic-language mobile to a phone that does not support the language results in a garbled message of punctuation marks or an empty text message field on the receiving phone.

French, and the other Romance languages, are written and read left-to-right. Roman letters have upper and lower-case forms, but other than that distinction, letters do not change shape within the word. Simple feature phones and smartphones support Roman letters.

The Berber alphabet, Tifinagh, is a glyph-based writing system that is written from left to right. It is not yet widely used in publications or taught in schools although in both public and private spaces in southern Morocco one can see Berber symbols and writing. Tifinagh has recently gained additional political and educational currency as a result of the Arab Spring unrest. In 2011, the Moroccan monarchy instituted changes to

the constitution recognizing the important role that Amazigh (Berber) culture plays in Morocco's patrimony. Those constitutional reforms mandate that Tifinagh be taught in Moroccan schools although, as of 2014, a Berber curriculum had yet to be implemented and few Berbers are familiar with the Tifinagh script (Figure 2).

Figure 2: **Example of the Tifinagh Alphabet (Ircam).**

2.5.4 Numbering Systems

Numbers present an additional challenge to mobile phone use among low-literate users. In addition to using the ten Western numerals (1, 2, 3…which are historically referred to as Arabic numbers), Moroccans also use the Arabic-Indic numbering system. Arabic-Indic numerals are not available on mobiles, with the exception of sophisticated smart phones.

2.5.5 Code-switching

The complex language environment has direct implications for low-literate, often monolingual, Berber women's use of information and communication technologies because those ICT require 'foreign' language skills. A lack of these skills is another factor contributing to the mobile utility gap among women. There are, though, many creative and elegant solutions to communicating across diverse languages. The multiple oral and written languages in use in Morocco lead to much code-switching and code-weaving in everyday speech as well as in technology-mediated exchanges (Salia, 2011).

While linguists have no universally agreed-upon definition of the term 'code-switching,' it generally refers to a person's ability to choose among languages within a single conversation or utterance depending on the topic or setting (Salia, 2011, citing Bentahila and Davies). Other terms, such as code-borrowing, code-mixing and code-weaving refer to the use of hybrid languages and words in informal speech and casual communication, be it face-to-face or digital communication (Salia, 2011).

In the communities involved in the water project, code-switching and code-borrowing are more common among men and young women (in their teens or 20s). It is less pervasive among older women.

2.6 ICT Use in North Africa and Rural Berber Communities

As is the case in many developing countries, there is widespread mobile access in Morocco, but substantial pockets of the population, such as women in rural areas, do not benefit from the full range of benefits that ICT can provide. The International Telecommunication Union (ITU), the UN agency for information and communication technology, reported approximately 35 million mobile phone subscriptions in Morocco in 2012, which exceeded the population (ITU, 2012b). According to the GSMA industry group, women in developing countries trail men in mobile ownership (GSMA, 2012a). Three hundred million fewer women than men in low and middle-income countries (of which Morocco is one) own a mobile phone (GSMA, 2012c). The mobile ownership gender gap is also wider in the Middle East than in other parts of the developing world. The Arab Human Development Report highlights the multiple restrictions on ICT access in the Middle East and North Africa based on "gender, economic capability, geographic location or social conditions" (ITU, 2012a, p. 171) all of which influence the use of ICT

and mobiles by rural Berber women in Aït Baamrane where this research is situated (UNDP, 2003). My research corroborates the existence of this mobile gap in rural villages where women have less access than men to their own operational mobile phone.

Women in developing countries also trail men in the use of SMS (GSMA, 2012c). My exploratory research revealed that the majority of the adult female population in the Coop and in villages participating in the new water system did not actively use SMS or other text-based functions on their phones. For those women, their inability to read, write or recognize numbers limited their use of mobiles primarily to phone calls. In general, only younger women in their teens or early 20s utilized the texting features on their phones.

Berber women, who bear the brunt of poverty and are most disadvantaged by lack of education and opportunity, also face gender-specific hurdles such as limitations on their physical range of movement and constraints on communicating with men who are not family members. In rural Aït Baamrane, mobile use is culturally conditioned, and access and use has a strong gender component. For instance, cultural norms prevent unrelated women and men from engaging in private conversations in person. For some, this prohibition extends across technologies to include restrictions on text-to-text and phone-to-phone contact. As discussed in Chapter 8, the prototype design of a socially and culturally appropriate water IS (the Fog Phone) accommodated these social norms.

Despite the multiplicity of spoken and written forms of language, low literacy levels and gender-based barriers, rural Berber women are active users of mobile phones. In order to understand this phenomenon and its potential impact on the design and implementation of the Fog Phone, I studied how low-literate Berber women, who

function in a largely oral-language society, use their mobiles. These issues are described in detail in Chapter 11.

Below, I discuss how the Coop and the villages involved in the fogwater project were selected as research sites.

2.7 Site Selection #1: Exploratory Research On Mobile Use At The Coop

The Tafyoucht Argan oil Cooperative (the Coop) is located in Mesti, Morocco, a regional market town of approximately 3500 residents in southwest Morocco. Similar to other artisanal Argan oil cooperatives in Morocco, Tafyoucht was set up to provide a reliable source of income for rural Berber women who have few means by which to support themselves (Kaboli & Liu, 2012). Currently, there are an estimated 120 women's Argan oil cooperatives supporting approximately 3500 members. Most of Morocco's Argan oil cooperatives are situated in the Souss Massa Draa region of southwest Morocco (ODCO, 2007).

The majority of the Coop members originate from poor, rural communities in Aït Baamrane. Producing Argan oil is their primary livelihood, for which they earn approximately $60/month. During this research, approximately 30 members regularly worked at the Coop, participating in all phases of the Argan oil production process (Figure 3).

Figure 3: A Berber woman holds Argan nuts prior to cracking them to make Argan oil.

Argan oil production is still primarily a manual process. Each member of the Coop is responsible for manually sorting, cracking, sifting and filtering her Argan nuts and kernels. Cracking Argan nuts is a tedious process that involves using a rock (measuring approximately three inches-by-two inches) to crack open a nut to release two small almond slivers. Those slivers are collected and, in the case of the Coop, are machine pressed to extract the oil. Home producers, such as women in villages related to the fogwater project, stone press the kernels to produce Argan oil to sell locally.

2.7.1 Association Dar Si-Hmad

DSH has an ongoing relationship with the Coop and communities in Aït Baamrane. The president of DSH was instrumental in the creation of the Coop in 1997, and the facility continues to receive occasional financial support from DSH. DSH is both

the project instigator and project manager of the fogwater system. The initial phase of the fog harvesting project began in 2005, when meteorological researchers became involved.

DSH was an important research partner and collaborator. They provided access to the Coop and communities involved in the water project as well as valuable direction on what they perceived to be important information needs related to the water project. DSH and its funders mandated women's participation in the new water system at the community and household level. They supported the use of ICT to accomplish water-monitoring tasks and to link water users, the DSH project managers and the local water manager. In early conversations, we discussed an ambitious end-to-end reporting system incorporating an online platform that links the three primarily stakeholders. The installation of an extensive information system was beyond the scope of this research, but these discussions did provide me with the impetus to design, implement and evaluate the Fog Phone.

2.8 Research Progression

At the Coop, I was able to conduct immersive ICT research with a core group of Berber women who regularly gathered in a single place. (It would not have been possible to regularly gather together women from communities involved in the fogwater project to study their mobile use due to their travel restrictions and domestic duties.) While working with women at the Coop, I developed a deep understanding of the mobile utility gap and the social, cultural and technical factors that affect low-literate Berber women's use of mobiles. Additionally, I recognized the crucial difference between personal and instrumental communication, which became important concepts in this research.

I originally surmised, though, that there was a link between ICT, rural Berber women and Argan oil resource management, but once in the field, I found that this was not the case. It became clear that Coop members were not directly engaged with the external market for Argan oil through wholesalers or direct or online marketing to the national or international market, which might have provided an opportunity to conduct research that had an ICT component. Furthermore, the women at the Coop were not involved in the physical management of the nearby Argan forests through harvesting or other activities where there might be an opportunity to develop ICT resources for and with the women. After approximately four months of observations and interviews, I discovered that there was no vocational use of mobiles that linked Coop members back to Argan forest management or out to the global value chain which would allow me to develop research encompassing my interests in natural resources, women and ICT. I therefore determined that in that Coop at that time there was no opportunity to conduct research involving women, ICT and natural resource management. The fogwater project, in contrast, provided an opportunity to conduct research on the communication needs and the potential role of ICT in service of an environmentally sustainable development project. Conducting research related to the fogwater project allowed me to work with a similar population of Berber women in a project that also addressed my interests in ICT and natural resource use and climate change.

When I changed research sites, I also changed research perspective. Exploratory research at the Coop was largely driven by and responsive to the needs of Coop members. Research on the development of the Fog Phone was a primarily researcher and DSH-

driven process. The research timeline (Table 1) describes dates, locations and research activities from July 2012 until February 2014.

Date	Location	Research Activities
July 2012	Mesti, Morocco- The Coop Aït Baamrane- The fogwater project	• Initial observations and preliminary interviews at the Coop. • Initial site visit to fogwater harvesting project and communities in rural Aït Baamrane.
November 2012- February 2013	Mesti, Morocco- The Coop	• Exploratory Research at the Coop. • Intensive investigation of mobile phone use by Coop members. • Conduct ICT interviews. • Develop and implement mobile phone-based literacy workshops with Coop women.
May-July 2013	Aït Baamrane- The fogwater project	• Conduct ICT and water interviews with water project stakeholders. • Piped water delivery begins to Agni Hiya. • Rapid participatory design of an alpha version of the Fog Phone. • Deploy alpha version of the Fog Phone. • Test alpha version of Fog Phone. • Collect data.
September- December 2013	University of Colorado	• Develop beta version of the Fog Phone.
December 2013- January 2014	Aït Baamrane- The fogwater project	• Deploy beta version of the Fog Phone. • Test beta version of Fog Phone. • Collect data.

Table 1: The Research Timeline

2.9 Site Selection #2: Primary Research On Prototype Information System For The Fogwater Project

Communities participating in the fogwater project are geographically dispersed, insular, rural settlements in the foothills of the Anti-Atlas Mountains. In the initial phase, the new water system is expected to deliver water to approximately 400 residents in five villages (Agni Hiya, Agni Zkri, Tamarrout, Id Soussan and Id Aachour), three rural schools and one Madrasa (Islamic religious school), none of which had running water. All of the these locations are in the rural district of Tnine Amellou, Caidat Mesti in the Province of Sidi Ifni in the Aït Baamrane region (Figure 4).

Figure 4: The arid landscape near Mt. Boutmezguida in the Aït Baamrane region of Morocco. Two villages connected to the fogwater system are shown.

The communities are located approximately 10 kilometers down a gravel road between the two small commercial towns of Mesti and Guelmim, which are 20-30 kilometers away. Villages consist of clusters of single-story mud and adobe-walled

family compounds with interior spaces that include both living areas and animal shelters. Large extended families often live in shared compounds or in adjacent structures. Thick walls keep interiors cool, sheltering residents from the oppressive summer heat. There is no running water or central heat although homes have electricity, and satellite dishes and televisions are ubiquitous.

Women in the communities involved in the fogwater project share similar characteristics with members of the Coop. In many cases, Coop members originate from these or nearby villages and still have family members there. Both groups of women are ethnically Berber, educationally disadvantaged and economically marginalized. At both sites, Argan oil production is one of the main income-producing opportunities for women. For rural women who work at home, collecting Argan nuts and producing oil are effective income-generating and savings mechanisms as the fruit can either be stored and saved to produce oil on an as-needed basis, or it can be sold when women need to raise cash, thus helping the family cope with financial shocks or events such as family or medical emergencies. Similar to women in the Coop, women in the communities involved in the fogwater project had a limited range of often low-quality simple feature phones.

2.9.1 The Fog Harvesting System

The regional topography, wind and weather patterns around Mt. Boutmezguida create the ideal conditions to generate heavy layers of advective fog that is some of the thickest fog in the world (Marzol & Sánchez Megía, 2008; Marzol, Sánchez Megía, & Yanes, 2011). Advective fog, one of seven types of fog, occurs in southwest Morocco when moist air flows inland off the Atlantic Ocean where it travels upslope to the peak of

Mt. Boutmezguida. There the wet winds meet warm air from the Sahara to envelop the peak in fog for up to six months of the year. The yield from fogwater harvested at Mt. Boutmezguida is highest between December-June, tapering off to non-existent in the summer (Marzol & Sanchez Megia, 2008) (Figure 5).

Figure 5: Water-saturated fog clouds and the fogwater harvesting system at the peak of Mt. Boutmezguida.

Meteorological data from the peak of Mt. Boutmezguida showed the second best fogwater production potential in the world (Marzol & Sanchez Megia, 2008). The fog-harvesting system is expected to capture enough water to supply 10-15/liters/day/person, which is enough to bring residents out of a state of chronic water anxiety and water stress. Project leaders estimate the new water system has the capacity to provide water to 400 area residents (Vavruska, 2012).

The fog season generally occurs between December-June, but fog does not necessarily, nor exclusively occur during those months. This can introduce a high level of unpredictability into the water distribution system, so when the system does not produce

sufficient water from fog, DSH will augment the system with water from a new protected

well owned by DSH. If necessary, DSH will augment the water system with purchased

water so as not to deprive residents of potable water.

CHAPTER 3

RELATED WORK

This chapter summarizes the most relevant prior work related to poverty, sustainable development, climate change, gender and technology, ICTD and human-computer interaction. These themes illustrate the complexity of sustainable development projects and intersect in this research in the design of a prototype gender-inclusive Fog Phone to help manage the novel fogwater harvesting project.

3.1 Relevant Perspectives on the Environment and Development

3.1.1 Poverty and the Environment

The two-way relationship between poverty and environmental degradation has been widely studied (L. Brown, 2009; De Souza, Williams, & Meyerson, 2003; Duraiappah, 1996; Mwakalobo & Shively, 2002; United Nations; United Nations MDG). Poverty can promote environmental degradation, and rural poor families such as those in the Aït Baamrane region often live in ecologically fragile zones where water is scarce, topsoil is eroded, and where drought is on the rise, among other environmental problems (De Souza et al., 2003). De Souza et al. (2003) point out that fragile populations and fragile zones often overlap, producing added burdens on "ethnic minorities, rural residents, and women [who] are much more likely than their counterparts to be poor. These same groups often are disproportionately affected by environmental degradation" (p. 17).

Many scholars point out the important links between personal and community wellbeing and the environment (Adams, 2001; L. Brown, 2009; Falkenmark, 1989;

Lovejoy & Hannah, 2005; Tekken & Kropp, 2012). De Souza et al. (2003) remark that "earth's natural resources and its human population are inherently connected" (p. 4). De Souza et al. (2003) and Sass (2001) summarize the negative impact that water scarcity due to climate change, drought or overuse has on communities. They note that lack of water contributes to the depopulation of rural areas (primarily by working age men), which has a deleterious effect on community stability and increases the burden on women.

3.1.2 Sustainable Development

Sustainable development prioritizes the dual goals of satisfying basic human needs and safeguarding environmental resources and ecosystems, and it integrates human development and environmental issues within social, political and ecological contexts (Global Water Partnership, 2010a; IUCN, 1991; Sharpley, 2010; UN CSD; WCED, 1987). The widely agreed upon definition of sustainable development stems from the World Commission on Environment and Development's Sustainable Development Declaration which states "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In this research related to the fogwater-harvesting project, the water supply involves climatological, ecological, technological, economic and social processes. Furthermore, the fogwater project that DSH is sponsoring falls within the rubric of sustainable development by trying to satisfy the basic human need for water by supplying potable water to communities in rural Aït Baamrane in a way that does not damage the environment or unnecessarily deplete limited natural resources. The Sustainable Development Declaration also links the concepts of social equity and

environmental protection in an effort to improve quality of life. Again, the DSH project aims to relieve rural Berber women of the time and labor burden of fetching water.

Development scholars have devised tenets to guide sustainable development practice. These tenets reflect the occasional tensions that arise in the simultaneous pursuit of two goals, those of safeguarding the environment while advancing a development agenda (Adams, 2001; Barbier & Markandya, 1990; Berkes, 2004; L. Brown, 2009; Chambers, 1988; Daly, 1989; Daly & Cobb, 1989; Duraiappah, 1996; Gladwin, Kennelly, & Krause, 1995; IUCN, 1980; IUCN 1991; Jenkins, 2009; Leach, 1991; Pearce, Barbier, & Markandya, 1990).

For instance, Barbier and Markandya (1990) give priority to environmental issues. In "The Conditions for Achieving Environmentally Sustainable Development," the authors argue that maintaining ecosystem services and the quality of the stock of natural resources "is an essential criterion for sustainable development" (p. 660). That concern is reflected in the fogwater project that directly addresses the decline in the stock of clean water in rural Berber villages. The associated Fog Phone addresses maintenance, service and quality issues related to the water project.

In contrast, other scholars highlight the importance of social sustainability. Redclift (1987) remarks on the necessity to integrate social and ecological sustainability in development initiatives. The author defines *social* sustainability as the social conditions and structures that are necessary to achieve environmental sustainability, an idea that resonates in this research through the inclusion of women in the management of the supplemental water system (Redclift). Gladwin et al. (1995) also focus on human aspects of sustainable development, surmising that sustainable development is a process

of achieving human development by widening or enlarging the range of people's choices in an "inclusive, connected, equitable, prudent, and secure manner" (p. 878). Chambers (1988) also elevates social concerns by suggesting that the main criteria for decision-making are the immediate and low-risk satisfaction of basic needs and security. The fogwater project meets basic water needs while the role of the IS tools are to lower the risk of service interruptions, and hence, help ensure the provision of water. Adams (1990) argues for the need to place environmental issues within a social and political context as well as an economic one.

Daly (2011) argues in favor of 'quality' development. Daly, who developed sustainable development policy guidelines for the World Bank, suggests that sustainable development must focus on containing ecosystems that are "finite and already overstressed" such as water resources in drought-hit southwest Morocco, by shifting the path of progress from "quantitative growth to qualitative development, from bigger to better" (para. 1). This is an especially important tenet of the combined fogwater and information system. DSH's mission aligns along principles of environment, equity, education and economy that alone or in combination provide qualitatively improved conditions for residents in rural Aït Baamrane. The fogwater infrastructure and the research on the tools and processes involved in creating the Fog Phone are consistent with principles of qualitative development as identified by Daly.

Sharpley's (2010) summary of sustainable development as "development that is fair and equitable and which provides opportunities for access to and use of resources for all members" (p. 10) builds on the themes espoused by DSH. Sharpley notes that the definition of sustainability contains the key concept of needs, particularly the essential

needs of the world's poor, "to which overriding priority should be given" (p. 10). That concept is central to the provision of supplemental water in Berber villages near Mt. Boutmezguida. The principle of equitable opportunity is particularly significant in this research that intentionally involves women. Social equity is addressed by relieving women in rural Berber communities of the time and labor burden of fetching water from compromised and depleted sources. It is also addressed by involving women in the design and implementation of the Fog Phone to assist in stewardship of the water project.

Consistent with another core principle of sustainable development, both this fogwater project and the information system are future-focused. The Fog Phone is designed to contribute to current and future functioning of the water system.

3.1.3 Critiques of Sustainable Development

Sustainable development is an emerging set of practices and perspectives that link human activities with the natural world. Like many inter-disciplinary fields including ICTD, critiques of sustainable development center around the lack of definitional clarity. Mitlin (1992) suggests that the sustainable development field is weakened by a lack of common agreement on fundamental concepts (Mitlin, 1992). Gladwin et al. (Gladwin, Kennelly, & Krause, 1995) on the other hand, remark that "definitional diversity is to be expected during the emergent phase of any potentially big idea of general usefulness" (p. 876). They recommend that practitioners and policymakers "embrace the unfolding process" (Gladwin et al.). Adams (1990), though, argues that sustainable development is an "intensely synthetic" development paradigm with no coherent theoretical core (Adams, 1990 as cited in Mitlin, 1992, p. 113). He suggests instead that sustainable development "is not about the way the environment is managed but about who has the

power to decide how it is managed" (Adams, 2001; Mitlin, 1992). Issues of power and community capacity are addressed by gender and development specialists in the spheres of Gender and Development (GAD) and Gender, Environment and Development (GED), which I discuss in Chapters 4 and 7.

3.1.4 Water Scarcity in MENA

Lester Brown, considered one of the fathers of sustainable development, looks at three main environmental threats: the shortage of freshwater, rising temperatures and other effects of climate change, and loss of topsoil. Brown finds "the spread of water shortages poses the most immediate threat" (Brown, 2009). Approximately one-third of the world's population lives in countries suffering from moderate to high water stress (defined as consumption that exceeds 10% of renewable freshwater resources). By 2030, approximately half of the world's population is projected to live in water-stressed areas (De Souza et al., 2003; Leahy, 2007) .

The Middle East and North Africa (MENA) "is the most water-scarce region of the world" (Sass, 2001, p. 1). MENA contains more than 6% of the world's population but less than 2% of the world's renewable fresh water (Sass, 2001). Water and population trends are moving in opposite directions. For example, twelve of the world's 15 water-scarce countries are in MENA, where, between 1970-2001, populations more than doubled, reducing by half the amount of fresh water available per capita (De Souza et al. 2003).[2] In Morocco, per capita annual renewable fresh water supply dropped by nearly 50% (47.6%) between 1970-2001 and is estimated to drop another 30% by 2025 to 741 m2/per person/per year (Roudi et al., 2002). Southwest Morocco is characterized by a

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[2] A country is considered "water stressed" when its total renewable freshwater resources lie between 1,000 cubic meters and 1,700 cubic meters per person per year (WHO/UNICEF). "Water-scarce" countries have an average of less than 1,000 cubic meters of renewable fresh water per person per year" (Roudi et al., 2002).

long dry season, a short growing season and low and inconsistent rainfall of approximately 170 to 285 mm (6 to 11 inches) per year (Berkat & Tazi, 2004). As of 2012, water resources in Morocco are near what the United Nations Food and Agriculture Organization (FAO) considers to be the *critical* supply threshold of 1,000 cubic meters per person per year (m3/per capita/per year), and water resources may reach *absolute* shortage levels by 2020 (Bargach, 2011).

3.1.5 Desertification in Morocco

Desert encroachment is a critical problem in Morocco. According to the FAO, 78% of the land area in Morocco is already defined as a desert or dry zone with average annual precipitation of less than 250 mm/year (9 inches/year) (Berkat & Tazi, 2004). With at least one-third of Morocco's population directly dependent on agricultural production, the more frequent and long-lasting periods of abnormally low rainfall are having an adverse effect to the economy (African Development Bank, 2006; FAO, 1992; Gommes, El Hairech, Rosillon, Balaghi, & Kanamaru, 2009). The Arab Development Report links droughts with "major negative impacts" (UNDP, 2003, p. 11) on the strategic agricultural sector and consequently on Morocco's economic growth rate trends, warning that droughts are exacerbating an already "disturbing" situation of rural poverty and social disparity in Morocco. Additionally, these fragile ecosystems suffer from soil loss due to wind and water erosion and loss of soil fertility (Berkat & Tazi, 2004).

Desertification has intensified in Morocco due to an increase in the occurrence and severity of droughts. According to the FAO, in the periods from 1979-1984 and again through most of the 1990's, Morocco suffered the longest drought episodes in recent history (Berkat & Tazi, 2004). As the desert spreads, it damages agriculturally productive

land and shrinks the habitat for the Argan tree, creating a double threat to rural farmers and Argan oil producers in the region where this research is being conducted.

The field of human ecology assesses the complex connections and interactions between humans and the natural world (Barrows, 1923; Bubolz, Eicher, Evers, & Sontag, 1980). The Argan tree is emblematic of the human-nature interactions on which the principles of human ecology are built and demonstrated locally. Despite its shrinking range, *Argania spinosa* continues to play an essential ecological function in areas of southwest Morocco (Charrouf & Guillaume, 2009; Ilahiane, 1999; Luth, 2004; Lybbert et al., 2002; Lybbert, Barrett, & Narjisse, 2003; Mellado, 1989; Stussi et al., 2006). The Argan tree provides an important source of income for Berber women, and the wider community benefits from vital ecological services from the Argan forest such as shade and soil stabilization. The tree's deep root system helps hold soil in place, which is crucial to preventing erosion. Reduced erosion and stabilized soil serve as a shield against desertification. Furthermore, traditional life in rural Berber communities in southwestern Morocco revolves around the Argan forest. Lybbert et al. (2003) estimate that 90% of the rural economy in the Argan zone depends, in one way or another, on the Argan tree. Harvesting of Argan nuts and production of Argan oil provides livelihoods opportunities for Berber women; fruit from Argan wood provides cooking fuel and Argan leaves provide forage for goats and sheep.

3.1.6 Integrated Water Resource Management (IWRM)

This research required an understanding of hydrological and climate principles, as these influence the availability and quality of water resources on which the Fog Phone is based. To understand these themes, I consulted policy documents and research on natural

resource management and on integrated water resource management (IWRM). IWRM specifically promotes water resource management that serves social and economic goals alongside of ecosystem and environmental sustainability (Global Water Partnership, 2010b, UNICEF, 2012). IWRM is an approach to the management of water resources "based on the understanding that water resources are an integral component of the ecosystem, a natural resource, and a social and economic good" (Global Water Partnership, 2012). It reflects the interconnected nature of hydrological resources and the many uses of water for agriculture, healthy ecosystems, human consumption and livelihoods. Ideal IWRM projects include participatory planning and management of water resources in a way that balances social and economic needs while ensuring the protection of ecosystems for the future (Global Water Partnership, 2010b).

Water resource management techniques are grounded in the knowledge that the natural resources may be exhaustible (or finite) or renewable, both of which require prudent use and optimal efficiency (Barbier & Markandya, 1990). Depending on the scale being considered, water may be either finite or renewable. On a global scale, water is considered a renewable resource. However, on a local and regional level, fresh water is considered to be a finite resource (Global Water Partnership, 2010a).[3] The supplemental fogwater system considers both scales: well water is a finite resource while fogwater is a renewable resource. In Aït Baamrane, water extraction from wells often exceeds regeneration rates, particularly in the dry season. Furthermore, wells are polluted with fecal matter from untreated human and animal waste. Due to its compromised quality and quantity, well water in villages involved in DSH's fogwater project is a finite resource.

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[3] Potable water sources include underground aquifers, groundwater, surface water (lakes, streams, oceans) and water in the form of ice, fog, rain and snow. On a global ecosystem scale, water is considered to be a renewable resource that is transported, purified and distributed through the hydrological cycle (Global Water Partnership, 2012).

The fogwater harvesting project is designed to supplement that finite water resource with a renewable water source from fog. The exchange of a renewable water source for a finite one, and the responsible use of new, protected (i.e. closed) wells meets sustainability objectives of minimal depletion of non-renewable water resources and sustainable use of renewable fogwater resources. Barbier and Markandya (1990) note that failure to obey the constraints of prudent use and optimal efficiency "will lead to a process of environmental degradation as the resource base is depleted, wastes accumulate and natural ecological processes are impaired" (p. 660). Those are precisely the conditions in villages targeted to receive water from the fogwater project.

Environmental concerns are not the only factor in sustainable development. It is also vitally important to understand the role of humans in the ecosystem. In the semi-arid pre-Saharan region of Aït Baamrane, water quality and quantity cannot be separated from issues related to human use and resource management. The Fog Phone was designed to integrate many of the IWRM principles by involving water users to efficiently, equitably and sustainably manage this new water service. The Fog Phone for water users is a rapid, simple alert and reporting system using at-hand technologies. It is designed to be efficient. It promotes equity by involving women in service reporting, and it is designed to promote the ongoing maintenance of the fogwater distribution system, i.e. the sustainability of the water system.

3.2 Information and Communication Technology for Development (ICTD)

Information and communication technologies (ICT) include hardware and software that facilitate access to communication and information. ICT include artifacts such as computers, mobile phones, mobile devices, the internet, storage and memory

devices, CDs, DVDs, photography, audio and video recording equipment, telecommunication infrastructure as well as the behaviors and norms that surround the use of ICT. Information and Communication Technology for Development (ICTD) refers to the practice of integrating ICT in international development initiatives and to the study of the impact of ICT in developing communities.

ICT are being rapidly integrated into poverty alleviation and social development programs across the developing world in the continued hope that computer literacy, internet access and mobile phone usage will transform the lives and livelihoods of the world's poor. As Heeks and Molla (2009) have observed, every year NGOs, along with the public and private sectors, invest billions of dollars in ICTD projects such as tele-centers, mobile-health and e-education projects. Paralleling this substantial investment of money and interest in ICTD is a corresponding increase in expectations of development "achievement" through both planned ICT interventions and organic ICT adoption. The World Bank (World Bank IEG, 2011; World Bank, 2012) is on record in support of the transformative potential of information and communication technologies: "ICT promotes innovation and can trigger fundamental economic transformation. Individuals…are unleashing the potential of their human capital and creativity" (World Bank IEG, p.4). The World Bank has backed its optimism that ICT can help reduce poverty, boost economic growth and spur accountability with billions of dollars worth of investment in large-scale projects such as the build-out of national broadband networks and other backbone infrastructure initiatives. High expectations are not limited to the World Bank and sector-level investments. Bhavnani et al. (2008) speak to the explosive growth in mobile phone ownership and coverage, and the social and economic benefits that mobile

telephony can provide to the rural poor. The GSM Association (GSMA, 2008) highlights studies demonstrating how mobile phones drive everything from "improvements in social links, the creation of social capital, improved market information flows and productivity, as well as increases in GDP and Foreign Direct Investment."

The World Bank, the United Nations Development Programme (UNDP) and other development agencies have identified ICT as particularly beneficial tools in rural development projects that seek to stabilize communities, expand women's roles, and mitigate social and environmental inequities (GSMA, 2008; Hamel, 2010; ITU, 2005; UNCTAD, 2010, 2011; Zhen-Wei Qiang, Clarke, & Halewood, 2006). The United Nations Millennium Development Goal MDG 8 (sub-article F) calls for the public and private sector to cooperate to leverage the benefits of ICT in developing countries. Information and communication technologies have become mainstream components of development efforts across all sectors, as discussed in the many articles that tout ICTD as a strategy for achieving the UN Millennium Development Goals (infoDev, 2013; ITU, 2005; Kaur & Tao, 2013; Siriginidi, 2009; United Nations MDG; Zambrano, 2013).

3.2.1 ICTD and Water

The authors of "Global Information Society Watch 2010: Focus on ICT and Environmental Sustainability" (APC & HIVOS, 2010) state that environmental challenges "provide an opportunity to place sustainable development at the core of our thinking and practice" (p. 7). They corroborate a point made by Ospina and Heeks (2010a) that ICT are among "the most important tools for addressing climate change" (APC & HIVOS, 2010, p. 7). Some authors observe, though, that the IS academic community, which includes ICTD scholars, has been slow in acknowledging the

challenge of environmentally sustainable development (Watson et al., 2010). Watson et al. (2010) comment that information system (IS) researchers and educators have been reluctant to recognize environmental sustainability as an urgent problem and have been hesitant to take action, preferring instead to remain focused on theory-building. They encourage IS researchers to leverage "the transformative power of IS" to create an ecologically sustainable society. While their research focus is on establishing a new subfield of energy informatics that applies IS skills to increasing energy efficiency, their broader challenge to incorporate information systems into environmental sustainability initiatives and research is relevant to this fogwater IS. Duncombe (2006) also confirms that information systems play an increasingly important role in monitoring natural assets and that a range of information is required to assess environmental impact and sustainability.

ICT also play an increasingly important role in environmental monitoring and in providing relevant information related to water, drought and desertification (ITU, 2012c; ITU, 2014). ICT are increasingly being employed to improve meteorological data collection and disaster prediction and early warning, for example. Much of the research linking people, ICT and natural resources are agriculture decision-support projects, such as Panchard et al.'s (2007) study of the COMMONSense Net wireless network in a drought-hit cluster of villages in Southern Karnataka (Panchard, Rao, Prabhakar, Hubaux, & Jamadagni, 2007). This report highlights the potential for ICT to help village residents manage crop-risk by efficient use of water and pest prevention, and it stresses the importance of allowing farmers to "connect to and act on the constraints of their own environment" (p. 54). Knoche, Rao and Huang's (2010) report on a wireless sensor

network for rural resource-poor Indian farmers who had uncertain water supplies had a less satisfactory outcome, initially. The researchers found "insufficient user participation, lack of attention to user needs and a primary focus on technology in the design process led to unconvinced target users who were not interested in adopting the new technology" (p. 1). They ultimately adopted a participatory and contextualized design approach that supported low-literacy levels, resulting in a mobile phone application to manage bore wells.

A number of studies discuss women's water collection. In "Sensors and Smartphones: Tracking Water Collection in Rural Ethiopia," the authors mounted low-power tracking devices on water containers to track how much time rural Ethiopian women spend traveling to gather water (Chaudhri et al., 2012). Crow, et al. (2013) also studied the time it takes to collect water. In their research, they compare results from two data collection methods – GPS and recall – in Kenyan slums. The researchers developed deeper insights by using mixed-methods research that combined ICT and interviews. They note "the use of GPS tracking provides a better understanding of time spent collecting water compared to interview data, but the two methods combined provide insights that neither could have suggested alone" (Crow, Davies, Paterson, & Miles, 2013, p. 1).

Brown, Marsden and Rivett's (2012) *WATER Alert!* research builds on "the small body of knowledge in the area of water quality management and citizen involvement through ICTs" (p. 9). They devised a system that uses mobile phones to address "the challenge of reporting complex and critical water quality information in a way that is accessible," similar to the goals of this research (p.1). They developed a prototype

symbol-based mobile phone application to increase citizen involvement in reporting water quality information (Brown, Marsden, & Rivett, 2012). This type of risk communication tool is applicable to the management of this fogwater system because it focuses on sharing information among stakeholders. Similar to my project, this system was designed to accommodate low-literate users and multiple (non-English) languages.

The United States Agency for International Development's (USAID) interests in Morocco extend to ICT projects in semi-arid regions where the agency supports an SMS-based service designed to send individually tailored irrigation advice to farmers' cell phones (Watson, 2012). The ICTD intervention helps Moroccan farmers conserve water resources by calibrating their drip irrigation schedules with local weather information. Ultimately, the system is expected to have sufficient computational capacity to compute water requirements for individual crops and allow technicians to remotely access weather data via the mobile network. Similar to my fogwater IS research, USAID's irrigation texting service integrates ICT, SMS messaging services and, importantly, face-to-face assistance from field agents.

Loudon et al. (2009) also highlight the important role that humans play in environmental monitoring information systems. The 'Human-in-the-Loop' water-testing prototype addresses many of the same challenges that this fogwater IS research addresses: those of hardware, software and 'humanware.' In both projects, the information system requires human effort in data collection and information processing. Their mobile-based reporting system, called the Aquatest, enables low-resource, low-literate users in South Africa to conduct rapid water quality tests using the phone as a water test reader and image-processing device. The phone is also used to send water test

results back to a central monitoring database. Similar to the water IS in Aït Baamrane, the Aquatest system is designed to be used in low-tech locations at waterpoints and water sources. As the authors state, "providing appropriate information at a local level can empower small communities by improving their ability to manage their water resources in a sustainable, decentralised way" (p. 48). The water sensor system incorporates low-end mobiles, a communications network and a "human-in-the-loop" to react to water quality readings. The design of the Aquatest mobile reader was informed by Marsden's (2008) "pragmatic design" approach in which he advocates for designers and practitioners to adopt a pragmatic approach to designing ICT solutions based on the use of widely available, pre-existing technologies and an understanding of the existing digital ecology such as inadequate resources and challenging environments. This design approach shifts the design focus away from skill limitations to view the user as a designer/co-designer of solutions. My research in Morocco with community members involved in the fogwater project attempted to also uphold a pragmatic, collaborative and responsive approach to local conditions.

3.2.2 Improving Information Flow

A number of ICTD research studies focus on the instrumental benefits of ICT to improve information flow in under-resourced, low literacy environments in developing countries. Development projects face the barriers that any enterprise is likely to encounter, including bureaucracy, corruption, and ineffectual or inefficient regulation. In addition, information flow is hindered by poor infrastructure. In their report on "The Role of Mobile Phones in Sustainable Rural Poverty Reduction," Bhavnani et al. (2008) offer an in-depth analysis of the impact of ICTD on rural communities. They state "both

poverty and lack of information are common bed partners. Thus, the dissemination of information together with serving rural areas has [a] double anti-poverty imperative" (p. 20). They argue that the benefits of mobile phone services are often higher in rural areas because information needs are greater, and the benefits of information are often more pronounced.

Cecchini and Scott's (2003) study of ICTD in rural India also contributes to an understanding of information flow in rural areas. Summarizing the challenges, the authors state "small farmers and artisans living in rural areas typically lack access to information about prices, data on crops, weather conditions, credit facilities, and market opportunities. ICTD can remedy such information asymmetries" (citing World Bank Development Report 1998/99). The authors highlight the importance of partnerships between grassroots intermediaries (local NGOs, social entrepreneurs and cooperatives) and community members that foster useful content and services that respond to the needs of the poor (Cecchini & Scott). These intermediaries are crucial partners that link ICT with the poor by mitigating the negative effects of 'powerful obstacles' such as illiteracy and low educational levels that stand in the way of ICT use (Cecchini & Scott). Javid and Parikh (2006) also explore information inefficiencies in rural India, identifying three factors that inhibit the integration of information technology solutions in a rural context (Javid & Parikh, 2006). These include low IT literacy of stakeholders, the complexity of supporting a system at geographically dispersed locations and the reliability of telecommunications in rural areas. Javid and Parikh argue that a useful rural IT system has to overcome all three of these barriers.

In addition to balancing information asymmetry and reducing ambiguity, ICTD literature often discusses issues of trust in relation to technology-mediated business or instrumental relations (Donner, 2009; Molony, 2006; Overa, 2006; Zainudeen, Samarajiva, & Sivapragasam, 2011). Trust relationships are often originally established via face-to-face communication. Once trust is established, ICT services such as SMS (short message service) texts and email can strengthen relationships with existing partners or customers. In Overa's (2006) study of ICT use by informal traders in Ghana, the author examines how mobiles can be instrumental in building two-way trust relationships between customers and employees, finding that the mobile phone "enhances trust building" (p. 1301).

3.2.3 Ambiguity and Failure in ICTD

A growing body of ICTD research discusses the ambiguous role that ICT play in the lives of users in developing countries either due to flawed technology or to flawed ICTD practices. Optimistic assessments of ICTD initiatives need to be balanced with an understanding that ICT are not unambiguously effective in improving the lives of people in developing communities (Best, 2010; Burrell & Toyama, 2009; Heeks, 2002; Heeks & Molla, 2009; Hosman, 2010; World Bank IEG, 2011). Research has found that many, if not most, ICTD interventions suffer some element of failure. Heeks (2002) estimates information systems in developing countries may have a failure rate near 80%, reflecting the stubborn challenges that can impede successful implementation of ICTD projects such as insufficient infrastructure, outdated or broken equipment, lack of training, lack of political support, sabotage or ICT-triggered cultural offense (Dodson, Sterling, & Bennett, 2012). In addition, even ICTD initiatives that are considered 'successful' often

fail to achieve scale outside of the test community. For example, an ICTD project may be designed to address a specific community-based need and the ICT solution does not easily transfer and apply in other contexts (Dodson, Sterling, & Bennett, 2012).

Chew et al. (2010) suggest that practitioners and scholars temper their enthusiasm for ICT as "gamechangers" for women in the developing world (Chew, Ilavarasan, & Levy, 2010, p. 13). For example, KIT and Oxfam (2005) researchers found that even when female entrepreneurs received training in ICT skills, they still considered ICT to be nonessential because they had little need for "high tech" components. The women believed the ICT were expensive and unnecessary, and when ICT were integrated into operations, efficiency decreased short-term due to time spent learning to use ICT (KIT, 2005).

Furthermore, it is not easy to parse the ways ICT are used from broader human experience. Personal use often merges with professional use, lives entwine with livelihoods, and enjoyment and employment often mix. Granovetter (1985) reminds us that work life is embedded in social life, a theme Donner pursues in "Blurring Livelihoods and Lives" (2009) where he finds that ICT "intermingle" with many aspects of life (Donner, 2009; Granovetter, 1985). Sey (2011) finds it both "unnecessary and misleading" (p. 3) to distinguish between economic and social uses of ICT because users pursue multiple goals in their use of technology (Sey, 2011). Rangaswamy and Sambasivan (2011) seek to understand how the use of technology blends with social activities in developing communities where ICT are embedded in everyday life, and Molony (2006) references the mix of work and social behaviors across petty trade and informal networks (Molony, 2006; Rangaswamy & Sambasivan, 2011).

3.2.4 Effective Use of ICT

This research also considers the work of internet scholars such as Gurstein (2003), Warschauer (2002) and Hargittai (2002) who elucidate issues related to social exclusion and effective use of ICT. This group of scholars highlights the extent to which ICT access and use is "woven in a complex manner in social systems and processes" (Warschauer, p. 4).

Gurstein (2003) shifts the discussion of the "mal-distribution" of ICT opportunities away from a focus on ICT access to other conditions that support what the author describes as active and "effective use" of ICT (p.1). Gurstein defines effective use as "the capacity and opportunity to successfully integrate ICTs into the accomplishment of self or collaboratively identified goals" (p. 6). The challenge is to provide the means by which individuals can make effective use of these technologies for an array of activities including wealth creation and transactional processes. ICT access, he states, "is a pre-condition and an enabler of "effective use" but is not a substitute for it" (p. 7). The author also highlights that ICT use "takes place within larger social contexts including the family, work groups and communities" (p. 10). Gurstein (2003) recommends that any examination of effective use of ICT include an examination of carriage facilities, input and output devices, tools and supports, content services, service access and provision, social facilitation and governance. In my research, content services are particularly relevant as they incorporate an awareness of usability and locally context such as language(s) and literacy levels. These dimensions of mobile use are captured in Ethnographic Action Research (EAR), the Sustainable Livelihoods Framework (SA) and the Stakeholder Analysis (SA). Gurstein (2003) further states that participatory design

and participatory action research support effective ICT use. In both my exploratory and primary research, effective ICT use is supported by EAR and Human-Computer Interaction for Development practices that inform the development of a localized, context-specific and responsive information system to help manage the fogwater project.

Warschauer's (2002) research on technology for social inclusion is especially relevant to my research on the socio-cultural barriers to mobile phone use. In "Reconceptualizing the Digital Divide," the author highlights that effective integration of ICT into communities and institutions "can only be achieved by attention to the wide range of physical, digital, human, and social resources that meaningful access to ICT entails" (p. 7). Warschauer (2002) focuses exclusively on computers and internet access, but the author's "resource list" can be adapted and applied to mobile phone use as well. For instance, physical resources encompass access to mobile network connections and access to mobile devices. Digital resources refer to content and material available on the ICT. Human resources revolve around education and literacy including "particular types of literacy practices" required for ICT use (p. 6). Social resources, such as community, institutional and societal structures also support access to and use of ICT. My ICT-related interviews were designed to investigate these resources (see Chapter 5: Methods).

DiMaggio and Hargittai's (2001) observations of a "second-level" digital divide were relevant to my investigation of the social, technical and cultural factors that constrain rural Berber women's use of their mobile phones. The authors cite five dimensions along which divides may exist. The first (potential) divide centers on hardware, software and the quality of connectivity. The second divide, autonomy of use, encompasses factors such as the location at which a user accesses ICT and the freedom

that user has to use the platform or medium for their preferred activities. The third divide focuses on ICT use patterns. The fourth divide relates to social support networks and the availability of other people to whom one can turn for assistance with ICT use. The final divide revolves around skill and a user's ability to use ICT effectively. The authors apply these potential second-level divides to their study of internet use, but, as is the case with Warschauer's (2002) analyses, they can be adapted to mobile phone use.

While useful in illuminating the complexities of ICT use, Warschauer (2002), Hargittai (2002) and Gurstein (2003)'s work does not identify gender as a substantial factor affecting access to and use of ICT. The authors either disregard gender or aggregate gender issues in with other cultural and social factors (presumably class, race and age). Furthermore, the authors focus exclusively on computer use, internet access and online content, and their findings from research on educated, high-resourced populations whose ICT use is generally not constrained by financial, educational, social, cultural, gender or technical factors are not as relevant to my research in poor Berber communities in southwest Morocco.

3.2.5 Mobiles for Development (M4D)

As a subset of ICTD, Mobiles for Development (M4D) initiatives are grounded on the premise that mobile phones are life-changing tools that can serve a wide range of under-resourced, developing communities. With more than six billion mobile phone subscribers around the world (ITU, 2012a), M4D strategies are predicated on the assumption that mobile phones can be a "smart catalyst to development" through the provision or adoption of mobile technologies and through the use of the services and features that mobile devices provide. Many M4D projects incorporate SMS messaging,

in part because SMS is available, robust, reliable and cheap. Texting "can be easier and more cost-effective to disseminate information to a wide population" (Kang & Maity, 2012, p.1) as opposed to phone call, voice message or Interactive Voice Response (IVR) systems. M4D initiatives contributed to the approximately nine trillion SMS messages sent in 2012 (mobiThinking, 2012). Network providers in the developing world often offer differential pricing structures between SMS and voice services that price texting far below the cost of calling (Dymond, 2004). Operators privilege texting, in part, due to the lack of infrastructure.

As Kang and Maity (2012) reflect, "the mobile phone is, in many cases, the first and the single modern technology personally owned by the poor," but users who have few material resources and limited skill and experience with ICT may not benefit from the services and features available on their mobile phones due to constraints that are often poorly understood such as complex social and cultural circumstances that contribute to the lack of basic, functional literacy. A lack of awareness of the myriad factors that contribute to technological literacy, e.g., device design and local language support, can also hinder the efficacy of mobile-based development efforts, especially for women, thereby contributing to the mobile utility gap where users have access to devices but are unable to benefit from many of the features and services that mobiles provide. As noted by Medhi et al. (2010), low-literate users face usability challenges with text-based user interfaces that prevent useful interaction with ICT (Medhi, Cutrell, & Toyama, 2010). These challenges include the inability to read and write alongside of challenges such as cognitive difficulties, cultural restrictions, intimidation, motivation, power relations and social standing. These challenges can preclude mobile phone users in developing

communities from benefitting from the communication, information and cost advantages of new technologies.

Nevertheless, many M4D initiatives are text-intensive. These initiatives assume that mobile users possess functional and technological literacy, or that users are in the vicinity of someone who has sufficient skills. For example, mobile systems such as mPesa rely on basic literacy and numeracy to operate the service (Safaricom). FrontlineSMS services often presume an ability to read or process numbers as a basis to understand and potentially take action on SMS alerts and messages (FrontlineSMS). Many of the features of the Ushahidi crowd-mapping platform employ text-based tools including SMS and social media (Ushahidi, 2013). UNICEF has embraced the RapidSMS platform to strengthen its programs in data collection, logistics and community feedback (RapidSMS, 2013; World Bank, 2012). Many more development-related programs rely on bulk SMS, interactive SMS services, SMS-based advisories, SMS-based crowdsourcing and SMS-based data collection to reach beneficiaries–applications that require at least a basic level of literacy (GSMA, 2012b; IDRC; Kasumuni, 2011).

The availability of SMS does not guarantee the productive use of the service. This is another example of the mobile utility gap where users may have access to mobile handsets but are not able to or interested in utilizing the features that the device offers. A number of studies have established that a large proportion of the poor in developing countries do not use SMS. Kang and Maity (2012) remark that the use of the mobile phone for services beyond voice is "still scanty" (p.2) among mobile phone users at the bottom of the pyramid (BoP), and SMS use is low even in projects designed for the poor. LIRNEasia confirms these findings (LIRNEasia, 2009). In an extensive survey of nearly

10,000 people across six South Asian nations, the LIRNEasia organization found that only one-third of mobile owners at the bottom of the pyramid in India and Bangladesh sent or received SMS messages. Respondents who do not use texting as a communication tool reported that they did not know how to use SMS services. They also did not think that these services were applicable to them, or they found them to be too expensive. Other disadvantages of using SMS include "limited communication possibilities and inconvenient usability" (p. 2), small screen size, limited message size, cumbersome input methods and complicated interfaces. Challenges need not always deter a user from benefiting from mobile phone features, though. Smyth et al. (2010) present a quantitative study of mobile users in urban India who exhibited "remarkable ingenuity" (p. 753) and perseverance to overcome obstacles such as complex interfaces and language issues in order to enjoy mobile media sharing services (Smyth, Kumar, Medhi, & Toyama, 2010). The authors suggest that high motivation to use a mobile service is an important component of successful ICT use.

The GSM Association (GSMA) notes that mobiles and text-based messaging applications may be particularly beneficial to women in developing communities by providing them with access to mobile remittances, literacy and life skills and maternal health and family planning services. This assumption is supported by the association's prediction that women will be the fastest-growing segment of mobile subscribers in low and middle-income countries (GSMA, 2010, 2012a, 2012b). Nevertheless, a 2012 GSMA mWomen study in four developing countries found that while 77% of women surveyed have made a mobile phone call, only 37% of low-resource women had sent SMS messages, regardless of literacy levels (GSMA, 2012c). GSMA mWomen identifies

this as the SMS utility gap. The report states "BoP [bottom of pyramid] women reported that they did not find the SMS service useful, thus products targeted at BoP women that use SMS should be of demonstrable practical value to BoP women" (p. 3).

3.2.6 Gender and ICTD

Gender and ICTD research explores barriers to women's access and use of ICT in developing countries. The GSMA mWomen report "Women & Mobile: A Global Opportunity" (2011) stated that, on average, a woman in a low or middle-income country is 21% less likely to own a mobile phone than a man. A woman in the Middle East is 24% less likely to own a mobile than a man (GSMA, 2011). Morrell and Sterling (2006), Gill et al. (2010), Hafkin and Huyer (2006), Jorge (2002), and Laizu et al. (2010) provide additional insight into the conditions that contribute to lower access to and use of ICT by women in developing countries. Gill et al. (2010) identify four barriers that hinder technology adoption by women: exclusion from technology education; little free time; social norms that favor men; and financial and institutional constraints. Other constraints that deter women from using ICT include high total cost of ownership that makes ICT use unaffordable for poor women, a lack of technology literacy and cultural barriers that preclude women from engagement with technology (Gill et al., 2010).

Scholars considering gender-related aspects of ICT use challenge the perception that ICT are gender neutral. Hafkin and Huyer (2006) state that women deploy ICT at a lower rate because they have less time and money to put toward ICT use, they may be unable to access ICT in public areas and they often do not receive equal or adequate training compared to male counterparts. Alone or in combination, these factors can represent significant barriers that make it more expensive to operate an enterprise in

under-resourced communities. Hafkin and Huyer also point out that gender biases and gender-based barriers such as inequality and low literacy levels adversely impact women's access to technologies and the benefits that ICT can provide, e.g., health information, business assistance and education. Odame, an author of the KIT and Oxfam sourcebook (2005) on gender and ICT for development, echoes these themes, stating, "technologies are neither gender-neutral nor irrelevant to the lives of resource-poor women" (p. 13). Odame reviews various biases that work against women's use of ICT including the lack of women's involvement in ICT needs assessments and the burden of battling discriminatory attitudes that discourage or prevent women from accessing information technologies. For example, women in developing communities are often treated as "passive recipients of information, not as active information users and communicators" (Hafkin & Taggart 2001 as cited in KIT, 2005, p. 16). Buskens and Webb (2009) posit that information societies in developing countries are often "not grounded in the realities of women" (p. 4), particularly the experiences of women who, for example, face gender discrimination or who do not hold positions of public power (Buskens & Webb, 2009). Morrell and Sterling (2006) note that a failure to consider women's specific needs vis-à-vis ICT can lead to the "unintended reinforcement of male-dominated power structures" (p. 325). "Gender, Society and Development" (KIT, 2005) recommends that measures be taken to put the "critical needs and benefits for women first and make ICT work for them" (p. 41), an approach that requires identifying information gaps and information needs among a small target group of women before pursuing a technology solution.

Numerous studies and initiatives highlight positive outcomes and numerous benefits that ICT can provide for women. The GSMA's mWomen initiatives focus on the social and economic benefits of mobile phones such as education, banking services and tools for managing small businesses (GSMA, 2014). Intel's "Women and the Web" report (2013) highlights the "profound benefits" that women in developing countries derive from being able to access the internet such as political participation, social inclusion and economic advancement (Intel, 2013). Despite often-formidable barriers, Hafkin and Huyer (2006) emphasize the potentially emancipatory impact ICT use can have on women, including increased decision-making skills, greater self-esteem and higher self-worth. In order for ICT to contribute to women's empowerment, which Sen (1999) identifies as one of the central issues in development today, Hafkin and Huyer (2006) contend that ICT users need "options, choice, control, and power" along with the ability to access, use, create and distribute knowledge" (p. 27).

3.3 Human-Computer Interaction for Development (HCID)

As a discipline, Human-Computer Interaction (HCI) is concerned with the study of computing systems for human use, but HCI does not generally consider the unique circumstances of technology use in under-resourced communities by often-marginalized or low-skilled technology users (Ho, Smyth, Kam, & Dearden, 2009). As is the case with sustainable development, Human-Computer Interaction for Development (HCID) is an emerging set of principles and practices related to ICTD. Emergent scholarship on HCID is based on incorporating the values of HCI with constraints found in developing communities (Ho et al., 2009). As Ho et al. (2009) explain, HCID frameworks seek to explain how interactive products and information systems can be designed to meet unique

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user needs while simultaneously addressing difficult infrastructure contexts in developing communities. This is accomplished through an understanding of specific social, cultural and infrastructure challenges found in developing communities along with an awareness of existing ICT and practices (Kabuire, Winschiers-Theophilus, Chivuno-Kurio, Bidwell, & Blake, 2010).

HCID is an effort to design ICT to meet the distinctive needs of users in low-resource communities while also coping with limited infrastructure (Ho et al., 2009; Ramachandran et al., 2007). HCID operates on the premise that poorly designed machines and poorly understood human behaviors can add, rather than alleviate, burdens on users in developing communities. Marsden's (2003) comment that "human-computer interaction (HCI) has a large role to play in empowering users and adapting technology to local needs" (p. 48) is echoed in the work of other user-centered and contextual designers for developing regions, all of whom explore the challenge of designing systems and devices to meet specific circumstances that arise in developing countries (Blom, Chipchase, & Lehikoinen, 2005; Ho et al., 2009; Maunder, Marsden, Gruijters, & Blake, 2008; Winschiers-Theophilus, Bidwell, Blake, Kapuire, & Rehm, 2010). The HCI for Community and International Development discussion at *CHI 2008* called for HCI practices to be adapted or modified to suit unique challenges in developing regions. The authors advocated for an analysis of users that incorporates an understanding of local context and practices as well as economic conditions (Thomas et al., 2008).

Winschiers-Theophilus et al. (2010) investigate the complexity of cross-cultural design in their research on rural-urban migration in southern Africa (Winschiers-Theophilus et al., 2010). They determined that standard ICT functionality based on

hierarchical structures and text-based searches did not effectively map onto oral-knowledge communities. Wong and Kodagoda (2011) make a critical case for "knowing your user" and reducing abstract functionality and interface complexity. Knoche and Huang's (2012) observations of coping strategies and use of mobile devices by illiterate and semi-literate immigrants in Switzerland suggest augmenting rather than eliminating text-based features of ICT. Their results show a positive effect on reading and writing skills. Van Biljon, Kotzé and Marsden (2007) suggest that while feature overload may increase desirability of a mobile product, it often reduces usability because it adds to the cognitive load on a low-skilled user. They recommend that mobile features be grounded in a user's motivational needs rather than in response to market pressures.

3.3.1 HCID Design Approaches

Contextual inquiry and contextual design approaches are central to the practice of HCID (Chipchase, 2006, 2009; Knoche et al., 2010; Marsden, 2003). They both incorporate a deep understanding of users' information needs in the context of their information ecology (e.g. low-literate users with low-end mobile phones in rural communities with low-strength network signals), and they incorporate this knowledge into the design of ICT and information systems (Ho et al., 2009; Winschiers-Theophilus et al., 2010).

In devising a new User-Centered Design for Developing Regions methodology, Maunder et al. (2008) stress the importance of developing the technology user along with the support structures in the user's living and working environments (Maunder et al., 2008). This, they say, can be accomplished through a progressive participatory design approach that keeps users and their broader environmental requirements at the forefront.

Highlighting the work of Chin and Rosson, Maunder et al. write that a focus on developing the user and the user environment ensures the "progression and development of user's knowledge base and skill set, thereby enabling the user to better understand the technology, the benefits it offers and how to utilise it effectively" (p. 35). The result of this approach is the "co-evolution of user[s] and their environment as technology design progresses, providing the best possible opportunity for active user participation" (p. 36). The authors fuse user-centered design with ethnographic principles to produce a detailed, or 'thick,' understanding of the users' information needs that are incorporated into ICT prototypes. Progressive participatory design calls for the incremental development, or 'evolution,' of the user's activities and processes alongside the design of the technology that supports them (Lalji & Good, 2008; Maunder et al., 2008). Progressive participatory design is based on continuous interaction between the designer and primary users, an interaction that is informed by a thorough investigation into the world of the users, their lives, relationships and concerns (Lalji & Good, 2008). This research also integrates principles of pragmatic design set forth by Marsden (2008) in "Toward Empowered Design." A pragmatic design focuses on developing practical ICT-based solutions and places the user in the role of lead designer. Additionally, Lalji and Good's (2008) 'considerations of use' framework identifies broad characteristics of a user population and identifies conditions relevant to mobile phone use such as financial, physical, environmental, mental and educational circumstances.

3.3.2 HCID and Literacy

In studies of how illiteracy affects users' ability to effectively use their phone, Blom et al. (2005) and Chipchase (2006, 2009) identified common coping strategies

including rote memorization, visual cues and the use of intermediaries to assist in phone use. Chipchase (2006) suggests that the adaptive and creative strategies employed by low-literate mobile owners may be harnessed to design ICT or interfaces for the developing world. He notes that illiterate participants may be "lead users for the rest of us" (p. 17).

Bidwell (2009) notes that it is important that HCID researchers "study the characteristics of local communities and understand how orality should inform technology and information design" (p. 5). HCID addresses this constraint through user-centered design for development, a framework that gives priority to the development of the user's and the supportive structures within a user's living and working environment (Maunder et al., 2008). In addition to supporting both users and their environment, a user-centered design approach advocates for a design process that prepares users to participate in the design process by building their skills and ensuring "progression and development of user's knowledge base and skill set, thereby enabling the user to better understand the technology, the benefits it offers and how to utilise it effectively" (Maunder et al., 2008, p. 6). I incorporated HCID practices into this research, paying particularly close attention to recommendations to understand the user and their environment along with the social, cultural, technical and infrastructure constraints that might affect the design and deployment of a prototype information system to enable low-literate Berber women to help manage the fogwater system.

CHAPTER 4

THEORIES AND MODELS

The multi-dimensional nature of this research and the complex multilevel relationships among stakeholders require the exploration of multiple theories, frameworks and principles. Research into the tools and processes to conduct this research fuses theory and practice from the fields of sustainable development, climate change, gender and the environment. I have identified theories relevant to my research that support a bottom-up, grounded approach that informs fieldwork, stakeholder engagement and the research design. I do not use these theories independent of one another. Concepts from sustainable development, gender and technology intersect across the theoretical, methods and analysis sections of this research. Models of ICTs, Climate Change and Development (ICCD), Gender and Development (GAD), and Gender, Environment and Development (GED) each contribute to the theoretical framework that inform my research questions. Furthermore, much of the literature from the various domains cited in Chapter 3 directly or obliquely references the theories and models I explore below. While the related work focused on field studies and top-level perspectives on the environment and development as well as technology and design, this chapter investigates the over-arching theories and models that inform my research into the tools and processes involved in developing a gender-aware, culturally appropriate IS for the fogwater system.

The availability, quality and quantity of water resources in the semi-arid, pre-Saharan Desert region of Aït Baamrane where the fogwater system is located cannot be separated from broader environmental factors. I explore these connections between humans and nature via sustainable development principles (discussed in Chapter 3), which I integrate into the ICCD model. Because the use of communication technology in

this project is intertwined with issues of gender, culture and power, I examine these relationships through the lenses of Gender and Development (GAD) and Gender, Environment and Development (GED) studies. GAD provides a framework to explore gender-related components of access to and control over resources in the villages, as well as women's participation in the design and implementation of an information system that is meant to increase their agency. GED is relevant to this research because GED links men's and women's participation in the management of a water delivery system to the provision of a service that is fundamental to human development (potable water).

This blending of ICCD and gender studies presents opportunities and challenges for my research, requiring significant breadth of knowledge as well as synthesis of information across a broad intellectual landscape. Such interdisciplinarity presents many challenges, starting with definitional differences. I have attempted to mitigate these perils by carefully defining terms used in the context of this research.

4.1 The ICTs, Climate Change and Development (ICCD) Model

The ICCD model describes a conceptual foundation that links climate change, livelihoods vulnerability, and the potential for ICT to support resilience in the face of environmental distress such as water shortages in southwest Morocco (Ospina & Heeks, 2012). ICCD also provides a foundation on which to analyze the role and potential of ICT tools in the context of development challenges and vulnerabilities (Ospina & Heeks, 2010b). As an emerging framework around which to conceptualize an initiative, ICCD allows the researcher great flexibility to incorporate the framework into both new and existing projects.

ICCD research focuses on the "ability of vulnerable groups to cope with and

transform in the face of climate change challenges and uncertainty" (Ospina & Heeks, 2012, p. 9). The ICCD model revolves around four research priorities. The ICT and climate mitigation priority incorporates issues related to how ICT contribute to or can help reduce carbon emissions. The climate monitoring research domain focuses on the utilization of ICT to help measure and analyze climate change and its impacts. The adaptation tier of the research agenda focuses on how ICT can help developing countries and communities adapt to the effects of short-and-long term climate change. In the ICCD model, the decision-making research agenda focuses on how ICT can help enable strategic actions on climate change (Figure 6).
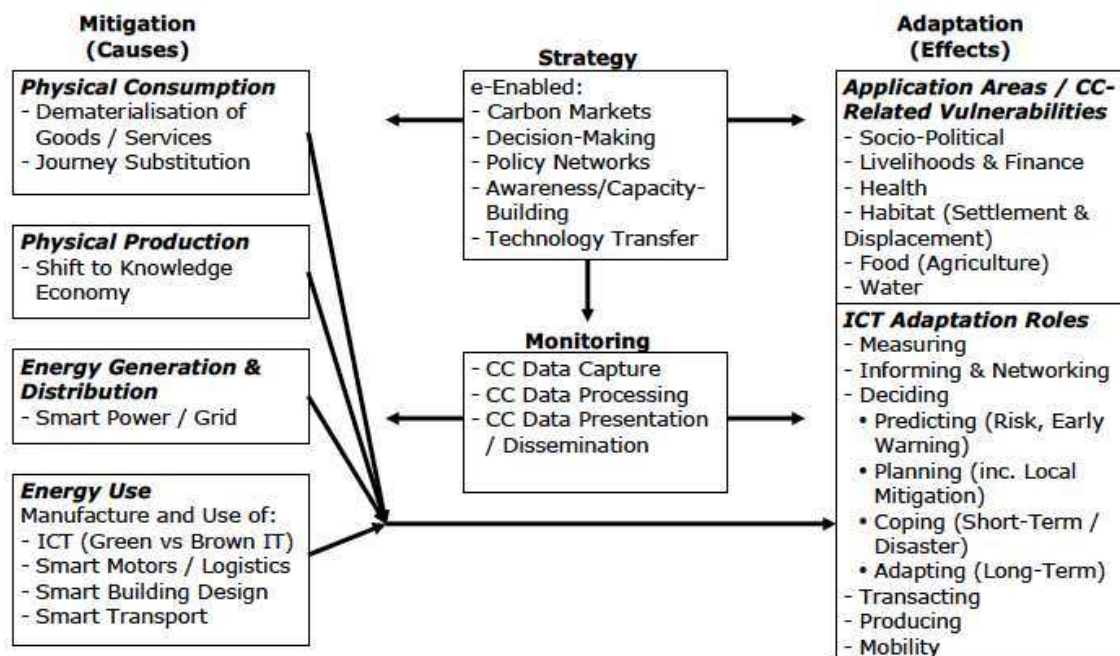
Figure 6: An overview of the ICCD model showing the main areas where ICT relate to climate change (Ospina & Heeks, 2010).

The fogwater project – and by extension my research on the development of the Fog Phone – aligns with the adaptation research priority. The Fog Phone is located in the adaptation tier of the model where it contributes to measuring, informing, networking,

deciding and planning (Ospina and Heeks, 2010a). The Fog Phone is also peripherally related to the monitoring agenda because it incorporates data capture, data processing and data presentation and dissemination.

The fogwater system and the companion Fog Phone are situated at the nexus of climate change, ICT and adaptation. Freshwater resources in southwest Morocco are under pressure from more frequent and longer lasting droughts brought about by climate change. Both the fogwater project and the water IS directly complement the Moroccan government's broad initiatives to conserve water and to explore alternative water sources in response to forecasts that climate change will substantially reduce overall water availability in Morocco over the next several decades. The supplemental fogwater system created by DSH is a response to decreasing water availability. The Fog Phone was designed to support that initiative by supporting communication between stakeholders about the functioning of the water system.

Ospina and Heeks make the argument that ICT play a significant role in climate change mitigation, monitoring, adaptation and strategy (2010a, 2010b, 2010c). In their "Future Research Agenda for ICTs, Climate Change and Development" strategy brief (2012), the authors argue that new research on the role of digital tools is needed to identify "innovative, locally-appropriate approaches to face the challenges and benefit from the opportunities posed by climate change" (Ospina & Heeks, 2012) (p. 1). Figure 7 illustrates the intersection among ICT, climate change and development.
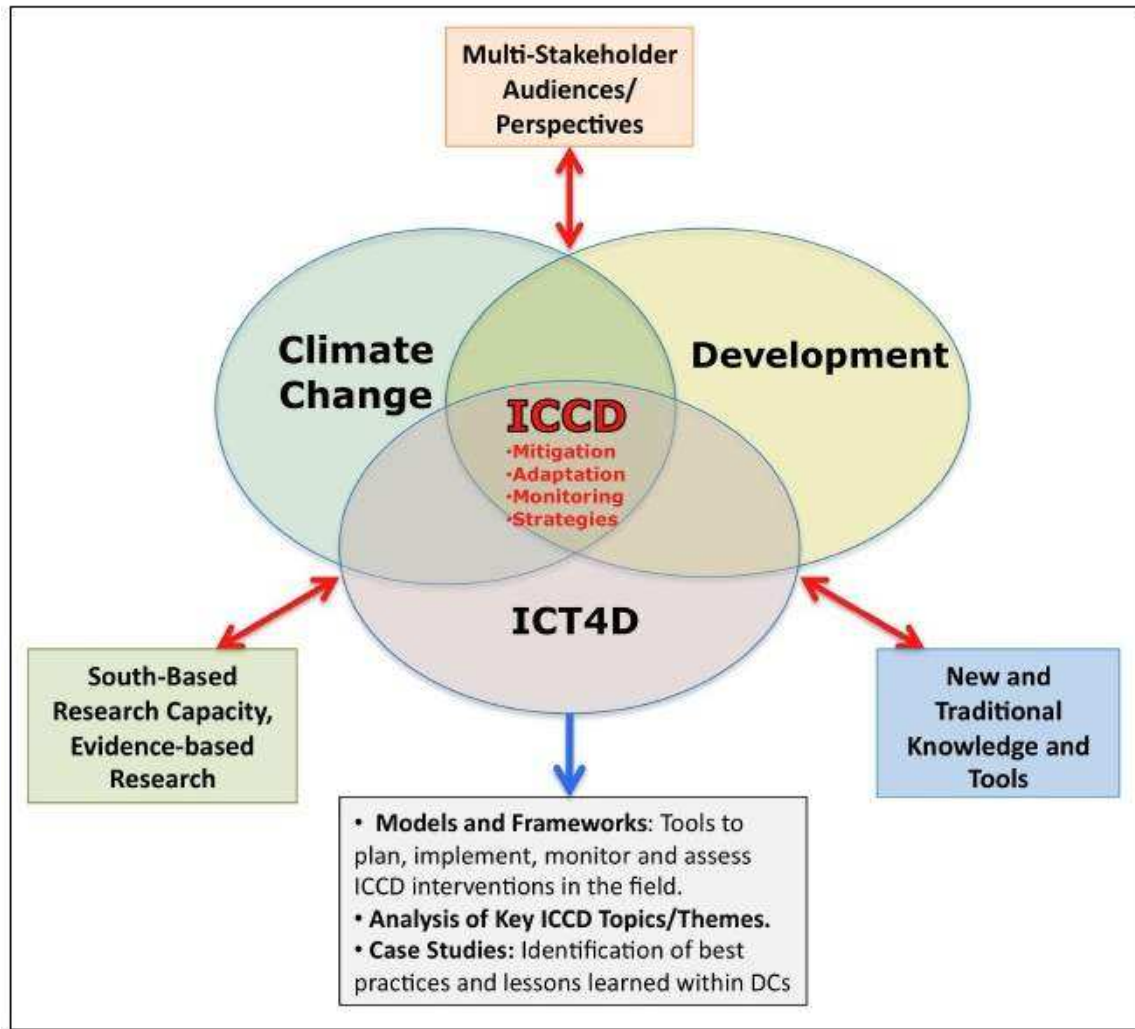
Figure 7: The ICTs, Climate Change and Development (ICCD) Model (Heeks and Ospina, 2012).

Heeks and Ospina highlight the opportunity to integrate ICT into innovative approaches to address climate change adaptation in developing communities that are on the front line of climate change effects due to acute weather events and chronic climate impacts (Ospina & Heeks, 2010a, p. 1). They advocate for a systemic and holistic perspective to consider the links between ICT, vulnerabilities, climate and broader contexts of poverty, which are consistent with principles of sustainable development. ICCD adds the important technological component to climate and development research.

As Ospina and Heeks note, there is a greater need "to explore further the links between ICTs, climate change and development, as these fields become increasingly interlocked due to the magnifying effect of climate change on existing development challenges and vulnerabilities" (2010c, p. 3). They suggest that ICT and natural resource management research and practice are most effective when projects involve substantial local participation. "The global scale of climate change impacts poses the challenge of achieving effective multi-stakeholder involvement in actions in the field; but it also offers the opportunity for greater citizen engagement through the use of ICT tools" (2010c, p. 13).

The ICCD model recognizes that issues related to gender flow through the model, but that "how gender influences the effectiveness of information and communication technologies in tackling climate change is under-researched" (Heeks & Ospina, 2012, p. 276). The model recommends the inclusion of gender analysis into ICT policies and initiatives (which I accomplish through the use of GAD Analysis). It also highlights the importance of crafting arrangements that improve gender inclusion and women's engagement in ICT-climate change interventions. I accomplished this by creating women-only ICT training sessions and through the use of female-centric participatory design sessions.

Furthermore, the authors signal the need for ICT to be utilized for local capacity building, which is a core element of this fogwater IS. "Access to the right information is a means of local and community empowerment and helps people enhance their capacity to sustain themselves" (Ospina and Heeks, 2010a, citing Labelle et al., 2008). However, the authors note that capacity building requires relevant information that is accessible to local

actors, a process which involves not only connectivity, but also "the use of dissemination channels appropriate to the local context" (2010a, p. 28). This fogwater IS creates contextually specific, locally relevant communication channels to help rural community members cope with limited water resources.

4.2 Theories of Gender and Development

4.2.1 Gender and Development (GAD) Theory

Research into the processes and tools involved in developing the water IS incorporates theory and analytical tools from Gender and Development (GAD). GAD is a useful theoretical approach to understand gender dynamics and issues of gender equity in developing communities. Gender and Development theory is predicated on the realization that development is not gender-blind. It recognizes that a gender-blind pursuit of development fails to consider women's and men's needs and viewpoints, and continues to undervalue women's contributions while ignoring women's central role in development as those who suffer the greatest burdens of poverty and disenfranchisement (Momsen, 2004; Parpart et al. 2000; UN Women, 2014).

A shift away from the women in development (WID) focus to a gender and development (GAD) focus was spurred by Ester Boserup's (1970) critiques of the Women in Development (WID) campaign. She highlighted the pervasive gender inequities in development strategies and pointed out gender-based divisions of labor and the under-recognition of the value of women's work in calculations of economic development (Boserup, 1970). In doing so, she brought to the fore the gender dimension inherent in development processes, observations that had sweeping policy implications. An awareness of gender inequities was adopted in the World Plan of Action of the UN

Decade for the Advancement of Women (Levy, 1992; Moser, 1989). GAD gained

traction in the mid-1970s as focus shifted to an analysis of how development reshapes

power relations (Momsen, 2004). Embedded in this discourse was a recognition that

power relations are imbued with issues of gender and gender relations. GAD challenges

existing gender roles and gender relations (Reeves & Baden, 2000). GAD analyzes how

development reshapes gender power relations, and it explicitly sees women as "agents of

change" (Momsen, 2004, p. 13).

In GAD, *gender* is defined as the socially acquired (rather than biologically

determined) "notions of masculinity and femininity by which women and men are

identified" (Momsen, 2004). *Gender identities* are socially acquired and are flexible, as

are gender roles. GAD does not view gender identities and roles as implacably fixed, but

neither are they homogenous. *Gender roles* are defined as the "tasks and types" of

employment that are socially assigned to men and women (Momsen, 2004, p. 2). GAD

scholars remark that gender roles become more flexible in response to changes brought

about by development, as those processes cause shifts in socially constructed definitions

of divisions of labor and power relations (Parker, Lozano, Messner, 1995). For example,

opportunities for women change as labor markets shift and development processes that

expand women's access to power can alter tasks and types of employment. GAD also

recognizes that "everywhere gender is crosscut by differences in class, race, ethnicity,

religion and age" (Momsen, 2004, p. 2). This is why it is important to consider gender as

the basis for development policies and projects.

Under the GAD framework, development encompasses more than just economic

attributes. It also involves social and gender issues. In order to expose barriers to

women's full participation in development (whether these barriers are economic, social or gender-based), GAD calls on researchers and practitioners to conduct a gender analysis to find the best strategies to address the different needs of women and men in developing communities (Marchand & Parpart, 2003; Momsen, 2004; Parpart et al., 2000; Parpart, Rai, & Staudt, 2002a, 2002b).

GAD is predicated on an awareness that development processes affect women and men in different ways, with women often faring worse in development planning because of gender-based discrimination and power differentials that disadvantage women (Boserup, 1970; Khoury & Moghadam, 1993; Mernissi, 1976; Molyneux, 1985; Momsen, 2004; Moser, 1989; Parpart et al., 2000; Parpart et al., 2002a; Tinker, 1976). Men generally have greater political and earning power, and their assigned roles provide them with greater access to information and resources such as wealth and influence (the key components of power). Furthermore, GAD recognizes that the subordination of women is universal: "for all societies the common denominator of gender is female subordination" (Momsen, 2004, p. 18). GAD-informed development seeks to address these imbalances and inequities while simultaneously advocating in favor of a gender-inclusive approach to development that involves both women and men as decision-makers in the planning and execution of development initiatives. In order to discern the differences in how development affects men and women, GAD encourages reflections on the different "roles, responsibilities, access to resources, constraints, [and] opportunities" between women and men (Moser 1993 as cited by Hafkin & Huyer). GAD leads to an understanding of how gender dynamics may affect participation in development

processes. GAD is specifically concerned with supporting gender equity in the management and participation in development initiatives.

GAD scholars endorse the view that gender equality is not defined by equal numbers or equal treatment of men and women. Instead, it refers to "equality of opportunity," and it indicates that women and men are able to lead "equally fulfilling" lives (Momsen, 2004, p.8). Equality takes into consideration women's and men's differing needs and priorities. It considers men's and women's distinct aspirations and constraints, and it distinguishes between practical needs that "would improve women's lives within their existing roles" and strategic needs that "seek to increase women's ability to take on new roles" (Momsen, p. 13).

GAD's usefulness lies in the identification of factors such as gender discrimination, lack of political empowerment and the manifold burdens that exclude women from participating in and benefitting from development (Parpart, Connelly, & Barriteau, 2000; UNESCO, 2003). In this way, GAD is grounded in the realities of women's lives and rooted in an analysis of gender inequalities. GAD Tools (discussed below) provide a systematic technique with which to consider these factors.

As a theoretical framework, GAD provides a systematic way to examine gender issues while GAD Tools are designed to help understand gender roles and responsibilities among stakeholders. GAD theory is operationalized in the 8 Tools of GAD Analysis (Parpart et al., 2000), a system to operationalize the interconnection between (and multiple jeopardies of) gender, class, and race (p. 141-143). Tool 1 explores the *gender division of labor* in a community. Gender divisions of labor relate to the types of work performed by women and men and to the patterns of work that are deemed acceptable for

women and men to perform. As Parpart et al. (2000) state, the differences in the nature of work are "a central aspect of gender relations" (p. 141). Tool 2 investigates *types of work*. GAD delineates among three types of work: productive, reproductive and community work. Parpart et al. (2000) offer that an intervention in one of these areas will affect the other areas because it may cause shifts in gender power dynamics. Productive work may be paid or unpaid. It generally involves the production of goods and services for both consumption and trade. Productive work encompasses self-employment, paid employment, fishing, farming and animal husbandry. Scholars note that women's productive work is often less visible and less valued than men's. Reproductive work refers to both biological and social duties (Momsen, 2004). Biological reproduction includes childbearing and infant nurturing and their effect on women's ability to undertake household maintenance tasks such as water collection. Social reproduction includes social management tasks such as kin-keeping, developing neighborhood networks and carrying out religious and social community obligations (Momsen). Social reproduction also includes responsibility for health, education and socialization of children, as "the household is the locus of reproduction so that social relations within the household play a crucial role in determining women's role in economic development" (Momsen, p. 48). Productive, reproductive and social/community work constitute double and triple burdens for women. "Women carry a double or even triple burden of work as they cope with housework, childcare and food production, in addition to an expanding involvement in paid work" (Momsen, p. 2).

Tool 3 considers *access to and control over resources and benefits*. This tool addresses the extent to which women's marginalization affects their access to and control

over resources and to what extent their disenfranchisement influences their ability to benefit from those resources. Tool 4 delineates *influencing factors* such as tradition, culture and the natural environment and discerns what impact those factors have on women. In Tool 5, *condition and position*, Parpart el at. (2000) distinguish between women's conditions and their positions relative to men. Conditions refer to material elements of women's day-to-day life such as daily needs for clean water and food. Position refers to women's social and economic status.

GAD Tool 6 considers *practical needs and strategic interests*. GAD pursues a two-pronged strategy of 1) identifying and meeting practical needs to improve women's lives within their existing roles, and 2) promoting women's strategic interests and needs that would enable them to take on new roles (UNESCO, 2003; Momsen, 2004). Practical needs include such life-sustaining necessities as water, food and shelter. Strategic gender interests refer to long-term and often entrenched factors of gender inequity and subordination that require structural change (Molyneux, 1985; UNESCO, 2003). Strategic interests relate to factors such as women's disadvantaged position, their lack of resources and lack of education. Meeting strategic gender interests help women achieve greater equality (World Vision International, 2008).

Tool 7 identifies *levels of participation*. Women's participation in development initiatives benefits both women and the programs. Development initiatives benefit from women's involvement as participants, beneficiaries and agents, and programs benefit from consultation with women. Women benefit from an involvement in development projects by gaining decision-making skills and management experience. Participation encourages women to organize and plan solutions (Parpart et al., 2000).

GAD Tool 8 highlights *potential for transformation*. GAD identifies the potential for women's lives to be changed through inclusion in development initiatives. As Parpart states, "transformatory processes create a better life, address inequalities and improve the position of women" (Parpart et al., 2000, p. 144). GAD Tool 8 focuses on the transformation of unequal power dynamics that disadvantage or marginalize women with the goal of intervening to disrupt or address unequal gender-based power dynamics that prevent women from fully participating in development.

GAD was a useful practical and theoretical approach to understand gender dynamics and issues of gender equity in the rural Berber communities participating in this fogwater project and how those dynamics may affect participation in the fogwater IS. I conducted a GAD analysis using the 8 Tools identified above. (Details can be found in Chapter 7.) Furthermore, consistent with GAD principles, the fogwater project and the attendant Fog Phone explicitly see women as agents of change as opposed to passive or compliant recipients of development (Grigsby, 2013; Momsen, 2004). Furthermore, GAD provided a useful lens through which to observe current ICT use by women and men in Berber villages. The results of my GAD Analysis are contained in Chapter 7.

4.2.2 Women in Development (WID)

The dominant competing theory to GAD is Women In Development (WID), which (1) perceives women as an economic resource, and (2) focuses on increasing women's income and productivity (Boserup, 1970; Marchand & Parpart, 2003; Razavi & Miller, 1995; Tinker, 1976). In its concentration on the economic benefits that stem from increasing women's efficiency and economic potential, WID often overlooks women's multiple domestic, economic and social roles (Momsen, 2004; Parpart et al., 2000). WID

has also been criticized for viewing women as passive recipients of aid and for "ignoring men's roles and responsibilities in women's (dis)empowerment" (UNESCO, 2003) (p.1). Furthermore, WID is not grounded in an analysis of gender roles and responsibilities (UNESCO, 2003). WID is often criticized for 'instrumentalizing' and 'essentializing' women by ignoring class, race and status which are highly relevant in GAD (Momsen, 2004; Parpart et al., 2000; Razavi & Miller, 1995). Furthermore, WID has been criticized for placing additional time demands on women through the pursuit of women-centric economic development activities (Parpart et al., 2000).

The WID approach, therefore, is not as relevant to my research because I am not pursuing a livelihoods or ICTD initiative that seeks to increase women's earning power. Instead, my research focuses on utilizing available ICT to enable women to be decision-makers and managers of a sustainable development project in ways that transform unequal relationships. Gender roles and responsibilities are of crucial importance to the sustainability of this fogwater project and the accompanying IS. WID does not provide a framework to consider these issues, thus Gender and Development (GAD) is the more appropriate choice for my purposes.

4.2.3 Gender, Environment and Development (GED) Theory

Gender, Environment and Development theory (GED) acknowledges that men and women interact differently with the environment and that those interactions are often established on the basis of gender. Gender, environment and development scholarship seeks to understand the "gender-differentiated interactions between people and their environment" (Dankelman, 2002, p. 2). GED is closely linked with sustainable development as "sustainable development asks for a basic understanding, recognition,

and focus on both environmental and social – including gender – aspects and their inter-linkages" (Dankelman, p. 2).

GED considers the "social, economic and environmental aspects of gender inequalities" (IISDa, IISDb, 2013) and takes into consideration women's considerable use of natural resources and their role in managing those resources. The "2009 World Survey on the Role of Women in Development" ranks women's access and control over resources such as water as crucial to the creation of a more equitable society (United Nations, 2009). Several UN conferences have recognized that women have an important role to play in resource use due to livelihoods and domestic duties that are often resource-dependent. Nevertheless, women typically have a minimal role in decision-making due to their marginalized status.

The 1992 UN Conference on Environment and Development (known as the Earth Summit), the Fourth World Conference on Women in Beijing in 1995, and the 2012 United Nations Conference on Sustainable Development all advocated in favor of increasing integration of gender concerns into environmental planning and policy (UN Conference on Women, 1995; UN Sustainable Development; UNCED, 1992). The 1995 Platform for Action on Women and the Environment calls on governments, NGOs and the private sector to involve women in environmental decision-making and to establish mechanisms to assess the impact of environmental policies on women (UN Conference on Women, 1995).

In light of continuing environmental degradation and increasing gender-based social and economic inequality, many development planners and policymakers, including the United Nations Development Programme, the World Bank, the Food and Agriculture

Organization and private-sector NGOs now take into consideration the differential relationships between women and men in terms of natural resource use and management and the differing impacts that environmental degradation has on women and men (Dankelman, 2002; FAO, 2014; IFRC, 2010; Levy, 1992; UNDP, 2014; WEDO, 2012; World Bank, 2013).

In "Population and Gender Equity" (2000), Amartya Sen promoted the dual goals of advancing women and saving the environment. Sen notes "advancing gender equality, through reversing the various social and economic handicaps that make women voiceless and powerless, may also be one of the best ways of saving the environment" (Sen, 2000). Sass (2001) examines how gender differences often determine how natural resources are used and how resource depletion affects women and men differently (Sass, 2001). Sass and others highlight that women's water-related domestic duties often put them in closer contact with the environment than men who work in manual labor or migrate out of rural zones (Roudi et al., 2002; UN Sustainable Development). Dankelmen (2001) also highlights the close relationship between women's work, the environment and environmental conditions, particularly the dominant role that women play in natural resource use at the local level (Dankelman, 2001). Despite this more intensive relationship with natural resources, women often do not have a role in the management of environmental resources nor do they have a role in related decision-making. "This limited participation in decision-making means that women's perspectives, needs, knowledge, and proposed solutions are often ignored" (Sass, 2001, p. 3).

Scholars warn that women's household duties "may dramatically increase with the depletion of resources" (Sass, 2001, p. 3), potentially widening the differential

between men's and women's responsibilities. This appears to be the case for women and men in Aït Baamrane villages who are affected differently by dwindling and degraded water sources and other natural resources (Roudi et al., 2002). For example, in the hottest summer months, women and girls travel longer distances to reach wells that have water because wells closer to home run dry in the summer. This search for water has implications for girls' school attendance and women and girls' health. As Sass (2001) explains, because girls are often responsible for fetching water, water scarcity contributes to higher school dropout rates. Due to expending more energy traveling longer distances to fetch water, they face increased risk of malnutrition and other health problems (Sass, 2001).

Some scholars argue that the achievement of gender equity is critical to sustainable development (IISD, 2013a; Levy, 1992). "The achievement of sustainable development depends on the availability and use of a coherent planning methodology to ensure" the integration of gender and environmental issues (Levy, 1992, p. 134). Momsen (2004) notes that "a gender-based approach to environmental issues, rather than a narrow focus on women's environmental roles, can enable separate, complementary and conflicting interests to be identified in ways that should lead to improvements in the sustainability and equity" of environmental programs and policy (p. 108).

GED is an appropriate approach for this research because the fogwater project and the water IS are both designed to address women's and men's water-related roles and responsibilities. Water service benefits women by relieving them of much of their water fetching tasks. An IS also benefits women by involving them as the guardians of the water and information systems.

4.2.4 GED and Water

The GED approach related to water is codified in the 1992 Dublin Statement on Water and Development, known as the "Dublin Principles." These principles recognize the increasing scarcity of water as a result of overuse and conflicting use. Dublin Principle 1 identifies fresh water as a "finite and vulnerable resource, essential to sustain life, development and the environment. Dublin Principle 2 states that water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels. Gender equity and women's empowerment are cornerstones of Dublin Principle 3, which states "women play a central part in the provision, management and safeguarding of water." Dublin Principle 4 highlights water as an economic good (Global Water Partnership, 2010a).

Gender equality, women's empowerment and environmental concerns are also cornerstones of the 2000 Millennium Development Summit, the 2002 World Summit on Sustainable Development and the Beijing Platform for Action (Global Water Partnership, 2010a, 2012b; UN Conference on Women, 1995). Women's pivotal roles as water users and environmental guardians have also been recognized by the United Nations General Assembly. In July 2010, the UN declared water to be a human right and firmly linked water access and governance with gender equality (Global Water Partnership, 2010a, 2012; UNESCO WWDR4, 2012a, 2012b). Implementation policies contained in the UN World Water Development Reports (WWDR) specifically call for gender considerations to be mainstreamed into water governance. This involves developing water policies that enable the broader participation of women. The UN also calls for the improvement of women's access to water resources. This clause of the UN's water policy calls for the

prioritization of water efficiency as a central tenet of water security and compels program officers and policymakers to foster initiatives that enable women to lead those efforts. The UN World Water Development Reports also highlight the need to enhance the "capacities of men and women to understand and address gender differences and concerns in water management." (UNESCO WWDR4, 2012a, p. 2). That clause specifically calls for young women to be trained and prepared for water-related careers in sustainable water initiatives like the DSH fogwater system and potentially, in ICT-based water livelihoods.

4.2.5 Other Theories Relating to Women and the Environment

GED shifts the focus away from an earlier model of development that concentrated on women, environment and development (WED). WED was largely considered ineffective because it often led to the marginalization of both the environment and women (Braidotti, Charkiewicz, Hausler, & Wieringa, 1994; Leach, 1991; Leach & Mearns, 1995; Levy, 1992; Momsen, 2004).

In addition to considering WED, I investigated, but did not employ, the applicability of Ecofeminist theory to this research, examining in particular Shiva's (1989) foundational work "Staying Alive: Women, Ecology and Development" that paved the way for consideration of the connection between the environment and women in developing communities. Shiva's reflections on the feminine qualities of nature are embodied in the concept of the 'feminine principle' (Shiva, 1989). That concept, evident in the phrase 'Mother Nature,' promotes the ideas that women intrinsically have a closer relationship than men to nature and that special connection makes them more aware of environmental issues (Momsen, 2004). Rocheleau et al. (1993) diverge from that view by

noting that differences in women's and men's experiences, responsibilities and interests in nature and the environment are not rooted in biology per se (Rocheleau, Thomas-Slayter, & Wangari, 1996). Braidotti et al. (1994) call Ecofeminism 'gynocentric', and Agarwal (1992) states that with its myopic emphasis on women's relationship to nature, Ecofeminism fails to account for differences in class, race, occupation and geographical context (Agarwal, 1992; Braidotti et al., 1994).

Momsen cogently sums up the flaws of Ecofeminism in her observation that Ecofeminism suffers from "multiple essentialisms" (p. 111). Ecofeminist principles, she says, are universalist and reductionist toward both women and nature. Furthermore, there is a troubled role for men in Ecofeminism, with some proponents blaming men and male hegemony for widespread environmental degradation (Momsen, 2004). Momsen (2004) also observes that it is difficult to reconcile Ecofeminist views with everyday field conditions.

CHAPTER 5

METHODS

This chapter describes the hierarchy of mixed methods of inquiry that were applied in both the exploratory research at the Coop and the primary research on the Fog Phone. Ethnographic Action Research (EAR) served as the umbrella method that informed more than eight months of fieldwork. Along with EAR, I incorporated the Sustainable Livelihoods Framework (SLF). The SLF provides a structure to investigate the vulnerability context that contributes to poverty and provides a way to assess the assets and capabilities individuals and communities have to cope with along with the stresses and shocks related to vulnerability. SLF "helps order complexity" and provides a cohesive structure around which to synthesize much of the data collected in the Ethnographic Action Research (DFID, 1999, p.2). Stakeholder Analysis (SA) was an effective tool to examine the dynamic relationships between stakeholders and to illustrate the contributions, benefits, risks and barriers to participation for stakeholders in the water IS (Mitchell, Agle & Wood, 1997; Savage, Nix, Whitehead, & Blair, 1991).

5.1 Ethnographic Action Research (EAR)

This research is primarily guided by tenets of Ethnographic Action Research (EAR), in which the researcher relies on ethnographic methods to assess, plan, implement and evaluate impact-oriented research (Tacchi, Slater & Hearn, 2003). EAR reflects a commitment to community participation throughout the research cycle, from needs assessment through intervention planning, implementation, reflection, iteration and evaluation. Furthermore, I used ethnographic methods to develop a "thick,"

contextualized description of individual behaviors and community-level patterns related to ICT use (Geertz, 1973).

This iterative cycle is captured in the four key questions that underlie EAR research (Tacchi et al., p. 5). The first question asks "what are we trying to do?" This question addresses the purpose and goals of the project. The second question, "how are we trying to do it?" turns project goals into specific plans. The question related to "how well are we doing?" highlights the requirement for iterative evaluation. The final question asks "how can we do it differently or better?" EAR stipulates that the researcher constantly review, re-evaluate and re-design an initiative in response to shifting circumstances.

At its core, EAR takes place "within a broad and embedded understanding of local contexts and needs" (Tacchi et al., p. 103). This research occurred over more than eight months of fieldwork in southwestern Morocco, providing me extensive time to not only observe, but to work with translators and local experts to better understand my observations and to build trust. Furthermore, EAR promotes the rich understanding of a specific place "in its own terms" (p. 11). The method demands that any development be contextualized within the community where the intervention takes place, and it requires that research be guided by local definitions of problems and opportunities.

Using EAR required observation and analysis of how ICT fit into the lives of the participants in the Coop, the stakeholders in the Fog Phone as well as the wider social context of the fogwater project (Tacchi et al., p. 10). As a participatory and change-focused form of research, participant observation is the foundation of EAR. I accomplished this by immersing myself in the daily life at the Coop where I spent

approximately 250 hours working alongside women either producing Argan oil or in mobile phone workshops and interviews.

The field methods described below were particularly useful in understanding the contexts surrounding ICT use that contributed to the mobile phone utility gap among rural Berber women. As defined earlier, the mobile utility gap is the condition where mobile access is pervasive, but use of mobile features is limited. These data informed plans for iterative and participatory phone literacy workshops at the Cooperative and in rural Berber communities involved in the fogwater project. My commitment to understanding relevant social, cultural and technical processes enabled me to develop a solid understanding of the potential role of ICT for women at the Coop and in communities involved in the fogwater project in order to plan the action phase of the research (Tacchi et al., p. 4). That plan was based on an appraisal of the utility of various ICT to communicate for personal and instrumental purposes. At the Coop, the appraisal of utility concentrated on whether women there considered asynchronous communication, such as SMS, to be a convenient and cost-effective alternative for staying in touch with family and friends. In communities participating in the fogwater project, I appraised utility in terms of whether rural Berber women perceived SMS to be useful and culturally appropriate for tasks related to water monitoring and reporting.

Consistent with principles of EAR, the Fog Phone had a change agenda to integrate ICT for instrumental use to improve monitoring and reporting of the water project. EAR and HCID methods coalesced in the collaborative design of the Fog Phone connecting the water users with project managers with particular attention being paid to the inclusion of marginalized women in the research processes.

I employ the term "Fog Phone" to identify both the alpha and beta versions of the communication system linking DSH and rural Berber women involved in the fogwater harvesting project. This moniker was a practical and convenient way to discuss the idea of a communication link and to plan and design the prototype system with English-speaking translators and DSH staff online, in-person and over the phone. The English-language shorthand name for the system changed when it was translated into and out of French, Darija and Tachelhit. Translators, women in Agni Hiya and I occasionally referred to the Fog Phone as the "telephone tagut" (tagut is the Berber word for fog) or, simply, "le système" or "le système brouillard" (brouillard is the French word for fog). I did not control the translations of the label nor did I deem it necessary to formalize the name of the system among men and women involved in the fogwater project. Similar to the lack of spelling and naming conventions in vernacular Darija and in SMS texts, imprecision when referring to the communication system did not deter participation in its development.

5.1.1 Participant-Observation

Participant observation served multiple purposes. It helped me build rapport with participants and stakeholders, and it illuminated social and cultural factors that contribute to the ICT utility gap difficulties with the user interface and language complexities. This information aided in planning mobile phone workshops and Fog Phone design sessions which were grounded in observation of patterns of work and daily life at the Coop, in the villages involved in this fogwater project, with the water manager and with project managers. In the villages, my participation included water fetching and learning water-related domestic tasks such as cleaning and tending animals. Planning also benefitted

from casual (translated) conversations about mobile use in the context of user's professional, personal and domestic lives.

5.1.2 Communicative Ecologies

To better understand the mobile utility gap, I assessed local "communicative ecologies" prior to planning and implementing ICT interventions in the Coop and in Agni Hiya, the pilot village for the fogwater system and the design of an accompanying IS (Tacchi et al., 2003, p. 15). A communicative ecology is the mix of media and communication activities through which people connect with their social networks (p. 17). Studying the communicative ecology involved understanding the "media repertoire" in use among ICT users at the Coop and in the water project. It also involved gaining an awareness of the relevant social networks among ICT users, including with whom users communicate, how and under what circumstances. It also required an understanding of how ICT use was organized around personal or instrumental activities. Communicative ecologies differ over time and space, across gender, age, caste and religious divisions. Furthermore, communication patterns differ within each 'ecology.'

This information helped me understand whether a particular ICT (for example, a basic feature phone, a smartphone or a tablet) or activity (such as SMS, calling or leaving voicemails) would fit into the existing social network or cultural system and whether the fogwater IS would be accepted by stakeholders' social networks (Tacchi et al., p. 16). It also revealed the potential to use ICT to expand personal and instrumental communication. Additionally, the study of the communicative ecology also incorporated an ICT technology inventory, described below.

5.1.3 Social Mapping

A "social map" of the fogwater project was also incorporated into Fog Phone planning (Tacchi et al., 2003, p. 19). For this effort, I concentrated on gathering details from residents in Agni Hiya in order to understand "the restrictions and freedoms in [women's] lives that determine what activities they can participate in" (p. 19). This part of the investigation involved gathering local demographic information about residents, constructing a genealogical tree of families in Agni Hiya to better understand social dynamics and relationship among water users, and the identification of available ICT, electrical and other infrastructure. The social mapping exercise also included an investigation of local information and communication needs regarding the new fogwater system. An awareness of these themes, relationships, problems and opportunities helped me plan an appropriate participatory approach to developing a potential fogwater IS. The data were incorporated into the SLF, GAD and GED analyses in Chapter 7.

5.1.4 Focus Groups

I conducted 10 focus groups in Agni Hiya pertaining to determining information needs, training and the iterative design of the Fog Phone to link water users with DSH project manager. Focus groups were held in family compounds and in public spaces around Agni Hiya, such as where women gathered to make Argan oil or in a shady spot under a tree. In those settings the research team and I trained women on how to send SMS messages and make phone calls. We also discussed useful water-related issues to include on a poster that would serve to remind water users how to monitor and report on residential plumbing issues. The focus groups informed the participatory design sessions where we collaborated on designing the Fog Phone using whiteboards, photographs and

paper. Further details are in Chapter 10.

5.1.5 Public Presentations of Research

I presented my research plan and described my role in the fogwater project in two separate, gender-segregated large-group meetings of women and men from communities participating in the new water distribution system. At those meetings, I described my interest in investigating the information needs related to the new water system. I also related plans to continue to conduct ICT-related interviews and additional water-related interviews. I announced that all participation in the research is voluntary and that there was no penalty for non-participation or for leaving the study at any time. I repeated this clause in focus groups and face-to-face interviews. These presentations helped build trust and understanding in the research project and the Fog Phone.

5.1.6 Technology Inventory

I conducted a technology inventory at the individual, household and project level to assess the type of ICT in use and in working order. This helped me ascertain what, if any, available equipment could complement the Fog Phone. I was also able to identify where additional devices might be employed. In semi-structured ICT interviews (described below), I posed questions about whether interviewees used or had access to mobiles, televisions, radios, DVDs, PC or laptops. I often asked to see an interviewee's mobile phone, and, after receiving verbal consent to look at their device, took note of the type of mobile, the brand and the condition. I visually evaluated the condition of devices and assessed whether they could be utilized in the Fog Phone. (In some cases, the numbers and letters had completely worn off the keypad, which would make it very difficult for a mobile user to easily send an SMS message. See Figure 8.)

Figure 8: Low-quality, counterfeit and used mobile phones are prevalent in rural Berber communities.

Occasionally, I photographed personal mobile phones, with verbal consent. I observed which ICT were present in the home (such as DVD players and televisions) and asked whether the equipment was in working order. I also asked interviewees whether they used the equipment and, if so, how had they learned to use it?

In order to discern whether a mobile phone-based IS would be practical from an operational standpoint, I investigated both telecommunication network signal strength and electricity availability for charging devices. With the water manager, I discussed his ability to get a cell tower signal from the site of the fog nets, at the cistern, along the main pipeline, at his home and in various villages. With water users, I asked whether they

could access an adequate signal (for SMS and calling) within the family compound or in the immediate area around the community. I also participated in the technology inventory by using my own mobile phone to gauge signal availability and signal strength in public and private spaces related to the water project. The results of this technology inventory are below.

Stakeholder Technology Inventory

I observed a wide range of ICT in use by the stakeholders, and I identified the various types of ICT in use for both personal and professional purposes, in some cases noting model and brand names. Low-literate rural Berber women tended to have simpler-feature phones. The water manager had more sophisticated ICT than women in the villages. He owned two smartphones, which he used for both personal and professional communication. He texts, calls and 'beeps' family and friends. He connected to the internet to sign on to Facebook and other social media sites, and he accessed entertainment via his smartphone. He regularly used his phones for purposes related to the fog project. For example, DSH regularly contacts him via calls or texts to give him project-related instructions and to share updates related to the fog collecting system implementation. He also used his phone to call or text laborers, contractors, transporters and male village members to discuss or initiate water-related work. DSH uses sophisticated computers, laptops and smartphones. DSH staff regularly used their phones for both personal and project-related communication, easily moving back and forth between these uses.

The mobile network was available at the fog net site at the peak of Mt. Boutmezguida, but coverage was varied along the water pipeline. Most residents in the

rural communities involved in the water project could not get a strong enough signal inside thick-walled family compounds to make or receive calls. They could occasionally receive and send SMS messages from within an interior courtyard but most had to exit their home and hunt for a signal strong enough to access voice services.

My assessment was that any coordinated water-related information network between household water users, the technician responsible for the system infrastructure (the water manager) and project managers would need to accommodate multiple ICT which were often in disrepair and used under rugged circumstances where mobile coverage was intermittent.

5.2 User-Centered and Contextual Design

User-centered and iterative design approaches were crucial in the implementation phase of this research. Human-Computer Interaction for Development (HCID) methods guided design relationships and interactions with stakeholders during the design phases of the Fog Phone. Informed by contextual information about ICT use by low-literate rural Berber women gathered from EAR, I employed progressive, participatory HCID design techniques such as to create relevant mobile phone-based literacy workshops with and for women at the Coop and with stakeholders in the fogwater project.

User-centered design methods were particularly appropriate for research on the design of the Fog Phone for the low-literate, marginalized women involved in the new fogwater system because the system was designed to help them monitor and report on the new water system, so I deemed their input to be crucial. This called for a participatory approach incorporating user feedback in an iterative design process to create the first phase of the Fog Phone to meet the identified and distinct needs of water users, the water

manager and project managers. Their participation was reflected in the water codes and the design of the water posters, discussed in Chapters 8 and 9.

5.3 Sustainable Livelihoods Framework (SLF)

Amartya Sen's (1999) work helps provide the conceptual foundation for "an alternative and broader" approach to development that focuses on the human dimensions of development, rather than solely economic issues (UNDP, 2013b). That conceptual foundation is grounded in an understanding of capabilities, or what a person is capable of doing, along with other quality of life characteristics such as functionings (self-respect, happiness, possessing a good job) and agency (the ability to make choices about 'functionings'). These ideas underpin the Capability Approach, which is operationalized in the Sustainable Livelihoods Framework (SLF).

The Capability Approach (CA) focuses on creating opportunities for freedom (Alkire, 2002; Anand, Hunter, & Smith, 2005; Sen, 1999). Freedoms, which are often inter-related, include political freedom, economic protections and freedom of opportunity. Poverty, Sen writes, is more than "merely low income" (Sen, 1999, p. 20). It is a deprivation of basic capabilities that often manifest as premature mortality, hunger and illiteracy. Enabling freedom, Sen (1999) writes, requires the removal of major sources of "unfreedom": poverty, poor economic opportunities, systematic social deprivation (social unfreedom) and neglect of public facilities as well as other obstacles. The issue of social unfreedom specifically applies to this research in that social unfreedom includes denial of access to education or clean water.

I employed the Sustainable Livelihoods Framework (SLF) as an analytic tool to gain an understanding of individual, household and community-level assets in villages

involved in this fogwater project that affect how community members cope with stresses, shocks and vulnerabilities. I also used SLF to investigate threats and opportunities that challenge those asset bases, to the degree that they could affect livelihood outcomes. Livelihoods are defined as the capabilities, assets and activities required to raise the standards of living or are a means of making a living. Livelihoods are sustainable when they help community members cope with vulnerabilities or recover from shocks while maintaining assets and preserving the base of natural resources (Chambers & Conway, 1991; Duncombe, 2006). As such, this water project and the accompanying IS can be considered a potential contributor to livelihoods (DFID, 1999; IFAD). The SLF derives from Sen's Capabilities Approach (Sen, 1999). The Capabilities Approach has generated numerous Sustainable Livelihoods Frameworks, including the mainstream SLF developed by the U.K.'s Department for International Development (DFID) and the modified framework created by the International Fund for Agricultural Development (Hamilton-Peach & Townsley, 2004; IFAD, 2010, 2013) (Figure 9). These frameworks emphasize the multiple and dynamic interactions among factors affecting livelihoods (DFID, 1999). SLF was incorporated into this research because it helped illuminate how different community and environmental factors could influence the fogwater project and the IS (DFID, 1999; Duncombe, 2006; KIT, 2005).
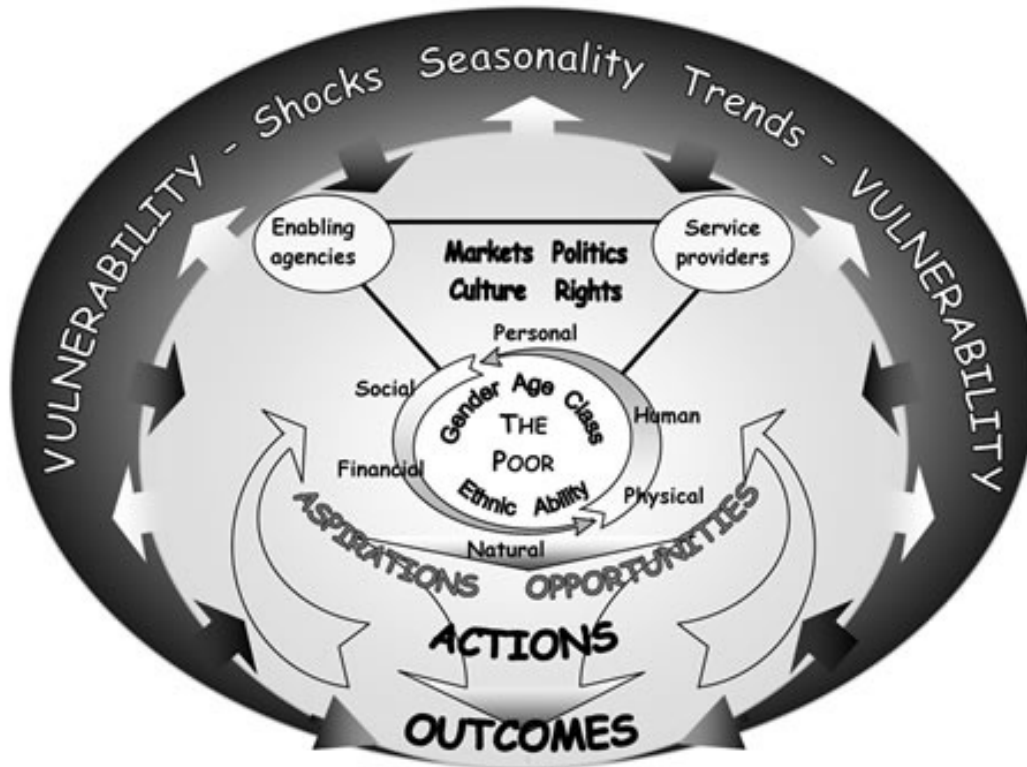
Figure 9: The IFAD Sustainable Livelihoods Framework (Hamilton-Peach & Townsley, 2004; IFAD, 2010).

There are important differences between the DFID and IFAD frameworks. Both frameworks incorporate actions, outcomes and opportunities, as well as vulnerability contexts and threats. My research uses the IFAD SLF framework. The significant difference between the two frameworks is that the mainstream DFID SLF analyzes only five capital assets: human, financial, social, physical and natural while the IFAD SLF adds a sixth asset, the personal asset, which represents personal motivations and spiritual life. Personal assets such as spirituality are important contextual components in the communities participating in the fogwater project, and it would be incomplete to exclude personal assets from this investigation. Furthermore, IFAD's integrated framework is

more germane to this research because it provides a more holistic view of the relationship between the vulnerability context and an individual or community's ability to manage vulnerability or pursue opportunity. IFAD also highlights components such as gender, age, class and ability, and it recognizes the interdependence and interactions between those components.

5.3.1 Definitions

The constituent elements of the IFAD SLF include vulnerability context; the six assets (or capitals); and social processes such as gender, age, class, ethnicity and ability; external structures, actions and outcomes. These elements are each described below.

Vulnerability Context

The SLF recognizes that "the poor" operate in a context of vulnerability, within which there are factors that exacerbate their vulnerability. The vulnerability context is defined as the external environment over which the poor have limited or no control such as political, financial or personal shocks or crises, seasonality related to crops and income-generation, and long-term conditions such as economic and climate trends (DFID, 1999).

Assets and Capitals

Human capital represents skills, knowledge, health and the ability to work. Indicators of human capital include life expectancy, education levels and access to information. *Financial capital* includes cash, reliable income, pensions, liquid assets such as livestock or jewelry or cash equivalents including savings and remittances. Financial capital tends to be the least available asset to the poor (DFID, 1999). *Social capital* is comprised of organizations, norms, trust, membership, honor, identity and extended

networks. An analysis of social capital also includes the presence and role of information networks. These elements can provide the poor with social safety nets as well as a buffer to cope with shocks. It should be noted that social capital is not always positive. For example, strong groups may exclude weaker members (i.e. women), and networks may be hierarchical or coercive. *Physical capital* is an essential component of wellbeing. It consists of basic infrastructure related to energy, water, transport, shelter and communications. Lack of infrastructure and other physical capital is often a core dimension of poverty (DFID, 1999, p. 13). The components of *natural capital* are access to productive land and trees, climatic conditions and water quality. As DFID (1999) states "the relationship between natural capital and the vulnerability context is particularly close" (p. 11). Finally, IFAD adds personal capital to the list of the five core assets found in mainstream frameworks (Hamilton-Peach & Townsley, 2004). *Personal capital* encompasses internal motivations, individual will to act and promote change, and spiritual dimensions of life which affect individual and household choices. Personal capital is an especially relevant aspect of this fogwater project and, by extension, the Fog Phone. As the primary water stewards for the new water system and as the primary water monitors and reporters, women's will to participate in the Fog Phone was a particularly important aspect of this research. Furthermore, women who participated in the plumbing workshops or SMS and phone training sessions did so out of an individual will to act and promote change.

Social Processes

The IFAD SLF adds a set of fundamental social processes such as gender, age, class and ethnic group because these factors "can influence everything at all levels within

the framework" (Hamilton-Peach & Townsley, 2004, p. 2). Social processes relevant to this fogwater project and the IS are examined throughout the SLF.

External Structures

In addition to core assets, SLF incorporates external structures, institutions and enabling agencies including service providers that can transform the lives of marginalized individuals. These are public, private and non-governmental organizations that set or deliver policy, goods and services. I have incorporated a Stakeholder Analysis (SA) as an adjunct to External Structures.

Actions

Actions (DFID uses the term 'strategies') are those activities that help people achieve livelihood goals. In this research, actions refer to activities related to current water gathering and water use activities related to the sustainable use of clean water (DFID, 1999). Actions also include the use of ICT to monitor and manage the water system.

Outcomes

Outcomes are the outputs, or achievements, of livelihood-related actions. Outcomes may include reduced vulnerability, more sustainable use of natural resources, increased income, or improved food security (DFID, 1999, p. 25). In this research, outcomes pertain to the effective and sustainable implementation of this fogwater project and the accompanying water system IS. DFID provides models for positive, sustainable and achievable outcomes, but IFAD differs here as well. As the IFAD SLF points out, outcomes are not universally positive if, for example, the marginalized tend to receive poor support from service providers (Hamilton-Peach & Townsley, 2004).

5.4 Stakeholder Analysis (SA)

I utilized Stakeholder Analysis (SA) as an additional method to conceptualize the community involved in the development of and use of the Fog Phone. Along with the SLF, the SA contributed to an understanding of mid-and-macro-level factors that affect both the water system and an accompanying Fog Phone. The stakeholder groups related to the Fog Phone include DSH, the male water manager, female water users, male members of the community and the relevant telecommunications authority and network providers.

Each stakeholder had different skills and capacity to participate in the research on the development of an IS, and each had different motives and willingness to adopt the IS or encourage or discourage its adoption. Each stakeholder group also had different resources to contribute to the research in terms of time, technology and tAabiya (mobile phone credits). Conducting an SA gave me insight into stakeholders' willingness and ability to participate in the development and use of the Fog Phone. It also provided a view of which actors might exert negative influence or serve as detractors on the development of the Fog Phone.

SA is intended to highlight potential allies and problematic relationships that can be controlled for, or at least partially mitigated, in the design of the Fog Phone. SA helped illuminate power relationships that pertain to political, social, gender-based or economic power. The SA was also useful in identifying secondary and tertiary stakeholders, who, while subordinate, may exert positive or negative influence over a development initiative. These 'shadow' stakeholders could conceivably have an impact

on the sustainability of the water project, and by extension, on the relevance of the Fog Phone to help manage the system.

5.5 Complimentary Methods and Models to Inform the ICCD Model

EAR, SA and SLF are complimentary to the ICCD model (and may contribute to the model by helping to operationalize it for other researchers).

I employed Ethnographic Action Research processes (observe, plan, do, reflect) throughout nearly eight months of field research. Over that time, I acquired a substantial amount of detailed information that allowed me to understand individual ICT use patterns and the communication patterns among Coop members and in communities involved in the fogwater project. The supplemental data helped me 'scale up' my view of the research communities and broaden my understanding of social dynamics, stakeholder relationships and wide-reaching vulnerabilities. These data served as inputs to the GAD and GED analysis, a Stakeholder Analysis and a Sustainable Livelihoods Framework analysis. I further scaled-up my view of the fogwater project and the accompanying Fog Phone by using the ICCD model to understand meta-level issues such as climate change, hydrological resources, and informing and networking roles that are part of the adaptation tier of the ICCD model. Figure 10 depicts these relationships.
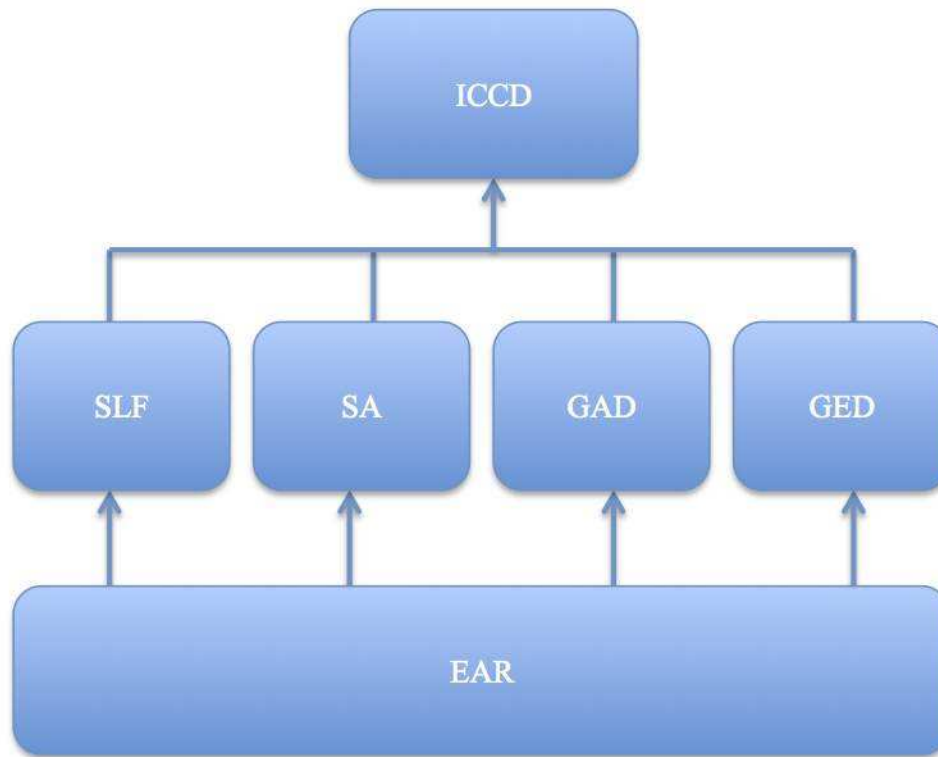
Figure 10: Ethnographic Action Research (EAR) data were used to populate the Sustainable Livelihoods Framework (SLF), Stakeholder Analysis (SA), Gender and Development (GAD) and Gender, Environment and Development (GED) analyses. Those methods and frameworks inform the ICTs, Climate Change and Development (ICCD) model.

5.6 Summary of Methods

In conclusion, Ethnographic Action Research (EAR) provided a structured format to acquire knowledge about the two research communities through an understanding of the participants, their needs and the socio-cultural and technical environment that frames their ICT use. EAR also provided an iterative and participatory approach to research that was useful in mobile literacy workshops and in prototyping this fogwater IS. The Sustainable Livelihoods Framework (SLF) was complimentary to EAR by offering a systematic exploration of community-level vulnerabilities, assets and strategies among

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stakeholders involved in the fogwater project. Stakeholder Analysis demonstrated in greater detail the many stakeholders of this project and the relationships between them.

Together, these mixed methods created a coherent set of procedures to conduct more than eight months of fieldwork in rural Berber communities in Aït Baamrane.

5.7 Research Instruments

5.7.1 ICT Interviews

In order to examine the communication patterns pertaining to ICT and mobile phone use by Berber women at the Coop and among stakeholders involved in the fogwater distribution project, I conducted 58 ICT-related interviews and focus groups with women in summer 2012 and again in spring and summer 2013. Between November 2012 and July 2013, I conducted 19 ICT interviews at the Argan oil Cooperative as well as an additional 39 ICT interviews with the local water manager and men and women in communities involved in the water project (the rural communes of Agni Hiya, Agni Zkri, Id Soussan, Tamarrout and Id Aachour). During those meetings, I explored technical, social, financial and motivational characteristics of ICT use. My aim was to give context to the mobile utility gap among rural Berber women where mobile access and ownership is pervasive but use of features beyond basic calling and texting is limited.

I used these interviews to gather detailed information on what communication devices were in use by stakeholders, levels of technical and functional literacy and opinions about exchanging information between unrelated women and men. Interviews also focused on aspects of phone ownership and use, including phone and service type, average expenditures, how often women made or received calls for personal and professional purposes and to what extent users accessed text-based features such as SMS

or the phonebook. I explored the use of 'beeping' and features such as the camera, radio or flashlight and inquired about coping strategies women use to operate their phones such as the use of intermediaries, or proximate literates, to repair their phones, to read and write SMS messages or dial calls (Ling & Donner, 2009).

In exploratory research at the Coop and throughout primary research on the fogwater IS, I investigated the reasons for the low adoption of SMS. I focused the questions on variables such as literacy levels, interest and motivation and cost barriers for SMS.

I interviewed participants and stakeholders on the perceived usefulness of their phone, perceived ease of use and the perceived value of SMS (Davis, 1989; Kang & Maity, 2012). I sought to discern to what extent low SMS adoption was due to structural obstacles such as lack of literacy or insufficient financial resources. I also asked interviewees about technical and linguistic barriers that discouraged their use of SMS such as the lack of local language script(s) on their phones and whether they experienced social and gender-based barriers to SMS use. Through conversations about mobiles use as well as observations of actual ICT use, I was able to identify cognitive barriers to use. My goal was to identify the cognitive barriers that impeded ICT adoption such as finding a mobile phone difficult to use (i.e. technical usability) or inability to understand how to access the SMS features of the phone (i.e. difficulties with user interface). Below I list the open-ended questions I used in the ICT interviews at the Coop and in villages involved in the fogwater project.

- Is your mobile phone important to you? Why or why not?
- What type of mobile phone do you have?
- What languages does your phone support? What language is your phone set to? Why?

- How do you make or receive a phone call? Can you show us?
- Do you send SMS messages? Is texting easy or convenient for you? Why or why not?
- Do you program your own phone? If so, how did you learn to program your phone? If not, who programs your phone for you and why?
- Approximately how many incoming and outgoing calls and texts do you have in a week?
- Do you access the radio, camera, games, alarm or other functions on your phone?
- Do you use the phonebook or contact list? How do you store or find phone numbers?
- Approximately how much money do you spend every week to purchase calling and texting credits?
- Do you make any financial sacrifices in order to buy credits for your mobile phone?

The interview instrument was revised early on to simplify the wording of some questions to make it easier for translators to communicate the meaning of questions. The interviews contained questions related to mobile phone use but were open-ended enough so as not to constrain the conversation. I was consistent in my use of the interview instrument, using it during more than six months of fieldwork. Uniform use of the interview instrument was also beneficial for translators who were not initially familiar with technical terminology. Findings from ICT interviews are presented in Chapter 10.

5.7.2 Water Use Interviews with Stakeholders

I also conducted semi-structured water use interviews with adult women in Agni Hiya from June 16-July 7, 2013, which corresponds to the duration of the pilot test of the water system. My goal was to understand how they organized their water fetching duties in their daily lives and to gauge their willingness to participate in this water IS. The open-ended questions are listed below:

- Can you tell me how and where you gather water? Please give me as much detail as possible about your normal water-gathering duties.
- How much time do you normally spend hauling water?
- What do you use water for? How much water do you use every day or week?
- What has been your experience with the new water system?

- How has having piped water to your home made a difference in your daily life?
- What information do you want to receive or send about the new water system?
- Would you be able to use your mobile to text or call about water issues? If not, why not?
- Can you access an adequate signal (for SMS and calling) in your home or in the village?
- Do you need the approval of family members to participate in water reporting?
- Do you foresee any problems from participating in managing the new water system?
- If you are interested in participating in a mobile phone based reporting system, would you be available for some short training sessions?

Those interviews were conducted in both private and public spaces in Agni Hiya, including at well sites, during shared meals and while performing shared tasks such as dishwashing. I also conducted interviews near water meters and water faucets in order to generate commentary comparing laborious water-hauling with the convenience of home water delivery.

I asked interviewees in Agni Hiya to provide a brief overview of how they gather and use water, as well as to provide any information that would assist me in understanding their role as guardians of water resources. I inquired about their experiences and impressions of the new water system and prompted them to provide details about what information they wanted to communicate or receive pertaining to the new water system.

Interviews with the local water manager occurred on site in Agni Hiya as well as at the net site at Mt. Boutmezguida. In addition to questions on the ICT interview instrument, I asked whether he thought it was efficient for him to be a point of contact for water users to report water problems and whether he preferred talking to men or women about water-related issues. I also spoke with him about mobile network coverage around

the fog net sites and along the main pipeline, and I asked whether he was able to make and receive mobile calls or texts in or near villages.

I had numerous discussions with project managers from DSH about the need for an information exchange system. I inquired about their interest in an overall ICT-based monitoring system to check the functioning of the fog harvesting infrastructure, and I discussed specific devices they might want to use. I asked detailed questions including:

- How might project leaders or DSH staff want to 'triage' information from and to the water manager and water users?
- How might they need to aggregate and disaggregate information in order to respond to individual service requests and requests from agencies and funders?
- What geographical and technical conditions might affect the collection and transmission of the water manager's infrastructure reports?
- What is the availability of network coverage from the fog net sites and the villages?
- What ICT security and maintenance problems such as the potential for theft, loss or damage need to be considered in the design of an IS?

5.7.3 Coding and Data Retention

Data from all of the ICT-related interviews were entered into spreadsheets and coded by responses to questions in the interview schedule. I also entered demographic data and interview location information along with detailed statements made in response to interview questions. The use of spreadsheets allowed me to identify themes among the responses. Themes included topics such as SMS use, use of phonebook, reliance on surrogates, dialing skills and financial outlays. I also entered comments related to self-perception of skills and social and gender dynamics related to mobile phone use.

I organized and coded water-related interviews by broad themes such as labor (related to water hauling), education, gender and power dynamics, water use, importance of water and comments related to reluctance or willingness to participate in developing or

using a fogwater IS.

I also utilized spreadsheets to enter in every incoming and outgoing text message between the Fog Phone and community members involved in the fogwater project. In the alpha test, these messages were sent to and from my personal cell phone. In the beta test, messages were logged into a program installed on a DSH laptop. I then transferred all incoming and outgoing messages from the beta test into spreadsheets in order to analyze and compare the results from the alpha and beta tests.

Throughout the exploratory and primary research, I took written notes while in the field and transferred them into a field log/field diary on my laptop computer. This enabled me to organize the information and utilize it in the Sustainable Livelihoods Framework (SLF), the Stakeholder Analysis (SA), the Gender and Development (GAD) analysis and the ICTs, Climate Change and Development (ICCD) model.

5.7.4 Secondary Data

Data from DSH's 2011 household survey containing community demographics, livelihoods, water use and perspectives on water quality and quantity were incorporated into this research in the Sustainable Livelihoods Framework and the GAD and GED analyses (Chapter 7). I also collected schematics, plans, maps and other documents from project managers to help me understand the organization's information needs including where water pipes were laid, where pipe community valves were located and how water service was controlled which were beneficial to the design of the Fog Phone because these details helped us understand potential issues with water delivery.

CHAPTER 6

EXPLORATORY RESEARCH AT THE TAFYOUCHT ARGAN OIL COOPERATIVE

I began my research into gender, technology and natural resources at the Coop. My original goal was to investigate the feasibility of developing the Fog Phone that might involve Berber women in the Argan oil value chain by using ICT to link them to Argan forest management and to the wholesale market (Figure 11). While my research moved from this site to studying the feasibility of the water IS for the reasons previously discussed, many interesting findings arose from my time at the Coop.

Figure 11: A Berber woman uses her phone at the Argan oil Cooperative.

6.1 Observations from the Exploratory Research

I interviewed a total of 19 women from the Coop. Study participants ranged from low-literate to illiterate and innumerate. Participants have owned their mobile phones for an average of six to ten years. Mobile phone users at the Coop placed a high personal value on the phone and report high levels of satisfaction with their phones. Women's phone use was limited almost exclusively to voice services, primarily for family 'kin-keeping' and maintaining contact with friends, as opposed to livelihoods-related communication (de Silva, Ratnadiwakara, & Zainudeen, 2011; Donner, 2004; Rashid & Elder, 2009). They also used their mobiles for convenience communication such as calling a child or asking someone to run an errand. Despite high levels of mobile phone ownership, most participants had not tried to use features such as phonebooks, voicemail or mobile-based radio or Internet options.

Berber women mentioned other, broader, benefits of mobile phone use including entertainment, security and status. Interviewees expressed pride in having and learning to use a phone; they found their handset fun; and they placed high emotional value on being able to contact family. For some women, the mobile phone replaced physical mobility, which was often restricted for financial and cultural reasons.

6.1.1 Types of Phones

Of the 19 women interviewed at the Coop, all but two owned simple feature phones. They had an eclectic array of simple and low-end feature phones, ranging from basic, small-screen, old-model mobiles to flip phones with cameras and color interfaces. Women obtained their phones from a number of sources including the souq (market), as hand-me-downs from family members who bring new and used phones back from

Europe, as well as purchased counterfeit phones from unauthorized cellphone dealers. Old, used, simple feature phones in use by Berber women at the Coop generally did not support Arabic script. Their phones only supported languages that use the Latin alphabet (for example, English, Spanish and French).

6.1.2 Cost of Ownership

Women at the Coop reported that they are active and enthusiastic users of voice services, often spending a significant portion of their monthly income on voice calls. Women fund their phone use primarily with earnings from Argan Oil production, occasionally spending up to 40% of their monthly income on their phone. Calling increases dramatically during the holy month of Ramadan or when family members migrate for work or serve military duty. Some users acknowledge spending more money to place a call than the value of the service received (i.e. they spend 5 Dirhams (about 60 U.S. cents) to request a 1-Dirham (12 cent) item from the store). Users recognized that using the phone just for voice calls does not exploit the functionality of even the most basic phone and is the most expensive way to use their devices. Respondents relied exclusively on pay-per-use call packages, installing calling credit on an as-needed basis. Similar to Banerjee and Duflo's (Banerjee & Duflo, 2011) findings, women occasionally prioritized spending on their mobile over both personal necessities and discretionary purchases. As one woman stated, *"When you have something that is important to you, you get rid of clothes or things to eat to pay for the phone."*

6.1.3 Limited Use

Women at the Coop openly discussed the importance of their mobiles and were forthcoming about their ability and lack of ability with various phone features. Many

women expressed an interest in expanding the use of their phone but were perplexed as to how that could be accomplished.

The majority of women in the study self-identified as illiterate and uneducated and were candid about their inability to read or write any of the numerous languages spoken and written around them (for example, Darija, Berber or French). Perceptions of inferiority pervaded interviews: many women felt they were not "qualified" to use SMS. *"I'm illiterate. How could I text?"* *"I am blocked. I cannot learn how to deal with the phone."*

Others highlighted language barriers that precluded them from using SMS. *"My phone only speaks French. I don't speak French,"* or *"I don't know how to send messages in French. If I learned French, I would send texts. I would like to be taught French."* Some women responded that texting was out of reach for them because of life complications. *"I don't have any empty space in my brain or my life to learn to text. My head is full of life, problems and hard work."*

I regularly heard complaints that women could not use many of the features on their phones because they could not troubleshoot problems. Old, broken and counterfeit phones required substantial maintenance, and low-literate women did not have the skillset to repair their phones or to restore functions. Despite these barriers, study participants appeared to have a well-developed ability to recognize patterns (i.e. number sequences, emoticons, design elements) on their phone screen and in tiny phonebooks that family members had created for them.

6.1.4 Importance of Proximate Literates

With the exception of younger women (18-25 years old), the majority of women at the Coop was unable to negotiate letters and numbers on their phone without the help of proximate literates and trusted others. These family members, friends and acquaintances provided crucial scribe services for women who are not able to negotiate letters and numbers on their mobiles. Illiterate and semi-literate Berber women reported that they capitalize on their networks to support their mobile use by giving their phone to others to install calling credits; they rely on children to program their contact list; they seek out trusted contacts to read and write text messages; and they have others dial and answer calls for them. Many of the women reported that they knew how to access an incoming call but did not know how to dial a call. They enlisted a friend or family member to perform that service. Those who self-identified as illiterate or innumerate said they often received help from children who program icons to represent phone numbers, allowing women to identify callers via a visual cue.

In religiously and culturally conservative Berber communities such as those I studied, female friends and colleagues play an especially important role as trusted sources of information on mobile phone techniques and services although these trusted others may also be low-literate and low-skilled. Due to low skills and low literacy, friends and colleagues may not provide accurate information. This speaks to the need to raise the skill level of both the mobile user and those in the user's environment, particularly in communities where gender-segregation may be the norm.

6.2 Mobile Literacy Workshops

In the exploratory research at the Coop, progressive participatory design involved working alongside women to create a casual curriculum to help teach numbers and letters using the mobile phone. Following the observations and data collection – and at the request of the women – I conducted ten mobile phone use workshops with Coop members tailored to the women's specific interests. Workshop topics also included using text-based features. The workshops were driven by the needs and requests of participants. Phone clinics and workshops were structured to support the co-evolution of the user (low-literate Berber women) as well as their environment (their social networks) to help them gain greater benefit from their mobile phone (Maunder et al., 2008) (Figure 12). The workshops continuously evolved in response to women's learning styles and concerns. On occasion, the workshops shifted away from literacy training to mobile phone trouble-shooting sessions between Coop members and translators.

Figure 12: Berber women learning to write and send SMS messages at the mobile phone workshops at the Argan oil Cooperative.

Seven to twelve Coop members participated in each of the workshops. I occasionally offered compensation in the form of SMS recharges valued at 10 Dirham (approximately $1.30 US) for 100 SMS messages to participants who regularly attended the mobile phone workshops and who did not have enough credit on their phone to practice sending texts or who did not want to use their credits while learning how to send messages. The phone credits facilitated women's ability to experiment with technology and practice the skills they wanted to learn.

Women's primary motivation to use SMS was driven by an interest in maintaining and expanding social connections. Workshop participants asked to learn Roman letters as opposed to Arabic or Berber script because the Roman alphabet would

help them get the greatest use of their mobile phones due to the letters on the buttons. The potential to save money by sending a text messages was also appealing: making a phone call in Morocco can be five times more expensive than sending an SMS. They also requested lessons on how to install pre-paid calling credits from a scratch-card – a skill that would give them more communication privacy and independence.

Navigating the mobile phone layout was integrated into the trainings. Women practiced identifying letters on phone keypads and on a chalkboard, and they learned to write names in their phone contact list and in the SMS message field. Participants learned to write their names on a chalkboard using their stored name in the phone as a reference guide. To support the use of SMS, participants devised a list of short, simple, relevant, easy-to-understand SMS messages that included Berber-language phrases for "call me," "come home now" or "send a *tAabiya* (calling credit)." I created small, individual paper-based SMS message books that contained the sample messages written in Roman letters. Users were encouraged to consult these books to practice sending texts to each other and to the researcher.

There is scant use of the Tifinagh (Berber) script in ICT in Morocco and women at the Coop said that they were not interested in learning the Berber alphabet. Few mobile phones support the Tifinagh language. In 2011, the main mobile operator in Morocco, Maroc Telecom, launched three handsets that support Berber script, but only a small number of them are in circulation (Maroc Telecom, 2011). Older model mobile phones do not support 16-bit Unicode that is necessary to display Tifinagh script and symbols. Because Berber (or Darija) is widely spoken among women at the Coop and participants in the fogwater project, oral communication such as phone calls in Berber can be utilized.

Where text-based communication for personal or instrumental communication is used (such as SMS messages to family members or for water reporting), those messages must be expressed in letters borrowed from either the Arabic or Latin alphabet. For instance, Berber words must be transliterated into Arabic script or Latin letters. This can create usability issues for mobile users not accustomed to writing in Latin or Arabic script.

Co-learning and co-teaching extended to mobile phone repair skills that had an immediate impact on women's ability to use their phones. The workshops provided Coop members with access to a much-needed handset mechanic: one of the translators was also an IT specialist who provided invaluable services free of charge, including repairing broken phones, restoring functions and general problem-solving. He also trained users to troubleshoot their own phone issues.

Over the course of three months, Coop members who attended the workshops made progress toward narrowing their personal mobile utility gap: those who had some SMS skills improved their ability to send texts, and a handful of illiterate women developed the ability to write their name in their phone, on paper, and on a chalkboard (Figure 13).

Figure 13: A low-literate Berber woman learns to write her name using her mobile.

6.3 Contributions of Exploratory Research to Primary Research

The findings and observations from exploratory research at the Coop led me to identify the mobile utility gap among low-literate Berber women. Findings related to the utility gap at the Coop were corroborated in interviews with women involved in the fogwater project. I provide detail on the technical, social and cultural barriers to use that contribute to the utility gap in Chapter 10. These barriers included interface clutter, challenges presented by broken and counterfeit phones and low access to smartphones.

Additionally, these findings laid the groundwork for primary research involving the design of the ICT components for the Fog Phone to help manage the new fogwater system. It was clear from exploratory research that any water-related information system would need to be designed to accommodate multiple devices and a wide range of mobile skills and literacy levels. It would also need to address cultural barriers that limit face-to-face, voice and text-based communication between unrelated men and women because male water managers and female water users cannot call each other's phones to discuss system status. This understanding of the richer context of the mobile phone utility gap informed the design, deployment and evaluation of a prototype Fog Phone. The design of the primary research is detailed in Chapter 8.

CHAPTER 7
COMMUNITY ANALYSIS

This chapter includes the outcomes of the application of the Sustainable Livelihoods Framework (SLF), Stakeholder Analysis (SA), Gender and Development (GAD) and Gender, Environment and Development (GED) analyses. The outputs of these methods informed my research design, which is discussed in Chapter 8. The Sustainable Livelihoods Framework (SLF) provides a mechanism to capture community-level processes that will likely work against or toward successful development interventions such as the Fog Phone. The Stakeholder Analysis (SA) helped generate a large-scale view of the Fog Phone in order to identify the groups that played an active role in its use, positively or adversely. It was also a useful method to help identify water-related information pathways among stakeholders. The 8 tools of GAD helped me identify and analyze women's current and potential marginalization in the community. These tools also serve as a scaffold to analyze Berber women's roles and responsibilities in Agni Hiya and how these factors influence their participation in the water IS research. GED concepts further ground this research in an understanding of gender roles and responsibilities pertaining to stewardship of both traditional and alternative water resources.

7.1 Application of the Sustainable Livelihood Framework

7.1.1 The Vulnerability Context

An analysis of the vulnerability context in the rural villages involved in the fogwater project requires the identification of trends, shocks and seasonality in order to understand the negative impact these factors have on rural communities in Aït Baamrane

and how these factors can be minimized. IFAD asserts that the vulnerability context is often immutable and that the elements that make up the vulnerability context are often "difficult or impossible to change and must be coped with," which is the case in rural, semi-arid regions near Mt. Boutmezguida (Hamilton-Peach & Townsley, 2004, p. 4). However, within the vulnerability context, community members have a portfolio of assets and coping strategies.

Below, I examine the vulnerability context and those factors that exacerbate vulnerability in the Berber villages involved in this fogwater system. I have identified five significant exacerbating factors of relevance to this research. These factors are climate and weather, poor water quality, water anxiety, gender and location, and government neglect (Table 2).

The SLF Vulnerability Context: Exacerbating Factors
Low water quantity due to climate and weather
Poor water quality
Water anxiety
Gender and location
Government Neglect

Table 2: Factors that exacerbate the vulnerability context in the semi-arid Aït Baamrane region.

Traditional water sources in the region are depleted by overuse, polluted through mismanagement and constrained by climate change. All of these factors contribute to the vulnerability context in rural Aït Baamrane. Climate change is perhaps the most intractable, as Morocco is one of the "most water-scarce region[s] of the world" (Sass, 2001). Seasonal weather patterns also lead to inconsistent water supply for village

residents. While this region of southwest Morocco regularly experiences extended periods of fog in the Anti-Atlas Mountains, it can be inconsistent. The presence, consistency and timing of fog are determined by an intricate set of weather conditions that are also affected by climate change. These climate and weather conditions contribute to periodic water shortages in the region. These shortages are expected to worsen due to climate change-induced desertification combined with the cumulative effects of poor resource management and overuse. There is therefore a need for supplemental water sources in the villages around Aït Baamrane. More than five years of meteorological data show that heavy fog is normally present for six months of the year near Mt. Boutmezguida. Fog, however, is neither a consistent nor continuous climatic phenomenon. Therefore, the fogwater catchment system can only be a supplemental source of clean water (Wanner and Kunz 1983, as cited in Eugster, 2008).

Increasing water needs are due to low rainfall and persistent drought coupled with deteriorating water resources in both quantity and quality. Prior to the installation of the fogwater system, the most intensively used water sources in rural Aït Baamrane included unprotected, unfiltered and over-used public and private wells that are both less dependable and often contaminated with fecal matter.

Climate change and weather factors have an impact on water quantity while usage and management patterns affect water quality. Together these factors create water anxiety in rural Aït Baamrane. In 2011, DSH conducted a household survey of 175 community members. That survey revealed that residents of the villages involved in this fogwater project live with constrained levels of water use, high levels of water anxiety, limited livelihood opportunities and burdensome domestic tasks, particularly for women and girls

(Dar Si-Hmad, 2011). Low household water consumption has caused "severe water anxiety" in the villages, with some residents reporting that they drink less than they feel they should because there is not enough water (Falkenmark, 1989; WHO/UNICEF). Survey respondents described their own water intake as below what they define as needed. Every family surveyed reported facing water shortages in summer months. This water anxiety has created ongoing human health concerns as well as concerns about the physical health of livestock. Water anxiety also contributes to financial anxiety because residents often have to use limited savings to purchase supplemental water.

Water anxiety in rural Berber communities is often borne by women: that anxiety is compounded by a lack of opportunity. According to DFID (1999), women face higher degrees of vulnerability in remote rural areas because they are physically isolated and have fewer income-generating opportunities. In the pilot villages that will receive the new water system, the majority of women work within the confines of the community in lower-income activities such as the production and sale of crops and artisanal Argan oil, thus linking gender and location in the vulnerability context. More men than women participate in entrepreneurial activities outside of the rural commune. These activities, including manual labor, selling products in the souq, taxi-driving and working in the building trades generate higher incomes.

Rural Berber areas in the southwest have historically been a low development priority for the government. Government neglect of rural areas in Morocco also exacerbates water anxiety and water stress. Despite the National Office of Potable Water's commitment to accelerating water service to rural areas, there appears to be no governmental effort to supply rural Aït Baamrane villages and townships with running

water. Therefore, there remains a pressing need to develop supplementary water sources in these rural areas to address the dual issues of compromised water quality and quantity (ONEP, 2011).

7.1.2 Capitals and Assets

The communities participating in the Fog Phone fit the profile of most rural Berber communities in southwest Morocco in terms of their asset, or capital, bases. To provide a baseline from which to design the research and conduct analysis, I evaluated the composition of the six capitals that comprise the IFAD SLF. This analysis was performed in Agni Hiya, the pilot village receiving this new fogwater system. Findings from that village can be generalized to the other nearby villages also involved in this fogwater project because residents in those communities represent the same population of rural Berbers in Aït Baamrane.

Based on observations, interviews and interactions, I determined that prior to implementation of the water IS, the overall baseline of community assets was low. Men had higher human, financial, social and personal capital than women. Nonetheless, communities have moderately low physical capital and very low natural capital – essentially fog and the dwindling Argan forests. I discuss the evaluation of these assets below.

Human Capital

Human capital represents skills, knowledge, health and ability to work. In the villages participating in this fogwater project, education levels vary by age and gender. Men generally have higher levels of education than women. Many young and middle-aged men have completed primary school (in public schools or Madrasas). Some younger

men have completed secondary school, but those who do generally do not remain in the villages. Many older Berber men and women (those approximately 55 years old and older) self-report that they are unable to read or write. Some village women between the ages of 15-35 attended primary school, but like many of the young girls in the villages today, they may not have attended school regularly.

Skills also vary by gender. Village life demands a significant amount of physical labor to secure food, water and firewood. Women and young girls perform most of these tasks. They learn from a young age how to fetch water and perform domestic duties, as well as participating in animal husbandry and small-scale agriculture (Figure 14). Women's lives are also generally constrained to a limited geographical area while men have greater ability to move about in and out of the community. This wider range of mobility for men has allowed them to acquire varied skills such reading, writing, driving and mechanical skills.

Figure 14: A Berber woman fetching water with her young daughter in Aït Baamrane.

Human capital is also affected by health problems that include diabetes and hypertension among older residents. Women and female children have reduced access to sufficient nourishment because cultural norms dictate that women and girls are fed less food and poorer quality food than men. Furthermore, women's human capital is affected by large family size. In rural areas, women bear an average of six to eight children for whom they have primary responsibility. While larger families provide more available labor, they also result in a heavier domestic burden for women.

In considering human capital (and all forms of capital), it is necessary to disaggregate the capital base by gender. Across the board, human capital for women is generally lower than that of men, due to the women's poorer access to education, knowledge and skills. Men and women appear to have similar levels of health and ability to work, but because there are often more working age women than men in the village, women's aggregate physical workload in the community is higher, which over the long term can be detrimental to their health and suppress their human capital.

Financial Capital

Household income and spending levels in Agni Hiya were discerned from observation and interviews. Area residents who participated in the DSH household survey confirmed that remittances from family members provide the primary source of income for many, if not most, households in the study. Households also benefit from income provided by working-age family members (predominantly men) who leave the home villages to pursue jobs in nearby cities, further afield in Morocco or in the service and agricultural sectors in Europe. For rural Aït Baamrani Berber women, home-based Argan oil production is one of the chief forms of income-generation. Women are responsible for

harvesting and drying the fruit, pounding the nuts, roasting the kernels and pressing the oil. Income from the sale of Argan oil is considered 'women's money,' which can be used for domestic goods, school fees and personal items. Households also benefit from informal and traditional Berber savings instruments such as women's collection of traditional Berber wedding and other ceremonial jewelry. Other sources of household income include manual labor and the sale of vegetables, prickly pear and livestock such as goats and sheep.

Household expenditures include items such as vegetables and a limited amount of meat, rent and electricity for satellite TV, mobile phones, simple washing machines and a few light bulbs. Families also spend on school supplies and fees, medication, soap, perfume (for welcoming guests), personal supplies, cooking gas and mobile phone top-ups. Men earn wages from formal or informal work with which they pay rent, electricity, gas and fuel costs. Women's savings are often spent on personal supplies, gifts and, occasionally, school-related expenses to keep a girl child enrolled. Young women often rely on their mothers or family members who live outside of the village for money to purchase mobile phone credits.

I observed that in the communities benefitting from this fogwater project, family financial capital is low, but above subsistence level. Individual financial capital is, again, gender-specific with men's financial capital higher than women's.

Social Capital

Positive social capital among community members stems from a strong sense of connection to family through blood or marriage as well as a notable level of allegiance and pride attached to being an Aït Baamrani Berber. On a day-to-day level, social capital

in Agni Hiya is comprised of extended, and extensive, family networks. Family members who live or work outside of the village often retain a home there. Extended family returns during Ramadan and holidays. Retirees often return to villages on a full-time or part-time basis.

The formation of social capital in rural Berber villages has a gendered component. Men enhance their social network by attending prayers and community events together at the nearby Mosque. Men are also regarded as the decision-makers in the family and community. Women develop bonds by visiting each other's homes, producing Argan oil together or sharing child-raising tasks with sisters, relatives and mothers-in-law. Social capital is also built up through visits and shared meals with relatives or out-of-town guests. Strong social bonds develop over tea and sweets, which normally occurs in gender-segregated spaces.

Social capital, however, is not always positive. Strong groups (i.e. men) may exclude weaker members (i.e. women), and networks may be hierarchical or coercive. For example, by virtue of living in close proximity in a small village, residents in Agni Hiya develop a mutual reliance on neighbors and family. These close relationships, though, can be strained by distrust, long-standing disagreements, old social wounds, miscommunication and dislike.

DFID (1999) highlights that social capital can be effective in improving both the management of common resources (natural capital) and the maintenance of shared infrastructure (physical capital). DFID also points out that high levels of social capital can help to reduce the "free rider" problems associated with public goods such as this new fogwater system (p. 9). This is an important point vis-à-vis this fogwater project

because community members have expressed a noteworthy level of distrust over potential free-riding neighbors and family members.

This concern for free-riders had a direct impact on the design of the fogwater delivery system. Village residents were adamant that they did not want a shared public water tap because of concerns that the common good would not be maintained or equitably shared. In addition to personal and historic animosities among neighbors, the DSH director notes that communities involved in this fogwater project are "a landscape of atomized villages" where each village depends on itself. DSH had hoped that the communities could agree to maintain a common water point (the community tap) which would have been a less expensive and easier solution than water service to individual homes. However, as the DSH director explains, the consequence of living with extremely limited resources is a steely, even rivalrous, determination to protect one's access to natural resources. That helps explain why community members demanded water service to individual homes despite knowing that water delivery would be more expensive. DSH, therefore, designed a water-delivery system that connects individual households to the water main.

According to DSH, this "atomization" ultimately limits the community's ability to plan for the future (Bargach & Dodson, 2013). Issues of local rivalry and inability to work together as a community complicate and potentially weaken the long-term sustainability of the fogwater project. The water IS was designed to help address this vulnerability because it facilitates both individual and group participation in managing and maintaining the water system. The Fog Phone enables individual residents to send

SMS messages, but in the case of service alerts or emergencies, a community reporting hierarchy is expected to be established through the community water committees.

As an overall assessment, I found that social capital in Agni Hiya is lower for women than for men. The gender-based restrictions on communication between unrelated women and men often lead to a lower quantity of communication interactions for women. Due to their regular meetings at Mosques and extended networks from work and travel outside of the village, men have higher social capital. Women's social capital is less broad, but is nonetheless deep. Women's social capital is concentrated within the extended family and in local communities.

Physical Capital

Physical capital in Agni Hiya and the other villages participating in the water project include adobe, mud, stone and concrete block housing compounds. Electricity is available to operate televisions, a few indoor lights, simple washing machines and other small appliances. There is no indoor heating or cooling. Mules and donkeys are used for transportation and as farm animals. A few men in the community own cars, and some community members share tractors. Roads in the area are graded gravel or dirt. The cellular network is widespread and fairly reliable outside of the homes, but thick brick walls reinforced with steel rebar prevent good coverage inside of family compounds. Two mobile operators (Maroc Telecom and Meditel) provide service in the area, and a third (Inwi) is erecting a tower nearby. There is no access to improved water sources and no water utility. Satellite dishes, televisions and mobile phones are ubiquitous in the four villages. These ICT are often gifts from family members who have moved away from the family compound or they may be from extended family living abroad.

Physical capital also involves an analysis of the physical environment and basic service infrastructure that has an impact on ICT use in rural areas involved in the water IS. For this part of the SLF, I adapted Bridges.org's "Real Access, Real Impact Environmental Analysis" (Bridges.org) in order to design an appropriate technology solution tailored to infrastructure and environmental constraints. I collected secondary material such as statistics on mobile penetration and mobile coverage maps, and I tested mobile signal availability during site visits to villages and the peak of Mt. Boutmezguida (see Appendix: Maroc Telecom coverage map). It was clear that any ICT-based water reporting initiative would need to compensate for constraints such as poor cellular reception inside of homes. There was often enough coverage that phones rang inside of homes, but signal strength was insufficient to hold a conversation or send an SMS. For these functions, mobile users had to exit the home and hunt for a signal which sometimes necessitated jumping ditches or wandering around in the dark or cold in search of mobile reception. In contrast, the mobile signal was strongest at the peak of Mt. Boutmezguida (which is only accessible by four-wheel-drive, on foot or by mule) where the fog nets and filter station share a site with a small military outpost that oversees the government's communication infrastructure for southern Morocco. Additionally, the telecom carriers have erected their towers at the peak, so it is possible to utilize those signals to send texts, emails and voice calls. Additionally, it is possible to get an adequate wireless network signal at the mid-point of the water system (at approximately 3.5 kilometers) near the water storage tank at Id Aachour. This may be an advantageous place for the water manager to use an ICT to send water system updates to DSH.

Overall, the physical capital in villages benefitting from this fogwater project is basic and generally functional, with the exception of water services. Widespread electricity and telecommunications coverage support the network requirements of the Fog Phone.

Natural Capital

Natural capital in and around the base of Mt. Boutmezguida is sparse and degraded, with the exception of the seasonal abundant fog. Due to its orientation between the Sahara desert and the Atlantic coast, the semi-arid Aït Baamrane region normally experiences persistent fog from September to June when heavy cloud cover and high relative humidity make water collection possible from the peak of nearby Mt. Boutmezguida.

On the ground, the arid landscape limits cultivation and production. Hills and slopes are dry and rocky with low scrub and little to no tree cover except for sparse stands of Argan trees (Figure 15). Argan branches and twigs are collected for firewood. The soil is dry and generally degraded. Prickly pear grows well, but due to poor soil quality and lack of water, the land only supports small-scale agriculture. There are no known mineral, gas or phosphate deposits in this part of Morocco.

Figure 15: Argan trees and prickly pear are some of the few plants that grow in the semi-arid region near the fogwater harvesting system.

These data indicate very low natural capital. There are few available, reliable water sources and the land has eroded. Intermittent fog and the valuable, but few, Argan trees do not compensate for the overall poor quality and quantity of natural resources.

Personal Capital

Personal capital encompasses internal motivations, individual will to act and promote change and spiritual dimensions of life which affect individual and household choices

Personal capital, the sixth capital in the IFAD SLF model, is an influential factor in this study. Spiritual life infuses daily life in rural Aït Baamrane. Islamic practices dictate prayer times, fasting schedules and holiday festivities. Religion and tradition also

determine general codes of conduct in these rural areas, including communication patterns, forms of dress and personal behaviors, which tend to be more restrictive for women. Furthermore, while Islam is the State religion, it is not the only belief system practiced in Morocco: saints and spirits also guide daily life and relationships, making spiritual capital a layered asset. Other personal assets such as internal motivations and household choices are often subtle and difficult to gauge, but the internal motivation dimension of personal capital speaks directly to women's participation in the Fog Phone. I found that encouragement and confidence-building exercises during focus groups and literacy and plumbing training workshops helped women develop personal and communal motivation to participate in water monitoring and management using an IS.

I observed that personal capital in Agni Hiya, and by extension the other villages involved in the fogwater project, is high for men but more constrained for women. Personal capital is relevant to this research because religious norms influenced codes of conduct related to the kinds of public information women had access to (such as conversations about water infrastructure) and personal motivations affected women's willingness to participate in the design and use of the Fog Phone.

7.1.3 External Structures

In SLF, the capital bases and threats are mitigated by external structures such as development processes, policies and institutions. In these communities, there are several institutional-level actors involved in the fogwater project that contribute through funds or in-kind services.

Public and private external funding agencies for the fogwater project (and to a much lesser degree, the IS) flow through DSH, which is the coordinator, instigator and

lead agent in both the fogwater harvesting system and the IS in terms of time, money and support. The impetus and early funding for this fogwater project came from DSH and a small group of international donors that included the Finnish Embassy, the Munich Re Foundation and small US grant-making organizations. Financial support from the philanthropic wing of the Munich Re reinsurance company (the Munich Re Foundation) has been crucial. DSH's relationship with the foundation is based on Munich Re's interest in the experimental nature of the fog collection. The German foundation has extended multiple grants to DSH to continue research and development of more robust fog-catching equipment. The grants are of moderate size and are targeted. Generally, the grants cannot be used for general operating purposes. The Munich Re Foundation funds numerous other development projects. Competition for limited philanthropic support means that the foundation cannot necessarily be considered a long-term partner in the operation of DSH's fogwater system.

USAID has recently provided a targeted grant to DSH to complete the construction of some of the water system infrastructure and to integrate a WASH (water, sanitation and hygiene) component into the water project. That grant recognizes that fog harvesting is an important environmentally-balanced initiative. Furthermore, the grant validates that women's participation will strengthen the project, communities, families and individuals by targeting them in the water and health education campaign and by including women in stewardship of the new water system. These benefits are expected to contribute to greater community resilience and stability, as potable water will improve women's lives by relieving them of the burden of hauling water. Additionally, the health benefits of clean water will extend to all members of the community while easier access

to water is expected to improve livelihoods opportunities for both men and women. Community residents appreciate the universal benefits of clean water. USAID is particularly interested in incorporating an ICT component into the WASH program. USAID has provided limited funds for the development of a WASH information system, which is outside the scope of this research.

The Moroccan government is deeply involved in the fogwater project through the awarding of public funds, the issuance of land and access permits and through provision of design and water engineering services. The project would not have been possible without this assistance, and it is likely that the ongoing operational sustainability of the project will depend upon State support. Moroccan public institutions and processes, however, can be challenging due to intransigence, bureaucracy, patronage and corruption, all of which have thwarted progress on the construction of the fog project. Due to inefficiency, caprice and petty rivalry at all levels of government, the State is a fickle partner. Laborious and sometimes unreasonable demands from the state bureaucracy have delayed project construction on numerous occasions, and the on-going need for DSH executives to make personal appeals to government officials or attend distant meetings at government agencies is not always constructive to the project. The project has, at times, been bogged down by unnecessary bureaucratic delays and the generally slow and inefficient pace of business in Morocco both at the highest levels of government and in rural townships. Public funds from the State require substantial effort to secure and are, generally, tightly controlled and documented. Managing the relationship with the government is a substantial burden on DSH.

7.1.4 Livelihood Actions

Livelihoods opportunities in rural Aït Baamrane are limited. In the 2011 DSH household survey, families reported a mix of income sources ranging from remittances to sales of livestock, seasonal harvest and sales of Argan oil. Men who remain in the villages farm small plots of land, which may be small (1-acre and less) plots contiguous to family compounds. Farm plots are often planted with marketable herbs and vegetables such as squash, root crops, onions, tomatoes and mint. Many families cultivate prickly pear, or Aknari, a major cash crop in rural Aït Baamrane. Prickly pear is cultivated in larger plots of land and on hillsides. Men also engage in beekeeping.

The majority of the working age men in the community have left in search of work, leaving women and children to pursue home and community-based income-producing work, mostly centered around Argan oil production. An additional livelihood for community members is tending livestock including goats, sheep, chickens and donkeys. These livelihoods are generally female-centric although this is not always the case.

The livelihoods for residents who remain in villages are constrained by the lack of water. Because water has long been scarce on the eastern side of the Anti-Atlas Mountains, residents have developed long-standing strategies to secure even minimal quantities of water. Village women and children are the primary source of labor for water collection, which typically requires up to 3.5 hours a day. This water collecting is often performed in heat that exceeds 100-degrees Fahrenheit (38 degrees Celsius). In addition, households have for centuries collected dew and what little rainwater that falls into in-house cisterns. Residents purchase water when well and cistern water are unavailable.

These alternative forms of water collection are unsustainable given current climate predictions and the poor state of existing water resources.

7.1.5 Livelihood Outcomes

Because of the large amount of time that women spend fetching water, finding ways to save time was a priority for this fogwater project managers. DSH expects that the time saved by reducing water-fetching chores could allow women to devote more time to economic activity, namely the artisanal production of Argan oil or other products in local cooperatives. Furthermore, instead of being tasked by their families to fetch water on a daily basis, the delivery of clean water directly to homes may free up time for young village women to attend school.

Water availability could also help stabilize the family system in the villages and reverse the trend of de-population. While remittances from the diaspora provide an important income stream to village residents, the absence of male heads-of-households and working-age men and women destabilizes family and community life. The provision of water could potentially reduce or reverse some out-migration by encouraging family members to remain in rural communities and pursue livelihoods opportunities there. With a reliable source of water, there may be income-producing opportunities for both women and men. Furthermore, communities where the age range is not skewed toward the elderly and the young are often considered to be stronger and more resilient.

In addition to having a positive impact on the lives of village women, by relieving them of time-consuming burden of fetching water, the fogwater project is expected to deliver additional social benefits for women such as water management skills, technology skills and plumbing knowledge. Continuous access to an adequate water supply will also

allow community members to keep their livestock even during the driest years (Vavruska, 2012; Bargach, 2011).

<u>7.1.6 Transformations</u>

The delivery of potable water to residents in drought-stressed Aït Baamrane has the potential to be transformational for residents there. During the pilot test of water delivery to Agni Hiya, women's lives were instantly altered when they no longer had to haul water to their homes. The pilot test period was too short for livelihoods to be reconsidered or changed, but residents commented on potential opportunities that might stem from flowing water such as new gardening and small-scale agricultural opportunities. At the women's community meeting held prior to the pilot test in Agni Hiya, many women commented that they would like to pursue training and education once their water-fetching burden was lifted, and a number of women discussed the possibility of starting local cooperatives.

This analysis of available SLF assets, combined with an understanding of the socio-cultural processes in Berber communities involved in this fogwater project are fundamental to the design, deployment and potential sustainability of the Fog Phone. The elevation of ICT in this fogwater project also holds the potential to be transformational. By integrating ICT into water reporting and water management, women in villages involved in the IS project quickly realized the potential benefits of expanding their skills and networks. For DSH and for women in the communities, the water IS is the first step in a broader plan to establish eLearning and mobile phone based health and livelihoods programs. The USAID WASH program is the first offshoot of the water IS. The project

also offers direct advantages to men who will benefit from easy access to water for daily use and for agriculture.

7.2 Application of the Stakeholder Analysis

The SLF alone was not sufficient to fully analyze the benefits and risks of the fogwater project and the Fog Phone to stakeholders. Therefore, I utilized SA to analyze the IS from the perspective of the three primary stakeholders, female water users, the male water manager and DSH as well as male community members and telecommunication agencies and carriers (Table 3).

Stakeholder	Influence	Benefits	Barriers
Female Water Users	Very High: co-designers and users	High if IS is implemented	Moderate: need for training, social pressure
Water Manager	High: co-designer and advocate	Moderate-to-High: job clarity, workload management	Moderate-to-High: risk of circumvention
Dar Si-Hmad	Very High: coordinator and implementer	High if IS is implemented	Low: staffing
Male Community Members	Moderate-to-High: potential users	Moderate-to-High: functional water system	Potentially High: social pressure
Telecom Authority	Low	Low	Low
Network Providers	Moderate: network availability	Low-to-Moderate: increased brand awareness	Low-to-Moderate: shifts in price structures, interest level

Table 3: A Stakeholder Analysis for the Fog Phone for the fogwater harvesting project.

7.2.1 Stakeholder: Female Water Users

The greatest benefits of the fogwater project accrue to community women by relieving them of the chore of fetching water and by making their domestic lives more efficient. Their contribution to the fogwater project is, in part, expressed through their

participation in the Fog Phone research. If women find the Fog Phone useful and usable, they may benefit from having a convenient and culturally-appropriate way to communicate with project managers. Women have substantial influence on the water IS through their participation in the design exercises and by implementing the water IS. That contribution is not just limited to designing, prototyping and integrating the IS into their daily chores, but their efforts to monitor and report on the status of the water system directly contribute to the sustainability of the system by helping keep it operational. Women in the communities, though, sometimes face substantial barriers to participation. Those barriers include social, cultural and technical barriers to using ICT, which are explained in more detail in Chapter 10. Barriers to participation also come from family members who may discourage or dissuade women from participating. Issues related to self-esteem, agency and ability or willingness to make decisions about their participation in this IS were addressed in focus groups and through conversations and friendships between the research staff and women in the communities. Cognitive and social support should be formalized into the fogwater project and the IS so that the greatest number of women in the area receive the benefits of participation and the skills and confidence that stem from that participation, as well as from follow-on projects such as the WASH program.

Risks to women include social pressure to not participate in the IS and financial risk from having to pay to send text messages to report on the water system. There are no overt physical risks to women's participation in the water IS. In fact, there are fewer risks, as they will travel less to access water and they will haul less water.

7.2.2 Stakeholder: Male Water Manager

The local water manager operates as the on-site contractor and the *de-facto* local boss of the project. This gives him substantial influence over the project and within the DSH organization. The water manager also oversees the day-to-day construction and maintenance of the fogwater system. The Fog Phone involves the design of ICT to help him perform some of those duties. The water manager also serves as a liaison or promoter of the fogwater project and the Fog Phone. As DSH's local representative, he has some power within DSH, as well as in local communities. His responsibilities include hiring and managing local workmen and overseeing construction work. He stands to benefit from the Fog Phone by gaining greater ability to manage his workload and by transferring residential plumbing chores to other contractors. DSH has entrusted him with substantial responsibility, and he has deep knowledge about the fog system. As the sole local water manager, DSH depends on him, which puts the NGO in a precarious situation of dependency.

Early in the research, the local water manager created an unexpected barrier and risk to the development of the fogwater IS by refusing to accept or participate in the fogwater IS if it required him to accept or make phone calls or share SMS texts with women. His opposition was primarily based on concern for his reputation. In rural Aït Baamrane, cultural norms restrict communication between unrelated men and women. The water manager abided by (and appeared to support) that convention. He adamantly opposed any role that required him to be the main vector for water-related communication with area women, which required the design of a system that triangulated water communication between water users, DSH and the water manager.

7.2.3 Stakeholder: Dar Si-Hmad

Dar Si-Hmad's contribution to the fogwater project and the accompanying Fog Phone is extensive. The organization serves as the core administrator of the project and the project manager for the design, installation and operation of the fogwater system. DSH executives have occasionally committed personal funds and unpaid, in-kind services to support the project (such as supplying equipment, food and non-DSH personnel). As such, it is exceptionally influential. Its commitment to the project stems from deep roots in southern and southwest Morocco combined with a mission to help address the needs of rural Berber communities that have long been ignored by the Moroccan government.

To accomplish that mission, DSH identified the need to provide water services to water-stressed communities in Aït Baamrane in the 1980s, and executives have pursued an innovative approach to supplying that service. DSH contributions include direct financial support and substantial time and efforts to marshal the project through to completion. DSH has also created and continues to coordinate an extensive team of researchers, engineers, hydrologists, public agencies, private donors, volunteers and full-time and part-time employees. Dar Si-Hmad's ability to build and manage the project is constrained by the small size of the organization, and occasionally, by lack of experience with infrastructure-scale construction projects. DSH's commitment to the project does not waver, but the scale of the project sometimes overwhelms its small number of employees (two executives and two to four staff members). Furthermore, DSH struggles with insufficient operating capital and bureaucratic distractions related to funding, which

in the long-term could compromise the organization's ability to effectively run a water utility in the region, regardless of the scale of the project.

Barriers to participation and risks include responsibility for the delivery of potable water to marginalized rural communities that have come to rely on DSH for this service. DSH has entered into a social contract with the communities participating in the fogwater project. The communities have provided land access, labor and a commitment to participate in this research on the Fog Phone as their portion of the social contract. The communities could potentially hold DSH responsible for the outcome and sustainability of both the fogwater system and the water IS. DSH faces multiple risks should it decide to transfer operation of the fogwater project to a public service entity or some other managing agent. DSH also faces financial exposure in terms of maintenance and operations costs if public and private funds are insufficient or if payments from community members fail to cover expenses. DSH has not yet devised a detailed financial sustainability plan for the fogwater project or the accompanying Fog Phone, and therefore, risks being unprepared for system operating costs.

Another potential risk for DSH is that residents receiving the fogwater system may believe that DSH is responsible not only for the delivery of safe drinking water but also for any shifts in livelihoods that may stem from water service. Rural community members may hold DSH socially responsible for the delivery of clean water on an ongoing basis. In an area where history and social connections continue to exert leverage and convey respect and authority, DSH is exposed to future ill-will should the fogwater project or IS be unreliable or unsustainable.

Male community members participated in the construction of the fog nets and the extensive system of piping. Men from the area also contributed to the project by helping dig the seven kilometers of pipe trenches to connect the nets, storage barrel and cistern. Teams of men helped transport cement, gravel, sand and other building materials to various building sites. Four community members spent two weeks cleaning the mid-stage cistern at Id Aachour of years of sand and waste deposit. DSH estimates that its personnel and workers made 600 trips to the mountain peak and various worksites in order to build the system.

Men also play an important role in the water IS by encouraging or discouraging and allowing or disallowing the participation of female family members. DSH personnel and I attempted to offset any suspicions or concerns about women's participation by hosting a men's community meeting prior to the launch of the pilot water tests in Agni Hiya. At that time, community men were informed of the purpose of my research and the longer-term goals of the Fog Phone as an integral part of the sustainability of the water project. The leader of DSH fielded questions and made a commitment to the community that communication about the Fog Phone would be transparent and that the research team would be available for feedback and suggestions.

Non-resident male family members (husbands, sons, fathers, relatives) are 'shadow' stakeholders in the Fog Phone. Whether they are transient workers who remain in Morocco, or working-age migrants who live overseas, men retain influence over family life in the village. These educated family members often provide remittances and resources back to home villages and, in some cases, they must approve a woman's

participation in the Fog Phone. We did not have direct access to these stakeholders, so we relied on information provided to them by their family or neighbors in the villages participating in the water project.

7.2.5 Stakeholders: Telecommunications Authority and Telecommunications Providers

Morocco's state telecommunications authority is an additional stakeholder in the fogwater project and the Fog Phone. The fog nets and related infrastructure on the peak of Mt. Boutmezguida are located on property owned by the High Commission of Water and Forestry. Those contracts and permits have been approved and are currently being honored, but as with any other bureaucracy in Morocco, legal contracts are not always consistently enforced, followed or honored.

Additionally, the Fog Phone is likely to benefit from specially negotiated pricing or services provided by one of the three network providers in Morocco (Maroc Telecom, Meditel or Inwi). These services may include discounts on bulk texting or free calling services that may be made available to DSH under a provider's corporate and social responsibility plan. While generous, these discounts and services cannot be relied upon in the long term, which creates a financial risk to the project.

7.2.6 Stakeholder Analysis for the Fogwater Project

In addition to the stakeholders involved in the fogwater IS, there is an additional set of stakeholders involved in the broader fogwater project. These stakeholders are referenced in the SA above, as well as in Chapter 2 (Culture, Community, Language and Site Selection and are incorporated in the Stakeholder Analysis shown below (Table 4). I conducted this stakeholder analysis in order to understand top-level issues that are likely

to be of concern to DSH when the fogwater system is fully implemented and, possibly, expanded.

Stakeholder	Benefits from Project	Contributions/ Sacrifices	Influence on Project	Potential Involvement
Govt. Entities 1. Rural Commune 2. Province 3. Local Govt. Orgs 4. Water Authorities 5. National Govt.	Indirect beneficiaries. Rural residents receive water a water utility not provided by the State.	Groundwater is a state resource. Fogwater jurisprudence is not established. Long-running land tenure tension.	High-moderate. Capricious bureaucracy can support or block project. Potential corruption, opportunism, careerism.	High-Moderate
Land-related Stakeholders 1. Army 2. Telecom Authority 3. Water & Forestry Depts.	No direct benefit.	Stakeholders authorize use of land for placement of fog infrastructure, storage cisterns. Piping may be on public or state-controlled land.	Potentially high. Bureaucratic inefficiencies and corruption. Stakeholders control land rights granted to install and operate fog nets and other infrastructure	High
Funding Agencies	Indirect beneficiaries	Direct financial support and in-kind services. Ongoing short-term support needed. Long-term support TBD.	High initially.	Moderate-Low
Neighboring Communities	Directly benefit from lower demand on local well water. No direct benefit from fog water system.	No direct contributions	Moderate-low. Nearby communities judge project and women's participation. Reputation, honor, jealousy, rivalry issues.	Moderate-Low

Table 4: A Stakeholder Analysis for the fogwater harvesting project.

7.3 Applying the 8 Tools of Gender and Development

Between 2013-2014, I conducted a gender analysis in Agni Hiya based on Parpart et al.'s "Theoretical Perspectives on Gender and Development" (2000). Below I explain the 8 Tools of Gender Analysis and how it informed my research into the design of the Fog Phone (Table 5).

Tool 1	Gender Division of Labor
Tool 2	Types of Work
Tool 3	Access to and Control over Resources and Benefits
Tool 4	Influencing Factors
Tool 5	Condition and Position
Tool 6	Practical Needs and Strategic Interests
Tool 7	Levels of Participation
Tool 8	Potential for Transformation

Table 5: The 8 Tools of GAD Analysis (Parpart el al., 2000)

Tool 1: Gender Division of Labor: In order to understand the roles, responsibilities and differing activities of women and men in Agni Hiya, I conducted an assessment of gender divisions of labor in the community in an effort to identify the type of work that women and men perform. An understanding of what men and women considered acceptable work for Berber women to perform was crucial to generating participation in the Fog Phone.

In the Berber communities where the water project is located, I assessed the division of labor between men and women related to water collection, water use and water management. I found a distinct gender-based separation of domestic chores where women were responsible for water-intensive chores such as laundry, meal preparation and housekeeping while men oversee most technical and mechanical functions in the home and the community. Water fetching was predominantly the job of women, but not

in every case. Men were tasked with collecting water when women or girls were absent, when women were elderly and unable to fetch water and when water fetching required passage through an area that was deemed dangerous due to snakes or animals. In the village of Agni Hiya, no woman or working age girl ranged beyond walking distance from the community for daily work.

Division of labor issues in Agni Hiya also incorporate gender-based financial responsibilities which are relevant to this research because the water system will ultimately require utility payments and because community members will be responsible for the cost of sending water-related SMS messages. Men in Agni Hiya and other rural Berber villages generally bear responsibility for paying for utilities, food and equipment. Women generally pay for clothing, personal supplies and school fees for girls.

These findings are particularly relevant to Research Question #3: How do ICT facilitate women's involvement in overall system management and communication of meaningful technical information regarding the fogwater system? An understanding of gender divisions of labor is pertinent to women's involvement in water system management. The use of GAD Tool 1 helped reveal that management duties for this fogwater project were initially perceived to fall within the domain of men. This information helped me craft a better research plan that included more overt communication with community members about my intentions to actively include women in the Fog Phone. An understanding of labor roles in the villages encouraged DSH to explicitly articulate that women have a management role in this fogwater project.

Tool 2: Types of Work: As discussed in Chapter 4, work can be productive, reproductive or community-based. Productive work may be paid or unpaid. I extend the definition of

productive work to include the production of information. Reproductive work may be biological, as in childbearing, or social, which includes caring for family members or community work. Momsen (2004) contends that social reproduction activities are essential functions that "ensure the development and preservation of human capital," (p. 48) thus linking GAD to one of the core assets of Sustainable Livelihoods Framework (SLF).

In Agni Hiya, productive work for men includes day labor work, taxi-driving, small-scale farming and other paid informal and semi-formal work. Women's productive work includes small-scale farming, tending animals, growing vegetables and Argan oil production. Reproductive activities for women include childbearing and nurturing of large families consisting of an average of seven children. Women are also heavily involved in social management duties such as preparing and serving meals and hosting family members and guests. Women in Agni Hiya also have primary responsibility for children's health, education and welfare.

The third type of work, community work, includes collective social services such as celebrations, ceremonies, spiritual events and other community activities. In Berber-Arab communities, community work revolves around religious life and social events such as funerals and weddings. This work is generally gender segregated. For example, men frequently pray together or attend meetings and events at the area Mosque. Women do not regularly attend prayers at the Mosque although they do pray in homes. Women arrange other community work such as funerals and weddings.

Cognizant of women's double and triple burdens stemming from productive, reproductive and community work, the fogwater project and attendant water IS were

designed so as to not add additional burdens to rural Berber women. Water delivery directly to homes is intended to remove one major physical burden on women by relieving them of the need to fetch water by hand. The Fog Phone assists in achieving that outcome by providing women with a way to send service updates and service requests to help keep the water system operating.

Understanding the types of work performed by women and men in Agni Hiya is particularly pertinent to Research Question #1: What information and communication requirements are critical to the major stakeholders in the fogwater project because the types of work women are involved in (productive, reproductive or community) can help determine the kinds of information that women water users find useful. In this context, the Fog Phone represents an intervention in both productive and community work.

Tool 3: Access to and Control over Resources and Benefits: GAD Tool 3 investigates how rural Berber women's marginalization affects their access to and control over clean water resources and to what extent their disenfranchisement influences their ability to benefit from those resources. Women in Aït Baamrane have access to water resources, but that access comes at a heavy cost in terms of physical labor. The mission of the fogwater project is to provide women with easier access to water and its benefits. Issues related to access and control of water resources are contained in Research Question #3, which focuses on the Fog Phone as an instrument to help Berber women better manage water resources. The Fog Phone is integral to enabling women to easily access clean water and enjoy the benefits of its availability, such as improved health. Providing women with an active role in managing the water system via ICT will help keep the service running, and thus, enable women to benefit from the water system.

Tool 4: Influencing Factors: The influencing factors of tradition, culture and the natural environment are highly relevant to the design of the Fog Phone. Research Question #2: What features are required to create a socially and culturally appropriate ICT system that allows unrelated women and men to communicate about the fogwater system? In Berber villages, tradition and culture are embedded in communication patterns. These patterns and expectations circumscribe women's participation in the Fog Phone. For example, cultural norms often discourage unrelated women and men from communicating, a condition that had a direct impact on the design of the Fog Phone. The Fog Phone was designed to accommodate this restriction. Instead of requiring women to contact the male water manager with service updates, information was routed through DSH. Additionally, women's communication is often subject to surveillance by family members. Therefore, the Fog Phone connecting female water users with project managers was planned so that water reporting symbols and messages were impersonal and objective. Furthermore, the natural environment in Aït Baamrane is an important influencing factor. The climatic and topographical features make it possible to harvest water from fog, but some of those same features (mountains, hills and valleys) can make it difficult to receive a mobile network signal. The Fog Phone was designed to accommodate these constraints by generally relying on lower bandwidth SMS messaging between water users and DSH project managers and store-and-forward functionality for communication between the water manager and DSH thus circumventing the gender restrictions on communication between unrelated men and women.

Tool 5: Condition and Position: Conditions refer to tangible day-to-day needs such as clean water, shelter and food. Position is a more abstract concept. It refers to a woman's

social and economic status. The fogwater project and its information system are designed to address issues of both position and condition. The water project addresses women's conditions by meeting material needs for clean water. The Fog Phone is designed to enhance women's position by involving them in management of the water system and promoting their full participation "as agents of development and change" (Parpart et al., 2000, p. 143). Issues related to women's condition and position address Research Questions #2 and #3: What features are required to create a socially and culturally appropriate ICT system that allows unrelated women and men to communicate about the fogwater system, and how does ICT facilitate women's involvement in overall system management and communication of meaningful technical information regarding the fogwater system? This aspect of gender analysis also intersects with social processes that influence access to capitals identified in the Sustainable Livelihoods Framework (SLF).

Tool 6: Practical Needs and Strategic Interests: Practical needs include food, clothing and water. Strategic interests, on the other hand, refer to firmly established factors such as inferior status and inequity. In the context of the fogwater project, women's practical needs are met by the provision of clean water which immediately improves the condition of women's lives in rural Berber villages. Furthermore, women's involvement as participants in the Fog Phone addresses the practical need to monitor the system and to report on service problems. The fogwater system and the design and development of the Fog Phone also address rural Berber women's strategic interests by involving them as designers, participants and water monitors.

Tool 7: Levels of Participation: Along with the identification of the practical needs and strategic interests of Berber women involved in the Fog Phone, this research analyzes

women's levels of participation and the potential for transformation vis-à-vis their participation in the Fog Phone. The Fog Phone was designed in consultation with women in the villages receiving the fogwater system. Women organized to contribute to the design of the Fog phone, and they contributed solutions to water reporting problems. Those features are reflected in the Fog Phone. Furthermore, they participated in making suggestions about the design of home plumbing systems which lead to the addition of water shut-off valves inside of the homes.

Tool 8: Potential for Transformation: Women's lives can be transformed through inclusion in development initiatives. Transformational processes can elevate women's power and address inequalities. In this research, women's roles as water stewards were transformed from a role determined by water-gathering duties to a guardianship role in the water system. This research explored how ICT could facilitate this new role.

7.4 Applying a Gender, Environment and Development Analysis (GED)

In rural Berber communities in semi-arid southwest Morocco, resident's lives are intimately entwined with the natural world, and residents are compelled to live within restricted environmental means (Bargach, 2011). The relationship between the environment and humans in rural Berber villages manifests in tasks such as the diligent collection of limited rainwater in household cisterns, long waits at well sites due to depressed water levels and the need to shift grazing locations in response to land degradation. Others factors closely related to the local environment include the fact that diets are affected by seasonal food crop availability, firewood is more difficult to obtain due to a loss of tree cover and ongoing drought has decreased the supply of Argan nuts. These factors are daily concerns for rural residents, particularly women, and many tasks

related to the land and natural resources in the communities involved in the fogwater project are women's duties. Thus, issues related to gender and natural resource use in rural Berber villages cannot be disassociated from each other.

As the primary water gatherers and dominant water users in rural villages, Berber women are inextricably associated with water and therefore play an important role in resource management in rural Aït Baamrane. They pay close attention to environmental signals such as decreases in rainfall and changes in water levels in wells. This close connection to the natural world will extend to their use of fogwater as a new, supplemental source of drinking water and to their involvement in the management of the fogwater system by virtue of their role as water monitors and water reporters. Due to their pivotal role as providers, users and guardians of water, the Fog Phone relies on women to participate in water resource management and decision-making.

Consistent with GAD and GED theory, this research also recognizes that men have important duties in water management. They have been involved in building the system and remain involved in some maintenance and repair work outside of the villages. Furthermore, men, whether present in the villages on a full-time or part-time basis, are involved in the water project by virtue of their status as heads of households. Male family members, whether near or far, can encourage or discourage, and allow or disallow a woman's participation in the Fog Phone and the broader management of the supplemental water system. Additionally, male family members are expected to bear the primary financial responsibility for paying water charges. This assignment of responsibility lead to the belief that men would assume physical and managerial responsibilities for the water project, but after discussions between community members and DSH, and with the

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subsequent development of the Fog Phone, the roles were separated. The Fog Phone helps transform women's relationship to water from one where they are solely water consumers to one where they are information stewards. That role is facilitated by ICT.

CHAPTER 8

SYSTEM DESIGN

8.1 Primary Research for a Prototype Fog Phone

This chapter explains the design, implementation and evaluation of the first phase of the Fog Phone connecting water users and DSH.

Observations and interviews conducted at the launch of the water system in Agni Hiya in June 2013 showed that household water users, technicians responsible for the system infrastructure and project managers were initially connected by an informal and ineffective communication network. The weakness of that ad hoc system was evident when a pipe broke in a nearby field. The leak went unreported for more than a week because community members said they did not know whom to contact to report the problem. The water project's operational sustainability depends upon timely and accurate communication between primarily female water users, the male water manager and DSH project managers. In order to operate sustainably, the water project required the regular exchange of information. The objective of the primary research was to create the first phase of the Fog Phone to connect these diverse and dispersed stakeholders. Initial data indicated that multiple information and communication technologies might be required to help manage end-to-end reporting of the water network because there were no common devices and no shared platform that all the stakeholders could use. For example, DSH relied on Wi-Fi and computers, but those services and hardware were not available in the rural communities. The water manager had smartphones, but women generally did not. Therefore, any proposed water-related information system must function across a range

of literacy levels, diverse technical skills, multiple devices, mixed genders, dispersed locations, rugged conditions and multiple cultural and social circumstances.

I initially discussed my suggestions for deploying an ambitious three-phase, ICT-enabled end-to-end water reporting system with DSH. We envisioned a potential information system that, in its entirety, could track household-level user messages sent via mobile phones, infrastructure status updates, and data from a remote meteorological station. We shared ideas about a system where women in the villages could share household water issues with DSH, such as leaks or burst pipes. Those discussions became the impetus for an investigation of the tools and processes involved in the design of the first phase of the Fog Phone to support the fogwater delivery system intended to supply potable water to rural Berber villages in southwest Morocco. This system came to be named the 'Fog Phone.'

8.2 Data Sampling and Recruitment

This research is based on the collection and analysis of data directly related to the research questions. These data are comprised of stakeholder-identified information needs related to water such as social, cultural and technical capabilities and constraints which all influence the design of the information system. The IS must support reports on water, stakeholder access to and use of ICT, and women's participation in water stewardship. The outcomes of the community analysis, discussed in Chapter 7 inform this research, especially the in-community interviews about the functionality that might be required of the Fog Phone. The discussion below explains the interview process in five villages.

Following initial introductions facilitated by DSH, I regularly visited private homes in rural communities and job sites in the mountains where I was able to establish

professional connections and friendships with stakeholders. These visits took place over the course of nearly eight months in June-July 2012, November 2012-February 2013, June 2013 and again in December 2013-January 2014. An atmosphere of mutual trust paved the way for me to recruit interview subjects and study participants. This trust was also the foundation for collaborative and participatory design of the first phase of the Fog Phone connecting water users and DSH.

I conducted two sets of interviews: general ICT interviews in the Coop and in villages involved in the water project and targeted water-related interviews with the three main stakeholder groups (female water users, the water manager and DSH project managers). Each interview type was designed to elicit a different category of information (explained below) that contributed to answering my research questions.

The target population for ICT interviews was any adult resident of a village involved in the fogwater project. Inclusion criteria were adults (18 years and older) who were full-time or part-time residents of villages participating in the fogwater project who use a mobile phone, were able to understand interview questions and could provide verbal consent to be interviewed. Exclusion criteria were minors, those who self-identified as unwilling or unable to understand and answer interview questions and those who could not provide verbal consent to be interviewed. Interviewees were recruited through non-random door-to-door visits and referral sampling in the rural communities of Agni Hiya, Agni Zkri, Id Soussan, Tamarrout and Id Aachour, all of which are involved in the fogwater project.

The target population for water-related interviews was any adult resident of Agni Hiya. Inclusion criteria included adults (18 years or older) who were able to understand

interview questions and could provide verbal consent to be interviewed. As with the ICT interviews, exclusion criteria were minors and those unwilling or unable to understand and answer interview questions and those who could not provide verbal consent to be interviewed. Interview subjects were recruited through non-random door-to-door visits and referral sampling in Agni Hiya.

The study population for participatory research on the development of the Fog Phone was comprised of the three primary stakeholder groups: women water users in Agni Hiya, the water manager and the DSH project managers. Eligible subjects from the target population in Agni Hiya included full-time resident adult women (18 years old or older). Inclusion criteria consist of female resident water users who are able to understand interview questions translated from English to Tachelhit or Darija, those able to identify water-related problems, those who volunteered to take part in this IS study, those who had access to a mobile phone and those who provided verbal consent to participate. Again, exclusion criteria include non-residents and part-time residents of Agni Hiya, male residents, people under the age of 18, those without access to a mobile phone, those who choose not to participate and those unwilling or unable to provide verbal consent. Participants were recruited for the study through non-random, referral sampling commonly used in qualitative research. At the time of the study, Agni Hiya had approximately 28 adult full-time residents, 18 of whom are female. The maximum sample size of female water users for this study was 16, excluding two elderly women who do not fit the inclusion criteria. I recruited 15 eligible women to participate in this research. Six women were between the ages of 18-24 years old, six women were between 25-45 years old and three were older than 46 years old (ages are approximate). Six of the

15 women self-identified as illiterate and innumerate. All of them reported that they had service with Morocco's main network provider, Maroc Telecom, instead of Meditel or Inwi.

I also interviewed DSH's Director and Chairman of the Board, as well as and the water manager as other important stakeholders.

8.3 Research Plan

There were two primary goals of the research plan: (1) an examination of the factors required to develop a socially, culturally and technically suitable Fog Phone that allows marginalized Berber women to participate in the management of a new water system, and (2) the development of the prototype Fog Phone to support the fogwater harvesting system. The overall approach involved an assessment of information needs, the creation of a Fog Phone, the testing of the Fog Phone and analysis of the pilot tests. As discussed, much of this data comes from the methods outcomes as well as the interviews as outlined. The approach for each of these steps is detailed below.

8.3.1 Determining Information Needs (Addressing Research Question #1)

To assess information needs related to the water system, I engaged in participant observation and semi-structured interviews with female and male water users, water managers, DSH staff members, plumbers, contractors and water engineers in Summer 2013 and January 2014.

In June 2013, I met with executives and staff members of DSH at association headquarters in Agadir, at project headquarters in Sidi Ifni and in pilot villages to get the project managers' perspective on water-related information needs. DSH executives

identified the need for major stakeholders to share meaningful information about the project so the water system will function properly.

Over the course of the three weeks (June 16-July 7, 2013) when the water flowed to households in Agni Hiya for the first time, I noted the kind of water-related information that was or was not communicated, to whom and under what circumstances. Examples of such information included community men telling the plumbing contractors about jammed faucets or female water users complaining to translators about leaking pipes or underground pipe leaks that created puddles that went unreported. I regularly visited Agni Hiya to observe and discuss how residents used and responded to the new water system. I inquired about how running water to home taps affected their daily lives, whether the water system functioned properly in terms of service delivery and what tasks were performed with the piped water (i.e., consumption, domestic tasks or animal husbandry).

In order to establish information needs at the local level, I interviewed female water users in the village of Agni Hiya to determine what information was important to communicate or receive about the water system. They provided specific suggestions such as the plumber's schedule, water shutdown notifications and water quality alerts.

As the sole local employee responsible for water system infrastructure and maintenance, the water manager's insights into service issues were crucial to the sustainability of the water system, as was the need to get information to and from him about repairs, water quantity and quality, leaks, construction planning and personnel. In order to ascertain his information needs, I joined him on maintenance checks in Agni Hiya where I discussed his concerns about regularly exchanging information with

unrelated women. In lieu of frequent contact between female water users and the male water manager, I discussed a possible ICT-based system where project managers would aggregate information from women prior to transmitting service-related information to him. He stated that his concerns could be allayed with an impersonal information system, such as the Fog Phone, and that that he would be comfortable if specifically designated male and female community members called him in the case of emergencies. In order to understand his communication needs regarding maintenance of the infrastructure and transmission of that information with DSH, I accompanied the water manager to Mt. Boutmezguida to examine the fog-collection nets, hoses and filter units. I interviewed him about the potential to use ICT to efficiently file regular maintenance reports, and he participated in user-centered design exercises with a paper mockup of a potential tablet based reporting system to track maintenance of the water infrastructure. This information can be used to guide future work.

8.3.2 Assess Community Readiness (Addressing Research Questions #2 and #3)

To address the issue of community readiness to participate in the development, design and deployment of the Fog Phone, I conducted semi-structured ICT and water-related interviews between January-July 2013 with male and female residents in the villages participating in the water project. These interviews focused on the ability and willingness of mobile users to use their available mobile phones to potentially report on water issues. I also engaged in discussions with female and male residents of Agni Hiya about opportunities for women to have a role in the new water delivery regime. These conversations often took place in venues such as women-only focus groups, gender-segregated community meetings and face-to-face interviews with women and men in the

community, conversations that provided me with invaluable insight into social factors that could affect women's participation in water management, thus addressing Research Question #3.

I also engaged in discussions with DSH project managers about their perspective on what constitutes a socially and culturally appropriate ICT system. I specifically discussed opportunities for women to integrate ICT to retain or advance their role as water stewards and guardians in the new water delivery regime. These conversations revolved around the level of women's agency in their homes and in the community, and factors that might encourage or discourage participation in the management of the water system such as lack of phone credits to send a text or make a call, difficulty securing a network signal inside of the family compound or family pressure to not use the system (described in greater detail in Chapter 10).

These interviews helped determine potential features to include in the Fog Phone based on users' technical skills and available technology, as well as the social, cultural or technical barriers to ICT use that might constrain participation in a water reporting system. I updated the Sustainable Livelihoods Framework and the Stakeholder Analysis by incorporating information on community readiness.

8.3.3 Encourage Participation (Addressing Research Questions #2 and #3)

I cultivated community-wide interest in women's participation in the Fog Phone through public presentations of this research. In mid-June, 2013, DSH convened gender-segregated community meetings for residents from rural communities slated to receive water from the fog-harvesting system. In these meetings, I explained that I was interested in discovering whether a coordinated water reporting structure was needed, whether it

was viable and whether female water users would participate and assume leadership of a technology-enabled water system. I explained that an information system might help users quickly and efficiently relay information about water problems or service requests to project managers who could then respond to and track repairs to keep the water system functioning.

8.3.4 Rapid Design of an Alpha Version of the Fog Phone (Addressing Research Questions #2 and #3)

Equipped with an understanding of the information needs and an awareness of the social, cultural and technical constraints of study participants, in Summer 2013 I engaged in collaborative design sessions with all three stakeholder groups to design an alpha version of the first phase of the Fog Phone based on mobile keypad letters and numbers. The alpha version of the Fog Phone linked female water users in Agni Hiya to my personal mobile phone. For the purposes of an alpha test, my phone served as a proxy for the Fog Phone. In the alpha version, the requirements for the Fog Phone were based on the use of available, simple feature phones. The system was designed to accommodate multiple devices in various states of disrepair used in rugged conditions. (The beta version of the Fog Phone incorporated an SMS aggregation platform which is detailed in a following section.)

The alpha version of the Fog Phone was based on an easy-to-use system of matching pictures to mobile keypad letters and numbers. In response to information needs identified by water users, the translation team and I created four iterations of the posters featuring photographs identifying four common water issues that had occurred during tests of the water system: no water, leaking tap, wet interior wall where the pipe

connected to the tap and wet exterior wall near the water meter. Each water issue was assigned a letter corresponding to a number on a mobile phone keypad. For example, the letter 'A' or 'a' indicated that the household had no water service. The poster carried an image of a mobile keypad showing that the letter A/a could be found on the number '2' key on a mobile phone. Each house in Agni Hiya was assigned a water meter number so service requests could be identified by number rather than a name or phone number. Each water issue on the poster had an explanation in Tachelhit (the local Berber dialect) written in both Arabic and Latin script next to the image and the keypad design. The poster instructed water users to send a text to the Fog Phone indicating the water meter number and the water report (Figure 16).

Figure 16: Water Poster #1 showing common water issues, used in the alpha test of the prototype Fog Phone.

During the alpha test in June 2013, after three days of use, the translation team and I redesigned the poster to replace pictures participants identified as difficult to understand with public domain images and clip-art icons downloaded from websites. We added an image and text indicating a water emergency and eliminated the design of the mobile keypad next to each water issue because participants said they did not need the visual prompt. Participants responded positively to these changes.

For water users who were not able to send SMS messages due to illiteracy and innumeracy, I devised a parallel reporting system based on voicemail for the alpha test. Requirements for this system included a voice recording by a female Tachelhit speaker (one of the translators) and training for women on how to dial a call and leave a voice message.

I funded women's participation in the pilot tests by supplying mobile telephone credits valued at 10 Dirham (approximately $1.30) that could be used for 100 text messages or one hour of talk time.

I assessed the alpha version of the Fog Phone by collecting the content of all of the SMS messages sent to the Fog Phone along with information on the time and date. I also had all of the voicemail messages left on the Fog Phone transcribed. I assessed the messages for what water problems were reported and the accuracy of the reports, as well as data on non water-related (social) messages.

8.3.5 Determine ICT for the Beta Version of the Fog Phone (Addressing Research Question #2)

Following the results of the alpha test, I moved into the beta test period of the Fog Phone research. The ICT for the beta version linking water users and DSH project

managers utilized the personally-owned feature phones operated by water users and a moderately priced laptop loaded with FrontlineSMS. FrontlineSMS supports SMS aggregation and bulk texting and a customizable customer relations management system. I chose a laptop instead of a desktop PC because DSH staff members may be located in any of a number of offices or in the field, and the equipment would need to be portable.

8.3.6 Design the Beta Version of the Fog Phone (Addressing Research Question #2)

Data from the alpha test of the Fog Phone was incorporated into the design of a more robust and deployable prototype information system that met communication needs identified by the three major stakeholders: female water users, the water manager and DSH project managers. The customized FrontlineSMS system was developed in Fall 2013 with students in the Masters in Information and Communication Technology for Development (ICTD) program at the University of Colorado, Boulder. The Fog Phone was devised to map to a wide range of mobile skills, literacy levels and gender-related communication norms encountered during preliminary research and the alpha test. The student team and I consulted with DSH throughout the design and build process. We also coordinated trials and feature tests to discern whether the system helped monitor and maintain the fogwater distribution system. The design of the Fog Phone addressed a number of priorities. It utilized available, low-cost technology, it addressed user-identified communication needs, it incorporated participatory user design for ease of understanding and adoption, it was appropriate for users with differing literacy levels and it did not violate cultural norms.

8.3.7 Deploy Beta Version of the Fog Phone (Addressing Research Question #3)

On my return to Morocco in January 2014, I deployed the beta version of the Fog Phone connecting two stakeholders (the female water users and DSH) in the test village of Agni Hiya. The FrontlineSMS system was deployed when, once again, DSH filled the water system with 30 tons of purchased water. Similar to the alpha test, water was delivered to homes in the pilot community of Agni Hiya. I installed the laptop at my field base in Sidi Ifni, approximately 30 kilometers from Agni Hiya. After my departure at the end of January, I transferred the system to DSH's office in Agadir, and, as part of the installation, I helped train DSH staff to operate the system and to troubleshoot launch-related problems. Additionally, I distributed an updated water poster to all participants and households in Agni Hiya. A new phone number dedicated to the fogwater project was printed on the posters, as well as clearer pictures of water problems and updated information on what to do in a water emergency (Figure 17).

Figure 17: The updated water poster used in the beta test of the prototype Fog Phone showing the dedicated phone number and updated images indicating water problems.

During the beta test, I collected feedback on the efficiency and effectiveness of the Fog Phone from female water users, DSH staff and the water manager. Although the prototype Fog Phone did not link in the water manager, I sought his feedback because he had participated in the design of the system, and DSH expected him to be a community advocate for the system. After collecting data and feedback, I made recommendations to address malfunctions, and I delivered specification documents to project managers. These findings are in Chapter 10.

8.3.8 Collect Data On Alpha and Beta Versions of the Fog Phone (Addressing Research Question #3)

Text messages between residents in Agni Hiya, DSH and me were captured on the FrontlineSMS system (see Chapter 9 for details). The SMS aggregation system collected system status reports from water users as well as exchanges and responses to information requests from me/DSH to study participants inquiring, for example, about whether the plumber was present in Agni Hiya, or requesting that residents shut their valves prior to equipment repairs. Residents voluntarily provided their phone numbers because they wanted to participate in the Fog Phone and wanted to get water announcements from DSH or me. Community members were aware that the Fog Phone included a contact list and that the system collected and matched phone numbers to names. This made it possible to identify the person or household sending a water messages via SMS and allowed me to easily disaggregate data by household and text sender. Having a contact list also made it possible to track water reports if an SMS message did not contain sufficient information (such as a water meter number or problem code).

For the alpha version of the Fog Phone, I collected data including call and SMS logs from my personal phone. For the beta version, I collected data from the FontlineSMS Fog Phone database. Notes from semi-structured interviews, observations and other relevant field records were recorded onto spreadsheets in order to easily compare answers from research participants.

CHAPTER 9

TECHNICAL DETAILS

HCID techniques provided a framework to address the complexities of cross-cultural design, particularly the design of the Fog Phone to meet the distinctive needs of low-literate ICT users in rural Berber villages. Maunder et al. (2008) provided the guiding premise for this research into the design of simple technology artifacts with instant utility. Principles of easy operability and immediate utility were of paramount importance throughout the design of the Fog Phone linking water users to DSH project managers. This approach to designing the Fog Phone enabled stakeholders to connect an information system to their daily tasks and activities "without needing to grapple with complex abstract design concepts and ambiguities that may exist as an effect of the prototype itself" (Maunder et al., 2008, p. 6).

Below, I outline the technical details of the beta version of the Fog Phone that was implemented in January 2014. The system was designed to accommodate the social, cultural and technical concerns evident among rural Berber women involved in the fogwater project.

9.1 Prototype Posters for the Fog Phone

The translation team and I conducted focus groups with adult female water users in Agni Hiya to collect their design suggestions for the posters showing what codes to use to report a water problem. In those sessions, we solicited input and feedback on effective images to use to indicate water system malfunctions. We presented a variety of images in order to elicit feedback on ease-of-understanding. We showed pictures of the actual water system in Agni Hiya along with stock images of plumbing fixtures from the internet as

well as slightly abstracted icons and clipart elements. I incorporated suggestions from these iterative and participatory design sessions into each of the four versions of the posters used in the alpha and beta tests of the Fog Phone.

9.2 Voicemail Recording

A voicemail option was included in the design of the alpha version of the Fog Phone in order to accommodate water reporters who were not able to send SMS messages. In some cases, mobile users did not know how to dial a phone number, others had phones with worn out keypads that made it difficult if not impossible to construct a text message, while others preferred voice reporting over text messaging. In order to accommodate these users into the research, female Tachelhit speakers recorded a voice mail message inviting water users to record their report of a water issue. The recorded message was: "Welcome to the voicemail of the Dar Si-Hmad Tagut (fog) water system. If you have any problems with the water, please leave your message here after you hear a signal (tone). Then say your full name, your water meter number and state your problem. Thank you." The voicemail option was eliminated in the beta test due to limitations of the FrontlineSMS system and because of time and training limitations. Sixteen voice calls were made to the alpha version of the Fog Phone (my personal phone). All but one of those calls occurred when women were practicing voice calling during a training session.

9.3 Personal Mobile Phone

In Summer 2013, I temporarily contributed my personal cell phone number to help in the development of the alpha version of the Fog Phone. This decision was slightly inconvenient for me because my phone was no longer a private device. Contributing the use of my personal device to the project appeared to have a positive impact on the project

as using my phone and phone number helped me establish trust with the community. Because I always had my cell phone at hand, I could immediately show water users the result of water-related SMS messages they sent. Participants who practiced using the "boite vocale" (voicemail) service during focus groups and training sessions could hear my phone ring and be assured that the phone number was valid. Women (and men) in Agni Hiya also saw me read their incoming texts and watched me key in and send them a text message using my personal phone. This helped address suspicions that water-related messages (SMS and voice) were being transmitted outside the 'water network' of stakeholders.

At the time of the alpha test, DSH had not yet negotiated a service package with a mobile carrier to supply services for the Fog Phone. That changed for the beta test when DSH supplied a dedicated phone number associated with the FrontlineSMS Fog Phone system. Posters were updated with that phone number and study participants were instructed to send text messages to that number.
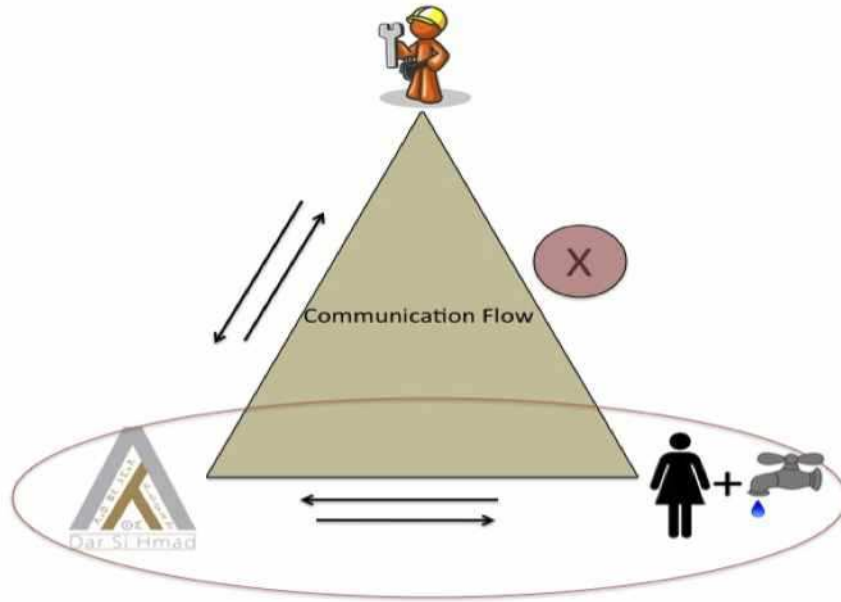
Figure 18: The FrontlineSMS Fog Phone system connects the water users and DSH.

9.4 Design of a Customer Relationship Management System

In Fall 2013, I worked with a team of students in the Masters in Information and Communication Technology for Development (ICTD) program at the University of Colorado, Boulder to design a prototype SMS aggregation and customer relationship management (CRM) system utilizing FrontlineSMS, a free, customizable software package used in many ICTD applications (Figure 18).

I chose FrontlineSMS for the ease of use of the software. It is possible that many users of the Fog Phone at DSH will not have English as their first language. The default interface is user friendly and uses a simple tab metaphor for navigation. It is easy to find the main page for the Inbox, Sent and Archive messages. It is also simple to find and edit the "polls" and contact lists that are likely to be the most often-used functions for DSH.

FrontlineSMS can be installed on any computer, requiring only a GSM-based modem on a USB thumb drive to send and receive data. While the user interface operates in a web browser, FrontlineSMS can function without an Internet connection as all SMS messages are sent and received through a SIM card in a GSM-enabled device. FrontlineSMS provides the necessary features to receive, categorize and store SMS messages sent from any phone (Figure 19). The application also allows for easy organization and filtering of incoming messages and provides a simple interface to create polls associated with trigger or keywords.
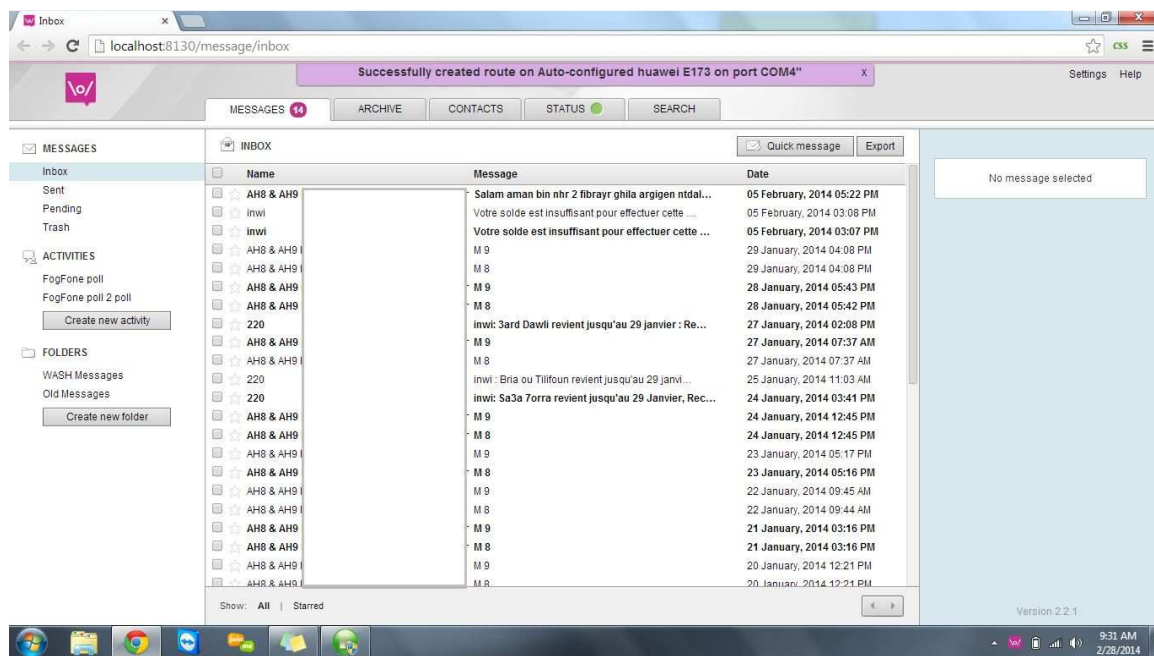
Figure 19: Text messages that do not precisely conform to the message protocol are filtered into the Inbox of the FrontlineSMS system.

9.5 The Hardware

I purchased a new laptop computer that was dedicated to operating the FrontlineSMS and the GSM device. I chose a midrange laptop (Acer Aspire E15312438 with 1.9GHz Processor, 4GD RAM and a 500GB hard drive) in order to help prevent the

computer running too slowly or crashing with FrontlineSMS. I also needed a computer with more than one USB 2.0 port, as the GSM device required a dedicated USB port.

FrontlineSMS recommends using a GSM modem as opposed to a mobile phone, as GSM modems are easier to connect to the PC. Having tested several types of GSM devices, I chose a Huawei E173 GSM modem that required no additional setup or configuration on Windows 7.

9.6 The Reporting Syntax and Trigger Words

The FrontlineSMS system was designed to sort messages into 'polls' based on the designated water problems (no water, leaking faucet, leak in an interior wall, leak on an exterior wall and no water problem). Incoming messages that used the syntax determined in the alpha and beta tests triggered this automatic sorting when the incoming SMS message started with a letter assigned to a water problem followed by a the unique number assigned to each meter (examples of correct syntax are "A1" or "12"). The FrontlineSMS looks for this syntax string and automatically categorizes the responses into the right poll. When a message does not conform to the reporting syntax, it stays in the Inbox, which displays the text of the incoming message with the sender's name or number. DSH employees can select a message to reply to, and they can forward a message to the water manager or a maintenance worker, for instance. They can also delete or move messages to other polls. Each poll enables like messages to be grouped. The FrontlineSMS system also records the phone number of each incoming text message, making it simple to create contact lists of water users. This will enable DSH to build an address book of names and numbers in order to better keep track of messages. Further, contacts can be assigned to groups for ease of communications and better reporting. For

example, DSH has the ability to create a group for each village or certain individuals in the community allowing easy mass communication to a geographic area. Water users were not limited to sending SMS messages about water issues, but only text messages that conformed to the reporting protocol are sorted into polls.

With an ICTD master's student, I trained women in Agni Hiya in the reporting protocol and created new posters for the beta version of the Fog Phone. The water reporting syntax was familiar to women in the community, as they had contributed to developing the letter and number sequences for the alpha version of the Fog Phone the prior year.

9.7 System Constraints

While FrontlineSMS provided a majority of the functionality for the CRM system, it lacked several features that would simplify communication. For example, we had initially pursued an option where low-literate women could leave a voicemail about water issues, but Frontline SMS did not support voice call sorting. The development team and I attempted a work-around whereby voice calls made to the Fog Phone number were forwarded to a phone belonging to a DSH employee. However, this necessitated an employee to listen to the voicemail, then create and send an SMS message containing the information from the voice message back to the Fog Phone to be filtered and sorted into a poll. Due to the overhead of this approach, the beta version of the Fog Phone focused solely on SMS messages. (Voice calls to the Fog Phone number appeared as calls in the FrontlineSMS call log, so it was possible to know a call had come in.)

As mentioned above, FrontlineSMS is unable to parse and sort messages that contain typing errors or that do not conform to the reporting syntax. If a message cannot

be interpreted, the message will go to the FrontlineSMS general inbox. From there, an administrator can manually add it to the correct poll and assign it a response category.

Additionally, software requires maintenance and updating, and employees may need technical support. I included TeamViewer, a software package that enables remote control of a computer, on the host computer to assist with troubleshooting. TeamViewer requires an internet connection, which DSH has. I also included basic FrontlineSMS and Fog Phone training documentation on the FrontlineSMS computer.

Backup is also a major issue. To address damage or theft, the FrontlineSMS configuration, including the database and configuration files, are stored in a single, easily accessible folder that can be stored on a USB flash drive or remote computer. I included an automated backup script that updated the configuration files daily to a USB flash drive. Since the daily log and configuration files are only a few kilobytes each, such storage will be adequate.

A final consideration is that system objectives and requirements could change in the future. New villages might be added, codes might change or actual water infrastructure might advance and require entirely new keywords. Such cases are impossible to foresee. The master's students and I provided a technology-savvy DSH staff member with sufficient training to reconfigure and administer the Fog Phone.

9.7.1 Cost Concerns

Water users in Agni Hiya expressed concern about the cost of reporting water-related issues via SMS and voicemail. The cost of texting and calling is a highly relevant issue for low-income residents participating in the fogwater project. Depending on the service package, mobile phone calls and SMS messages can cost approximately 1 Dirham

per minute or per text. If female water reporters were required to bear the cost of regular (daily or weekly) water reporting, telecom charges could strain women's available income. To deflect some of these costs to water users, DSH might opt to absorb calling costs by creating a toll-free phone number through a mobile carrier. That is a potential service option for an IS based on voice calls and voicemail. To transfer the costs of SMS texts, the design team and I considered the use of a free-to-sender short code to send water reports but rejected that option out of concern that short code number series would be too confusing. Future work might explore whether this option is effective with low-literate mobile phone users.

CHAPTER 10

FINDINGS

This chapter consolidates research findings from both the exploratory research at the Coop and primary research in communities involved in the fogwater project. (The community analysis of the methods is not included in this chapter as those outputs were used to inform the research design). During that time, I conducted a total of 58 ICT-related interviews, 40 water-related interviews and ran a pilot test of an alpha and beta version of the Fog Phone to help manage the water system, which received 81 SMS messages during the alpha tests and 38 messages during the beta test. These data gave me the data necessary to answer my research questions. This chapter summarizes my research findings in the context of these research questions, including findings related to the use of progressive, participatory, contextualized Human-Computer Interaction for Development (HCID) techniques. Additional analysis of the implications of these findings, particularly for ICTD scholars and practitioners, can be found in Chapter 11.

10.1 Data Management and Data Challenges

I triangulated data from semi-structured interviews, participant observations, focus groups, participatory design sessions and SMS and call logs in order to draw conclusions regarding the usefulness and effectiveness of a Fog Phone water reporting and monitoring system. I reviewed the data to determine the information needs related to water, women's social, cultural and technical barriers to ICT use and participation (and lack thereof) in the design and implementation of the Fog Phone. I coded these data and themed them based on descriptive labels such as ICT use, social barriers, technological skills and barriers, gender issues, education and water commentary. Data related to ICT

use, participation in management of the water system and complaints or problems related to water delivery were entered into spreadsheets and SMS and call logs (which were also imported into spreadsheets). I removed data that included extraneous information unrelated to the research questions. Incomplete data such as error messages, transmission errors, and communication that indicated confusion or a lack of understanding of the reporting system all constitute relevant data for this study because they speak to the effectiveness of the Fog Phone.

Due to handset sharing, it was not always possible to identify the person sending an SMS to the Fog Phone system. While community members were informed that this research focused on women's use of mobiles to report on the water system, I did not control access to individuals' handsets, nor could I demand that only women participate in the research. For instance, I occasionally received elaborate text messages from low-literate women's phones that were clearly written by someone who was literate. Occasionally, a message would contain the name of the sender, thus indicating their identity or gender.

I did not consider the inability to identify participants to be a weakness of the study. When I could not discern the identity of the sender, I did not discount messages as data errors. I considered those to be an acknowledgement of the social and technical layers involved in mobile phone use by this population of rural women in southwest Morocco.

10.1.1 Translators

I relied on a team of translators throughout my fieldwork. I instructed them to identify and translate commentary in messages related to water use, ICT use,

participation in management of the water system and complaints or problems related to water delivery. I also requested that translators provide me with nuanced details on social and cultural issues that often affect women's work and domestic lives such as family dynamics, the role of religion or access to information, as these details inevitably had a bearing on women's ability, interest or willingness to participate in the interviews and Fog Phone use.

10.2 Findings: Information Needs

Research Question #1:

What information and communication requirements are critical to the major stakeholders in fogwater project?

Home water delivery to Agni Hiya began for the first time in mid-June 2013 after DSH deposited 30 tons of purchased water into the storage cistern. Project managers had budgeted 50 liters/day/person for human consumption for approximately 30 people, which was five times more than residents reported as their daily consumption rate. The water trial permitted DSH to test the household plumbing system and allowed me to observe water use and water-related information needs.

When water delivery to Agni Hiya commenced, so too did plumbing problems. I conducted semi-structured interviews with all three primary stakeholder groups to identify their water-related information needs and what circumstances or events elicited the need to transmit information. Through participant-observation and stakeholder interviews, I monitored communication bottlenecks related to water delivery that occurred between the three main stakeholders. I found that communication congestion occurred regarding unexpected plumbing problems and water system shutdowns. I also

witnessed difficulty on the part of DSH in relaying concerns about the rapid consumption of water during the pilot test in Summer 2013.

Below, I detail findings from interviews and participant observations with DSH, female water users and the water manager that address my research questions.

10.2.1 Identifying Information Needs: DSH

Early in my research, DSH executives identified the need for major stakeholders to share meaningful information about the water system so that the system could function properly. We discussed the potential use of ICT to help accomplish this task. Furthermore, we established that it was vitally important to have an IS where female household water users could transmit relevant water maintenance and system emergency information to DSH. It was also crucial to have communication channels in place to link the local water manager with community members in case of water-related emergencies. I worked with DSH to envision, and ultimately develop, the first phase of the Fog Phone that would allow DSH to 'triage' information to and from the water manager and water users, including the ability to aggregate and disaggregate information in order to respond with specificity to individual service requests and to provide generalized reports to funders. These efforts became the Fog Phone. Additionally, DSH identified an interest in the ability to send out periodic bulk SMS messages to water users for such purposes as notification of a temporary service interruption, water-related health alerts, sanitation advice or conservation reminders.

10.2.2 Identifying Information Needs: Female Water Users

In interviews and conversations in January/February 2013, June/July 2013 and again in January 2014, I asked 27 female water users detailed questions about issues

related to water delivery. Women reported that they were enthusiastic that water would be delivered to their homes and relieve them of the burden of hauling water. During this time, I participated in many discussions about the important role that primary water users – usually women – might have in alerting project managers to problems such as lack of water, low water pressure and water quality issues. We discussed how local and household-level information about the water system was key to operational success. Additionally, as women were often the only adult at home, it would be useful to know how to report a water problem. Without that information, the water manager and DSH would not know what problems needed to be fixed, thus imperiling water delivery for everyone in the villages.

Unfortunately, the high rate of equipment failures at the launch of the first water service in Agni Hiya in Summer 2013 created frustration among residents. Nonetheless, both the positive response to having running water and the annoyance at having intermittent service helped galvanize women's participation in this study. Women expressed surprise and impatience over the numerous plumbing problems. They were quick to identify problems such as leaking taps and leaking pipes in interior walls. When translators and I opened water meter boxes to show women the pipes and dials that control water delivery to their homes, it was immediately clear that there were leaks on external walls as well.

Adult women in Agni Hiya made suggestions about who to alert about water problems and how those parties might be contacted. For example, some women suggested contacting the water manager, as they assumed he was also the designated village plumber. Others suggested calling the Chairman of the Board of DSH, as he was

familiar to many community members, and it was assumed he could get plumbing problems fixed quickly. Other women reported that their husbands or men in the community would be responsible for reporting any water problems.

In interviews about whether women thought using mobile phones might be an effective way of letting the water manager or DSH know about water-related issues, younger women were intrigued but were unclear how this would work, given that they were not accustomed to using their phones for instrumental purposes. Older women were perplexed by the idea of a mobile phone-based monitoring platform. Young mothers appeared to be ambivalent about the concept, which I discovered later was a reflection of "rusty" literacy and numeracy skills as well as concerns about male authority (discussed in Chapter 11).

10.2.3 Identifying Information Needs: The Water Manager

In casual conversations and semi-structured interviews with the water manager, he explained what constituted important information to send and receive. He contended that it was inefficient for him to be the main point of contact for water users because he might be out of network range when community members tried to contact him. Furthermore, he was tasked by DSH to manage the fog catchment infrastructure and did not consider it his job to be a residential plumber. Additionally, he stated that he preferred to talk to men rather than women. This preference was not limited to communication about water issues. He stated that, in general, he was not comfortable having any communication with women in villages via mobile phones due to the adverse effect it would have on his reputation. I discuss this concern in greater detail in a following section.

10.2.4 Responding to Information Needs: Rapid Participatory Design of Water Posters

for the Fog Phone

The absence of a communication system combined with a high volume of problems led me to initiate participatory design workshops with female water users, DSH and the water manager in the first week of water delivery in June 2013.

In consultation with the three primary stakeholders, we quickly compiled a list of what appeared to be four common or likely water problems. These included no water service, a leaking tap (or 'robinet'), a leak in an interior wall and a leak affecting an exterior wall. I added 'water emergency/burst pipes' to the list of potential problems and made the decision to include 'no water problems' in order to encourage women to monitor their home systems and to practice generating water reports. These six issues became the basis for the participatory, and iterative, design of water posters. (DSH executives, the water manager and I discussed the inclusion of potential water issues such as water taste, smell or appearance, but found these factors to be too subjective to include in the initial prototype.)

After collectively agreeing with all the stakeholder groups on a list of six issues that merited monitoring and reporting, I conducted focus groups and participatory design sessions with women in Agni Hiya to iteratively design water posters to help guide them to report problems with the water system. I found that one possible solution to communicating information about the water system was through the use of a universal set of vocabulary, images and symbols to transmit information about community and household water issues.

The posters provided several images of potential water problems, and each image corresponded to a short sequence of letters and numbers. The posters were designed around mobile keypads. Water problems were assigned a set of letters corresponding to one button on the keypad. For example, a,b,c on keypad #2 was the designated reference for the 'no water' problem. Keypad #3 (d,e,f) indicated a 'leaking tap.' Each individual water meter was assigned a corresponding number. For example, an SMS message of 'A10' meant that there was no water at the home of meter Number Ten.

I redesigned the original poster after three days of use in response to feedback from water users. Study participants recommended that we replace a few pictures they said were difficult to see. For the second-generation poster, I used public domain images and clip-art icons downloaded from websites. I also added an image and text indicating a water emergency such as burst pipes, and I eliminated the design of the mobile keypad next to each picture of a water problem because water users participating in the Fog Phone design sessions were so familiar with their phones that they did not need the visual prompt. Participants responded positively to these changes.

I field-tested four versions of the poster during the two water delivery periods (June/July 2013 and January/February 2014).

10.3 Findings: **Understanding Social, Cultural and Technical Constraints**

Research Question #2:

What features are required to create a socially and culturally appropriate ICT system that allows unrelated women and men to communicate about the fogwater project?

For Research Question #2, I collected data addressing stakeholder capabilities and constraints in terms of social, cultural and technical factors. These data were collected through the SLF, SA, GAD and GED analyses as reported, as well as ICT-related interviews.

Between January-February 2013, and again between June-July 2013, I conducted a total of 58 semi-structured ICT interviews to establish current mobile phone-enabled communication patterns. Across both the Coop and water project, I interviewed 46 Berber women: 19 women from the Coop and 27 women from one of the five villages participating in the water project (Agni Hiya, Id Soussan, Agni Zkri, Tamarout and Id Aachour). I also interviewed a dozen men from Agni Hiya.

Women interviewed ranged in age from approximately 18-80 years old. (It was not always possible to collect information on a woman's age. Some women did not know their age or the year they were born. Women often identified their age in relation to how many children they had, how old or what year their children were in school, or by referencing life, community or political events to provide a relative age.)

Of the 46 women who participated in ICT interviews, nearly three-quarters of them self-identified as illiterate or low-literate (Table 6). Almost half of them could not independently make or receive a phone call, and the majority could not independently make or read an SMS text. Women who reported that they could independently send or read a text message (three women at the Coop, nine women in the villages) ranged between 18 years old to women in their mid-30s. All of the young women under the age of 24 were able to send SMS messages.

Women who…	
Self-identify as illiterate or low-literate	74%
Cannot independently make or receive a phone call	46%
Cannot independently send or read an SMS text	74%

Table 6: Perceptions of literacy levels. From 46 interviews with Berber women from the Coop and communities involved in the fogwater project.

ICT-focused interviews were directly relevant to the design of a socially and culturally appropriate prototype information system. These interviews helped determine potential features to include in the Fog Phone based on users' technical skills and available technology and what social, cultural or technical barriers to ICT use might constrain participation in the water reporting system. These data add context to the information needs established in Research Question #1.

10.3.1 Features of an Appropriate IS: Project Managers

In lengthy discussions, DSH project managers provided their perspective on what constitutes a socially and culturally appropriate ICT system that would support women in retaining their role as water experts in the new water project. Project managers were concerned about the generally low level of women's agency in their homes and in the community, their lack of access to formal education and time constraints. Additionally, they noted that low literacy levels and lack of technical skills might discourage women's participation and could reduce women's willingness to participate in the design and testing of the Fog Phone. We concluded that a simple mobile phone-based system that was co-designed by women in the community could help offset some of those concerns.

10.3.2 Features of an Appropriate IS: Female Water Users

Interviews with women in the communities involved in the water project revealed similar demographic and ICT characteristics as low-literate Berber women at the Coop (in some cases, women in the villages were sisters or relatives of women at the Coop). Similar to women at the Coop, women in the communities had received minimal formal education. Some young mothers and older women had never been to school. Those women were generally monolingual in Tachelhit. Younger women in both locations had likely attended a few years of primary school and possessed basic writing and reading skills. Younger women could often understand Darija, and some could speak it. At both research sites, Argan was the primary livelihood although women in the rural areas generally had fewer income-earning opportunities than women employed in the Coop. Rural women also tended animals and had small gardens. Both sets of women had extended families that provided remittance income.

The findings on ICT use in communities involved in the fogwater project were also consistent with mobile users from the Coop. The mobile utility gap was pervasive among both populations: women have access to mobiles but do not or cannot use their devices beyond accessing basic functions. Furthermore, low-literate female phone owners used simple feature phones for predominantly personal communication. With the help of surrogates, however, they made and received local, national and international calls to and from family and friends. Similar to Berber women in the Coop, women in the communities involved in the fogwater project infrequently used their mobiles for instrumental communication. On the rare occasion when they did use their phones for

business purposes, it was to make contact with a client to arrange the private sale of homemade Argan oil.

I had many and varied discussions with community women about whether they wanted to, or thought they could, use their mobile phones to let someone know of a water-related problem in their home. Many of them, particularly younger 18-24 year-old-women without children, were interested in using their mobile phone to report water problems. Young mothers and older women were worried that it would be difficult for them to use their phones due to lack of skills.

From private conversations and from two large-group community meetings held in Summer 2013, I discerned general anxiety over communication between unrelated women and men. Prior to receiving any mobile phone training or participating in collaborative design workshops, a number of women had to seek the approval of male family members. They were successful in securing such authorization: within four days, every eligible woman in Agni Hiya had participated in mobile phone workshops, focus groups or participatory design sessions.

Women water users in Agni Hiya also disclosed that they faced gender-based limitations on their range of movement and communication. These constraints could potentially limit their ability to communicate about the water system. Interviews and observations in the five rural communes slated to receive supplemental water service indicated it would be difficult for female water users to easily convey information to male water managers due to cultural restrictions that preclude unrelated men and women from communicating. For instance, women described that it would be difficult to directly contact the male water manager or a plumber. Traditional and religious norms that limit

face-to-face communication between genders extended to voice and text-based communication, thus affecting the ability of women water users to text or call male water managers with system status updates (Figure 20). Community men and women involved in the water project and the water manager expressed similar concerns that conversations between a female water user and a male water manager might cause harm to his, her or their respective families' reputations. It became clear at that time that any potential water IS must consider these cultural and social factors.

Figure 20: Low-literate Berber women generally use their mobile phones for 'kin-keeping' and personal communication. They are restricted from contacting unrelated men.

Additional factors also constrained women's participation in monitoring the water system including lack of money to purchase phone credits and lack of confidence. It was

clear that participation in the Fog Phone would be compromised unless low confidence levels and lack of technical skills were addressed.

10.3.3 Features of an Appropriate IS: the Water Manager

The water manager (a young man in his mid-20s) was a skilled user of smart phones and social media. He had one personal phone as well as a DSH-issued smart phone. He was unusual in that he set the language display on one of his phones to Arabic. Furthermore, he used his phone for radio, photography, video and internet access. This reflects the advantageous combination of personal choice, advanced skills and a more sophisticated device.

The interview with the water manager occurred early in this research. His objections to being the nexus of water communication triggered the idea for the Fog Phone for the water system. He expressed very strong opinions about cross-gender communication, stating that he did not want women to text him nor did he intend to call or text women about water issues because it would damage his reputation. He feared a woman might manipulate an incoming text from him and show the altered content to a male family member. He did not want to create trouble for women by sending them texts, but he appeared especially concerned with preserving his reputation.

Furthermore, despite DSH's plans to include women in water stewardship, the water manager had pre-identified numerous men in each community who he would rely on to report water and plumbing problems. He said that it "if the husband is in the house, it is his job to report water problems." When pressed on whether he would support, for example, his sister sending a text to a man about the water system, he said if both the female SMS sender and the male SMS receiver were educated, it would be not be a

problem for men and women to text each other about professional issues such as water service. The water manager represented a potential risk to integrating the Fog Phone IS into the water project as he had developed workarounds to the complex gender-related communication constraints. Over the course of approximately eight months of interviews, focus groups, participatory design sessions (in which he participated) and the launch of the water project, his attitude toward the Fog Phone and women's involvement in helping monitor the system appeared to shift slightly. He expressed that he understood that women's involvement and communication could help keep the water system operational and he realized that he would have fewer disruptions in his work if women communicated water issues directly to DSH instead of to him.

He suggested that any Fog Phone for the water system should be gender neutral. For example, if DSH passed out a poster or calling card to women with a phone number on it to report water problems, the documents should only reference DSH and not contain names.

10.3.4 Corroboration

Findings from interviews in the pilot water village of Agni Hiya corroborated my findings from exploratory research at the Coop as well as the methods outputs. That immersive, ethnographic research provided me with an initial understanding of technology access and use by under-resourced, low-literate rural women. At the Coop, I established that multiple social, technical and cultural layers contributed to the mobile utility gap among low-literate, rural Berber women. I validated those findings with the parallel population of women in communities involved in the fogwater project. Below, I explain the utility gap in more detail.

10.4 Barriers that Contribute to the Utility Gap

While a lack of literacy represented the overriding barrier to rural Berber women's use of text and more advanced phone features, observations and subsequent training sessions supported extending the standard definition of "utility gap" to include specific technical and sociolinguistic barriers that exacerbate the difficulties low-literate women have with their phones. While these gaps can be studied and addressed individually, they are often related and occur in combination with one another. These related barriers to more advanced phone use need to be understood within the context of relevant cultural factors in Berber communities. The following enumeration of these barriers demonstrates how researchers and practitioners pursuing ICTD interventions might better understand how literacy, gender, economics and culture affect intervention adoption (Table 7.)

Technology Barriers	• Myriad vendors and operating systems • Interface clutter • Poor quality phones
Sociolinguistic Barriers	• Multiple spoken dialects • Multiple written languages • Multiple numbering systems • Unsupported Arabic script • SMS messages written in "Arabish"
Social and Cultural Barriers	• Shared phones • Gender-based access to devices • Lack of smartphones

Table 7. Summary of barriers that contribute to the mobile phone utility gap.

10.4.1 Technology Barriers

One set of barriers to women's advanced phone use was technical. A top-level concern of mobile users at the Coop and in communities involved in the water system was the operability of their ICT devices: the mere presence of a mobile phone, whether it is new or used, did not guarantee that the device was usable. Below, I identify a few of the technology-related challenges that hindered the use of mobiles by low-literate, low-skilled users.

Myriad vendors and operating systems

Mobile phones in circulation in southwest Morocco represented myriad vendors and operating systems, thus interfaces and functions are not standardized. Phones ranged from newer-model Nokia and Motorola feature phones to simple Samsung handsets. Some phones required as many as eight steps to send an SMS message. Some mobiles supported icons in the phonebook. Some handsets had text-based interfaces while others had icons. Pre-programmed shortcuts and hot-keys vary across phone models. For example, on some phones, it was possible to access a function by holding down a key, but the result was not always the same depending on the phone model. The range of devices, settings and operating systems made it difficult for novice users to share advice or train each other on how to operate their phone.

Interface clutter and low repair skills

Many participants were confused by the array of buttons and menus on their phones. Small, over-cluttered alphanumeric keypads made it difficult to easily locate letters and numbers. Retrieving phone numbers from a call list or navigating to the SMS text field often required multiple steps through puzzling phone menus. These

cumbersome processes often discouraged women from experimenting with the features of their phones.

Poor quality phones

Further complicating the lack of standard interfaces was the poor condition of most of the phones. The simple feature phones in use were primarily second-hand purchases or gifts that were not always fully operational. Many phones had features that were broken or jammed: keys would stick, navigation toggles did not work and it was difficult to see menus through cracked and cloudy screens. Counterfeit phones were an additional problem: merchants often target illiterate buyers who are unable to distinguish between fake and legitimate hardware. A number of women reported that they unwittingly spent meager financial resources on fake phones. One low-literate Coop member was justifiably troubled when the camera on her new phone did not work. The vendor had assured her she was purchasing a Motorola brand phone, but in fact he sold her a 'Mobiola' phone. The purchaser said she recognized the letters 'M' and 'o' and thought she was buying a Motorola. She did not have sufficient reading skills to identify the correct brand name.

Maintenance and troubleshooting problems

Often, mobile owners could not use phone features because they were unable to troubleshoot problems. Old, broken and counterfeit phones require substantial maintenance, and low-literate women did not have the skills to repair their own phones or restore functions. (Phone owners sometimes unwittingly changed their own phone settings and were unable to recover original or familiar settings.) Fake and second-hand phones of questionable provenance do not come with instructions or manuals. The lack of

documentation also meant that even when illiterate users have access to a proximate literate, that surrogate often did not have the benefit of a user's manual (unless they had access to an internet connection, which is rare in rural Morocco).

10.4.2 Sociolinguistic Barriers

In Morocco's polyglot communities, ICT users face myriad challenges related to the complex, layered language environment. For low-literate mobile users in oral-language communities, new, second-hand and counterfeit mobiles have text and voice-based features that are in languages that differ from the ones they see, hear or speak.

Linguistic complexity

As detailed in Chapter 2, three alphabets and three different scripts are in use in Morocco: the Arabic script, the Roman-letter alphabet and Tifinagh, the Berber alphabet (Hoffman, 2008; IRCAM). The two widely spoken dialects are Tachelhit (the Berber dialect) and Darija (colloquial spoken Arabic). When used in social media exchanges or SMS texts, Darija is written in the Arabic or Roman alphabet, or a mix of both.

Used phones display unfamiliar languages

Berber women's phones are primarily, although not exclusively, programmed in French – a vocabulary not echoed in daily life. The written words a user sees in her daily life bear little resemblance to the French words she sees on her phone screen such as *effacer* (erase), *supprimer* (delete) and *annuler* (cancel).

Confusing letter shapes and sequences

Additionally, letter sequence and letter shape can be confusing. Low-literate mobile phone users are exposed to both Arabic (written and read right-to-left) and French (written and read left-to-right) which complicates the task of writing text messages,

reading interfaces and dialing numbers. Capital (uppercase) Roman letters look significantly different than their lowercase counterpart. This led some women in the workshops to mistake the letters for two different alphabets. Some women struggled to match the name of a letter to its corresponding image on the keypad. This required the user to match the name of a number to the image of the number on the keypad and to match the sound of a letter to its written form (i.e., tap the '5' two times to get the letter 'k.'). Having little to no formal education, participants were confused by number shapes and number sequences: some low-literate Berber women were not familiar with the concept that numbers *follow* one other. Due to the bi-directional complexities of multiple languages, suggestions such as "8 comes after 7" were not useful. For some women, it was difficult to discriminate between the similarly shaped numbers 6 and 9 and similarly shaped lowercase letters such as b, d, p and q (Figure 21).
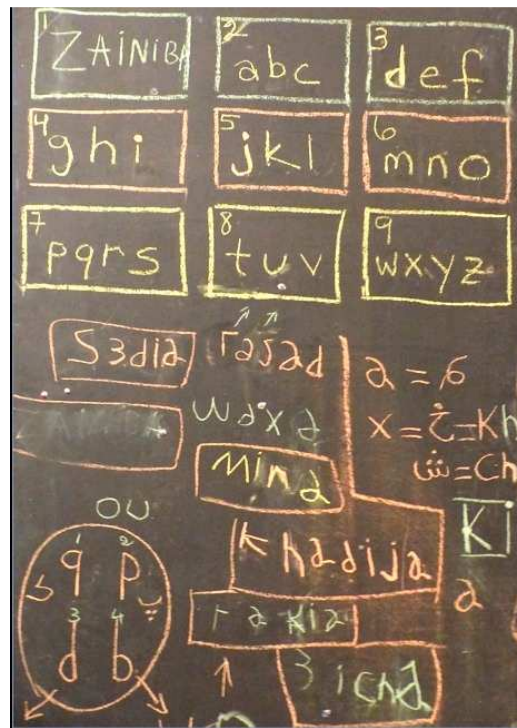
Figure 21: Berber women learn to recognize letters on their mobile keypad during literacy workshops at the Argan oil Cooperative.

Unsupported Arabic script

Some mobile users were able to read a limited amount of Arabic but owned phones that did not support Arabic script. On phones that could support Arabic script, the device had to be set to display that language – a task often beyond the reach of even literate users. Changing the language setting on a phone requires multiple key taps and an understanding of menu hierarchy. Sending and receiving texts in Arabic also required higher-level skills: in order to display Arabic-script SMS messages, phone parameters must be set to 'full character support.' (Factory settings are normally set to 'partial character support,' the minimum required to display Roman languages.) Without full character support, an incoming Arabic text message will either not display (i.e. the text field will be blank) or will display as a series of garbled symbols. It is not possible to write an Arabic-script text when phone parameters are set to partial or half character support. Character support is complicated by the fact that Arabic letters change shape depending on their position in a word. Additionally, phones that support Arabic script may not have Arabic-letter keypads – typing in Arabic characters required scrolling around a small display screen hunting for the correct letter and letter-form to use.

SMS Texts Blend Languages and Symbols

The mobile form factor lends itself to shorthand and symbols. This convention, which keeps text messages shorter and less costly, makes it difficult for semi-literate and emerging literate mobile users to 'correctly' learn new words and phrases. SMS messages often use numbers to represent Arabic letters and phonemes. Because there is no direct transliteration of Arabic words into Latin letters, and neither Darija nor Berber has a written form, text messages are often written in 'Arabish' – a creative, non-standard,

informal writing style that blends alpha-numeric code and mixed-language words (Bianchi, 2012). Thus, for low-literate users in oral-language communities, texting syntax becomes another language in an already complex linguistic environment.

10.4.3 Other Social and Cultural Barriers

The mobile phone as artifact and possession affects the way women use their phones. Access to mobile phones was often determined by family dynamics and gender-related factors as well as economic considerations.

Shared phones

Participants often shared their phones with other family members. Device availability depended on the number of phones in a household, amount of credit on the phone and gender-based hierarchies of use. While shared phones can be an efficient use of equipment, multiple users lead to inconsistent settings. Children often changed phone settings to suit their preferences, and previous users sometimes "locked" the phones and neglected to share security codes with the next user. Furthermore, mobiles were sometimes programmed with "free" ringtones and call-waiting music that ceased to be free after initial trial – which created a recurring cost to users who were not aware they were paying for the service. Additionally, advanced users often programmed the SMS setting on a borrowed phone to T9 predictive text. This was problematic for novice texters as many women in our study were surprised by what seemed to be 'runaway writing' that appeared in the SMS text field. Additionally, husbands, sons and brothers often had priority over operational phones and more sophisticated devices, including smartphones.

Lack of smartphones

Smartphones were not always available, affordable or accessible to low-income Berber women. Only four of the 46 women I interviewed owned a smartphone, in part due to the technology 'pecking order' in their families. Where smart (or smarter) phones were available, they were not always accessible. Marginalized women in conservative, traditional rural Berber communities were often the last person in the family to receive upgraded equipment. Multiple household members may have multiple smartphones before an adult woman had access to one of those sophisticated devices. Furthermore, out of a sense of duty, women may 'gift' an upgraded phone to other family members. Cost was another factor. Few Coop women, for example, were prepared to buy a new smartphone because that may cost anywhere from 3-months' to more than one year's salary, excluding talk and data plans (Meditel; Miller, 2013). (Women at the Coop earn approximately $3/day.) Furthermore, separate from issues related to smartphone availability and access, a low-literate woman may not want an upgraded device. Users faced a steep learning curve with new equipment – a process made even more difficult by lack of literacy. The prospect of a new phone with additional functionality highlights many of the socio-cultural gaps discussed above and presents what are perceived to be insurmountable challenges to phone use, leading women to reject upgraded equipment.

Below are some salient quotes from the open-ended portions of the interviews.

"I don't know how to read. When I get a message I give the phone to my daughter to read." (52-year old woman at the Coop)

"My phone numbers are written on paper. I give the phone and the paper to someone to dial the number for me. (Older woman)

"I don't know how to dial. I only know how to answer." (Older woman)

"No! Old women don't send texts!" (Older woman)

"I taught myself. Even if the phone doesn't want me to use it, I use it, against the will of the phone." (Young mother)

"I wanted to learn how to text. When you want something, you can do it. If you have a dream you can make it true." (Coop member)

"I use my phone to learn English. At the beginning, I programmed the phone in Arabic, then I switched it into English because I want to learn English." (19-year old woman)

10.4.4 Conclusion to Research Question #2

Data from Research Questions #1 and #2 laid the foundation for tests of the alpha and beta versions of the monitoring and reporting IS to support the fogwater system. In combination with information needs determined in Research Question #1, social, cultural and technical factors that affect low-literate Berber women's ICT use were considered in the collaborative design of the Fog Phone using mobile phones to help monitor and report on the new water system.

10.5 Findings: Women's participation

Research Question #3

How do ICT facilitate women's involvement in overall system management and communication of meaningful technical information regarding the fogwater system?

In analyzing whether ICT facilitated women's communication of technical information and overall involvement in the fogwater system, I referenced data from ICT

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and water-related interviews, casual conversations in public and private spaces, participatory design sessions and data gathered from the alpha and best tests of the water IS. I coded information related to social and cultural issues, paying close attention to statements by women and men related to gender and its impact on participation in the management of the new water system.

10.5.1 Women's Participation: Community Views

Socio-cultural barriers were closely tied to women's participation in this research on the Fog Phone for the new water system. Male and female community members expressed mixed messages about women's participation in monitoring and reporting on home and community water issues. They conveyed both doubt and enthusiasm. For example, both men and women expressed low expectations about women's ability to understand and contribute to water management. Concerns about women's participation in water system management revolved around two main issues: literacy and culture. Many community members said that even if women wanted to participate in monitoring and reporting on their home water systems, they did not have sufficient technical or functional literacy to use their mobiles to perform water-reporting tasks. Others mentioned anxiety over communication between unrelated women and men. These views, however, were not universal. Some women and men reported that women should be able to participate in reporting or managing the water system. This apparent acceptance of women's participation in the project occurred before water delivery began to homes in Agni Hiya, and thus cannot be considered to be a binding commitment.

Over the course of my field work, I regularly inquired about perceptions of women's roles in water monitoring, trying to isolate whether the transmission of water-

related information had a gender component. I found that water-related (and other) communication was influenced by a combination of cultural norms that control or restrict women's communication face-to-face and across ICT. I identified these factors through interviews, conversations and participant observation, learning, for instance that women's absence from conversations about the water service was often due to restrictions on face-to-face-contact between unrelated men and women. For example, one father regularly excluded his daughters (young women eighteen to twenty-two years old) from gathering near the family water meter when other men in the community and the plumber were explaining or repairing their pipes. I repeatedly witnessed male family members denigrating the intelligence and abilities of women in the family, arguing that the women were incapable and "too ignorant" to participate in a potential IS. This behavior was not confined to men. Women also made disparaging remarks about their own lack of education and expressed concern that they were not qualified to help manage the water system. Nevertheless, they participated in this water IS research.

Male authority was evident on a number of occasions in Agni Hiya, the pilot village for the fogwater project. For instance, one woman's participation in a project-wide community meeting required the approval of her husband who was in France at the time. In order to include her in the community meeting, the project manager was compelled to place numerous international calls to the woman's husband seeking authorization for her to attend the meeting. That authorization was initially denied. (The female DSH leader subsequently met personally with that resident at her family compound in Agni Hiya. One-on-one and individual household meetings, though, are not a scalable development strategy.) In a related instance, family authority had been

transferred to a son who lived three hours away from Agni Hiya. Prior to participating in the research on the development of the Fog Phone, that mother reported that she had to notify her son of her interest in participating. Other women reported that absent husbands and sons were suspicious of their participation in water system management. These factors are directly relevant to the design and deployment of a socially and culturally appropriate Fog Phone, and they speak directly to women's participation in the implementation of the Fog Phone. They also highlight the contradictions inherent in this research where women regularly expressed lack of confidence yet participated in the Fog Phone. Additionally, women and men who expressed suspicion were often forthcoming in interviews and contributed ideas and opinions on the design of the Fog Phone.

10.5.2 Findings from the Alpha Test of the Fog Phone- June/July 2013

In June 2013, I launched a small-scale, alpha version of the Fog Phone in Agni Hiya. The prototype had been rapidly designed in the field and tested for ten days (from June 27, 2013 until the water dried up on July 6, 2013). The alpha test utilized women's mobile phones, my personal mobile phone and a poster showing possible water problems as discussed in Chapter 8. Approximately 12 women participated in the alpha test, representing all eight occupied households. It is not possible to identify precisely who was using a woman's phone at any given time. From conversations and observations, I surmised that 12 women participated in the alpha test. I also identified SMS messages from one man. My phone received a total of 81 SMS messages from six households. Women from the remaining two households did not have or attain sufficient skills to send an SMS. They participated in voicemail and general mobile phone training.

Of the total SMS messages sent to the Fog Phone in the alpha test, slightly less than half employed the water reporting protocol containing a code with a letter indicating the water problem and the water meter number. More than half of the SMS messages were in longer form SMS messages sent by younger women (18-24) who had literacy skills. Approximately two-thirds of the text-based SMS messages related to water. The remainder contained social content such as Ramadan blessings (Figure 22.)
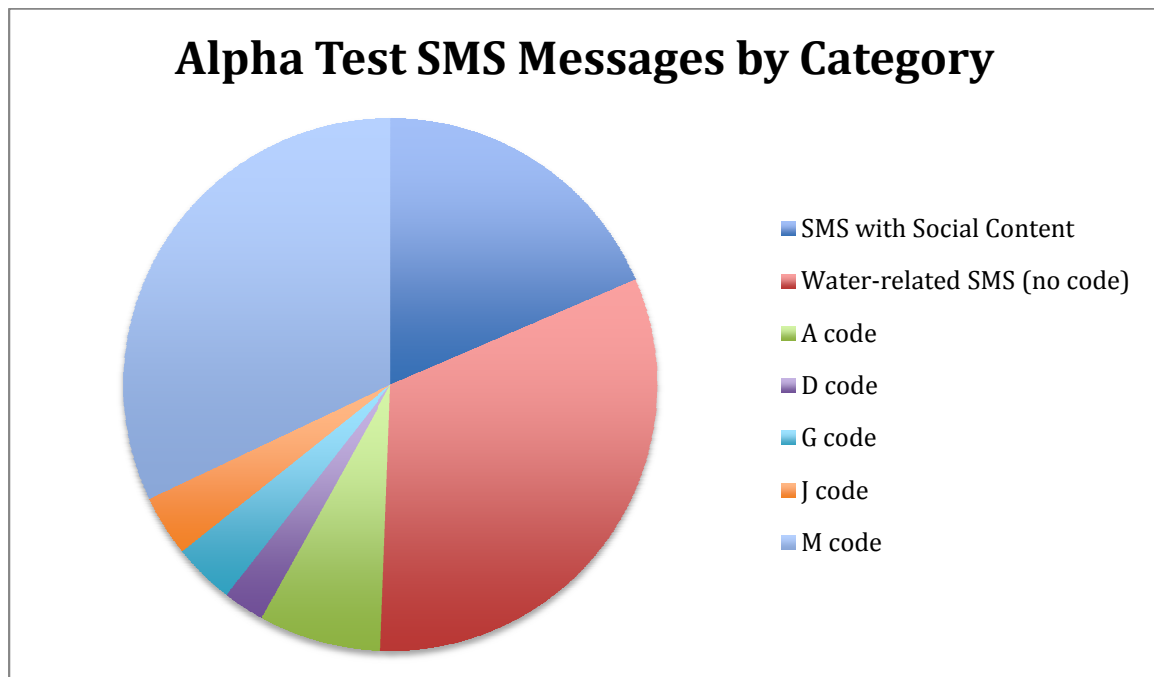
Figure 22: SMS Messages received during the alpha test of the prototype Fog Phone, sorted by category. A=No water. D=Leaking faucet. G=Leak on interior wall. J=Leak on exterior wall. M=no problems.

Below are some sample long-form text messages, with translations:

Slm cv Rah kokchi sdinah safi by (*Hi how are you. We closed everything well. Bye*)

is rin llan waman? (*Will there be water?*)

salam chef lmaa ky9t re mn saret lihkmat 3la rebinit (*Hi Boss. The water is dripping from the shut-off valve inside the house.*)

sbah lkhir akbiti mabrok l3wachir ramadan karim lah idkhlo 3lina balkhir (*Good morning little sister, blessings on the Ramadan feast. May God/Allah bring prosperity.*)

10.5.3 Installation of FrontlineSMS System and Beta Test of Fog Phone-January/February 2014

The beta test utilizing the Frontline SMS system was launched on January 8, 2014 and operated until January 29, 2014. The three-week beta test period coincided with DSH re-stocking the cistern with 30-tons of water and delivering it to homes in Agni Hiya. The test of the Fog Phone system concluded when the water ran out. Seven households were occupied during the beta test. Eight women from five of those households participated, as did staff from DSH.

During the beta test, fewer adult women were present in Agni Hiya than during the alpha test period (16 during the alpha text, 11 during the beta test). During the beta test, one woman was sick, one young woman had gotten married and had moved to her new husband's village, two adult women were out of town accompanying an elderly woman for medical treatment and one home was closed for the winter. In addition to a smaller participant pool, there were fewer plumbing problems to report. In the

intervening months between the alpha and beta tests, the plumber had made substantial

improvements to pipes, taps and meters

The FrontlineSMS platform required a stricter reporting protocol than in the alpha

test. Only one text message met the standard. Thirty-seven text messages did not

conform to the reporting parameters and, thus, did not sort correctly into the

FrontlineSMS polls. Those messages remained in the 'inbox.' Twenty-eight of the non-

conforming messages used some form of the code, i.e., the letter/number sequence

appeared within the text message but not at the beginning of it, or the SMS contained

spaces or punctuation marks separating letters from numbers. Those sequences had not

been anticipated and thus had not been programmed into the system as trigger words.

Additionally, in order to stimulate return messages, I occasionally sent out bulk SMS

messages to women in Agni Hiya enquiring about water service (Figure 23).
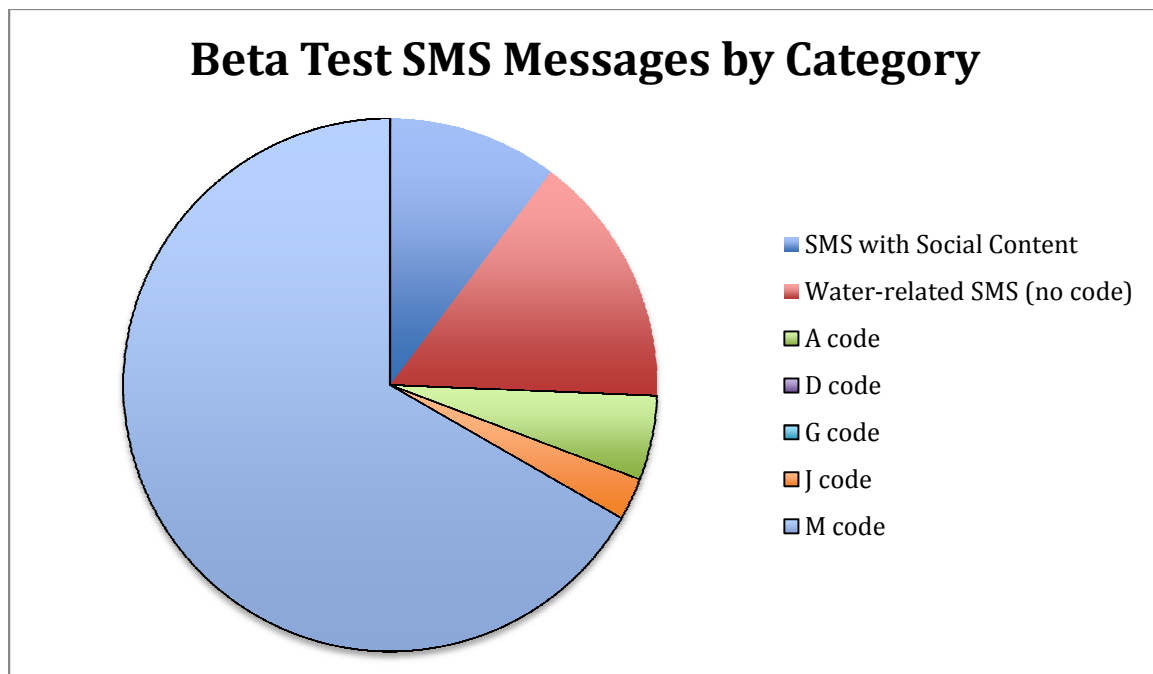
Figure 23: SMS Messages received during the beta test of the Fog Phone, sorted by category. A=No water. D=Leaking faucet. G=Leak on interior wall. J=Leak on exterior wall. M=no problems.

In contrast to the high participation rate during the alpha test when 81 messages were sent, only 38 messages were sent during the beta test. Furthermore, just one participant sent 75% of the messages sent to the Fog Phone during the beta test. Three other households sent the other 25% of messages. There are several possible reasons for this low rate.

Women reported various tangible reasons for non-use or non-participation in the beta test, including the lack of phone credits to send an SMS and an inability to send SMS after the mobile network failed during a particularly strong windstorm. They also identified the low frequency of water problems during the beta test as another reason for their low response rates. The Fog Phone had been designed to address what were routine problems in June 2013. During the design phase of the CRM in Fall 2013, many of the water problems in Agni Hiya were fixed. Therefore, when I returned to Agni Hiya for the beta test, I installed an information system that had been designed to address problems that either no longer existed or were less of an issue. The lower participation rate appeared to be tied to the decrease in water problems and reduced need to send reports. I also identified an increase in plumbing skills and do-it-yourself capabilities among male residents in Agni Hiya allowing them to fix minor water problems. Women, therefore, had less need to use the Fog Phone.

In casual conversations during the beta test, women reported that they thought the Fog Phone was useful for reporting water problems and that they trusted the IS. Women offered up sentiments such as *"Yes, I trust it. If not I wouldn't have given my phone number." "I shared the messages with my husband, and he likes it a lot." "My son was*

the one who sent it because I didn't know how." "The numbers are clear but not the

letters," and "I didn't care about it because my daughter took care of it."

10.5.4 Conclusion to Research Question #3

These inquiries address variables from all three research questions: stakeholder-identified information needs, features of a socially and culturally appropriate ICT system and women's participation in the management of the water delivery system.

Small-scale versions of the Fog Phone linking water users to DSH proved to be simple enough for most low and semi-literate mobile users to employ. Interviews and focus groups with women in Agni Hiya revealed that a possible ICT solution to reporting water issues could operate utilizing SMS messages on simple mobile phones although the reporting syntax for the FrontlineSMS system needs to be adjusted to accommodate a greater variety of acceptable strings (such as water reports that separate the water code and meter number with a space or a full stop or period). As a non-native Darija or Tachelhit speaker, I was able to process data from participants who sent water messages via SMS with the help of translators. The alpha test conducted in June 2013 also revealed that a voicemail-based communication system was a viable approach for water users who did not have texting skills or preferred to use voice services to receive and transmit water reports. However, as mentioned in the Chapter 9, the FrontlineSMS system did not support the processing of voicemail messages. In the next chapter, I analyze the implications of these quantitative and qualitative findings.

CHAPTER 11

IMPLICATIONS

The goal of this research was to generate new and useful knowledge about the ICT tools and research processes involved in developing a culturally appropriate and gender-aware information system for natural resource management in rural, gender-segregated Aït Baamrane. My time in the field and creating the Fog Phone brought several interesting observations to light have broader implications for those conducting related ICTD research and for scholars who engage with ICCD, GAD, GED, SLF and SA theories and models. These observations are summarized here. This chapter also includes personal reflections on the research process.

11.1 Observations on Gender and Generational Patterns of Mobile Use in Rural Berber Communities

While I have described the reasons why women had not used texting much before this intervention, there are other reasons that highlight aspects of women's use of ICT, not just the difference in men's and women's ICT adoption rates. For example, generational differences and life stages also appeared to affect mobile phone use among rural Berber women in Aït Baamrane. As a case in point, despite owning mobile phones for longer than five years, the majority of older rural women (approximately 50 years old and older) with little or no formal education did not access SMS services. Despite their lack of technical skills, older women reported that they were enthusiastic about the Fog Phone and experimented with their mobile phones when social support was widely available (i.e. when the translation team and younger women in the community were present).

Young mothers (in their late 20s and early 30s) initially appeared to be the most reluctant to engage in the design and use of the Fog Phone. They were also most hesitant to participate in mobile phone training. Many women in this group had some primary school education but were one-to-two decades removed from schooling. Many had either never achieved literacy or had forgotten how to read and write. Additionally, they were busy with young children and domestic duties, and they lived in the shadow of in-laws and husbands who were present in the communities, or were absent. All of these factors may have had a chilling effect on their interest and participation in the Fog Phone.

In contrast, young, unmarried women (18-30 years of age) in communities involved in the fogwater project were the most technologically literate. They were relatively active SMS users and easily extended their proficiency to the design and testing of the Fog Phone. I attribute this, in part, to being closer in time to their school years. They remained eager to learn despite having been taken out of school, and some viewed their phones as educational tools. They were quick to try, eager to learn and enthusiastic to train others, including their mothers.

This points to the potential that young, unmarried women bring to M4D and ICTD initiatives. As a group, young women can be key participants and transmitters of enthusiasm and knowledge. They are often curious, better educated and easier to engage. In this research, young, single women served as project animators by cajoling and coaching other women to use their mobiles to report on the water system. Not incidentally, a number of younger women also made great strides in learning basic plumbing skills.

However, as is the case in rural Berber communities in southwest Morocco (and many parts of the developed and developing world), young women are often in flux. Single women often leave their natal village at marriage. In some (rare) cases, young women leave the countryside to pursue higher education or paid work. They are often crucial interlocutors between the elderly in their family and institutions (as was the case of one young woman who was absent during the beta test because she had accompanied her mother and grandmother to Casablanca for medical treatment. The younger woman went along to serve as a liaison and translator between her Berber-speaking grandmother and doctors and hospital staff.)

The transient quality of young, unmarried women is not necessarily undesirable. It speaks, instead, to the potential for young women to engage and be engaged as "infomediaries" who contribute to the dispersion of skills and information.

11.2 The Friendship Gap

I practiced a continuum of contact with community members in Agni Hiya. In Summer 2013, I focused on highly personalized interactions, spending a considerable amount of time interviewing community members, socializing and engaging in the participatory design and implementation of the alpha version of the Fog Phone. Such regular face-to-face interaction with women appeared to spur interest in the system. In contrast, during the beta phase of the Fog Phone in January 2014, I spent less time in Agni Hiya, focusing instead on the technological solutions to water reporting and on the functioning of the backend FrontlineSMS system.

The response rates were lower and slower in the beta phase. Among the many reasons for that, in addition to fewer participants, fewer water problems and the lower

novelty factor, I suspect that participation was also negatively affected by the lack of personal contact between women in Agni Hiya and the research team. In order to explore this idea, I conducted two informal tests when, after three days of scant reporting to the FrontlineSMS system, I pushed messages out via the online platform in an effort to spur responses. I also analyzed response rates against my visits to the community. I discovered that there was a noticeable up-tick in response rates on three occasions. On January 11, the research team and I actively engaged with women in Agni Hiya for more than 5 hours of training and socializing. The FrontlineSMS system received twice as many messages during the day we were present in the community versus the total number of messages received on any of the previous three days. On January 15, after noticing a lull in reporting, I was curious as to whether I could 'pull' messages by 'pushing' out a message. To test this conjecture, I sent out a bulk SMS message that said "Eid Said. Manik gan aman?" (Blessings on the Prophet's birthday. How is the water?) to everyone on the Agni Hiya contact list. In less than two hours, the system received four messages, another later in the day and four the following day. I attributed this two-day 'spike' in responses, in part, to having extended a friendly message along with an enquiry about the status of home water systems.

On another occasion, January 18, during a welcome winter rainstorm in Agadir some three hours away from the villages, I sent a bulk message out from the FrontlineSMS system to residents in Agni Hiya asking whether it was raining there. The FrontlineSMS system registered an increase in messages shortly thereafter. In addition to using the water reporting protocol in messages (for example, M8), residents sent greetings such as: "It is raining, we have water, life is wonderful." "Hello, how are you?

Yesterday it rained, thank God." Rain and water system related messages continued for two additional days before messages tapered off again.

I identify this (positive) relationship between social contact and personal communication and an increase in instrumental communication as the 'friendship gap.' I surmise that M4D and other ICTD initiatives might benefit from considering the 'friendship gap' along with other complexities of the utility gap. Future work could consider the role of the friendship gap in adoption of initiatives that utilize ICT for instrumental communication.

The 'friendship gap' also manifested in other ways. One of the most celebrated affordances of technology is the efficiency benefit that accrues from ICT use (Donner, 2004, 2009). For example, Kang and Maity (2012) found that mobile phone users at the 'Bottom of the Pyramid' preferred to use SMS as a means of practical communication relating to work and business rather than for intimate and bonding communication with those with whom they had a personal relationship. Contrary to those findings, my analysis suggests that low-literate Berber women did not embrace a strictly instrumental use of their mobiles to report on the water system. Responses from alpha and beta tests highlight the importance of friendly communication. Efficiency benefits and utilitarian, productive communication did not appear to be as highly valued.

I surmise that low-literate rural Berber women involved in this research found it difficult to transition from personal to instrumental use of their mobile phones. The overwhelming majority of women involved in this research used their phones for kin-keeping and other social/personal communication. Those habits appeared to influence

(and sometimes override) the instrumental aspects of the Fog Phone (i.e., water reporting protocols and 'rules of use' for the Fog Phone).

The Fog Phone was designed to enhance communication between female water stewards and DSH in order to better facilitate management of water resources. The reporting language for the reporting platform was based on impersonal reporting protocols (a problem code followed by a meter number). The system was not designed to parse SMS messages that fell outside the reporting protocol. I found, though, that respondents often sent social messages along with water-related messages, and water-related response rates were higher when women received messages containing social content along with water inquiries. This suggests that social contact eclipses efficiency benefits as one of the drivers of IS use or adoption. This suggestion challenges common M4D and ICTD assumptions that efficiency benefits are a commonly shared value. I surmise that other values, such as friendliness and social courtesy may, under some circumstances, take precedence.

Future work might investigate the processes involved in balancing highly personalized (but difficult to scale) communication systems with highly technologized systems (that ignore social conventions and thereby undermine adoption). Future work might also focus on the processes involved in 'humanizing' a system in a way that information or data can be sufficiently systematized while retaining social connections.

11.3 The Paradox of Social Networks

Social complexities and cultural norms both positively and negatively affect Berber women's mobile phone use. Due to low literacy levels, women rely on assistance from an array of trusted others to help them manage and use their phones. This reliance

on a network of helpers, however, often comes at the cost of privacy and independence. This is the 'paradox of social networks': family, friends and acquaintances play a pivotal role in a rural Berber woman's ability to use her phone while simultaneously exerting an oversight role over her phone use.

I found that the use of mobiles can lead to social tension. In this study, the existing social structure, which is often repressive for low-educated, low-literate, resource-poor rural women, is replicated and propagated through the mobile device. In rural Berber, conservative traditional and religious values limit communication between unrelated women and men. These restrictions persist independent of the modality of communication. Limitations on communication between unrelated women and men extend beyond face-to-face interactions to encompass the virtual, digital and electronic spheres. In this study, taboos on mixed-gender communication extended across technological platforms to include phone-to-phone (voice) contact as well as text-to-text exchanges.

Mobile communication both challenges and disrupts gender-proscribed communication patterns and has led to new forms of surveillance of Berber women's ICT use. This control and oversight mechanism was evident in observations and conversations in the community, where it was clear that male authority figures worried about women's mobile use. Anecdotally, Berber men expressed concern that female relatives would be tempted to use their mobiles to interact with men outside of the family, and they made oblique references that mobiles encourage infidelity by women.

It is important to note, though, that the concern that women need to be protected from dishonorable contact with men outside of the family was not just the domain of

men. Many mothers I interviewed closely monitored their daughter's incoming and outgoing calls while simultaneously depending on their daughters for help using mobiles. Men and women, fathers and mothers and siblings all contributed to an atmosphere of suspicion and surveillance of women's phone use. Surveillance occurs within the family as well as by friends and acquaintances. Berber women often rely on shopkeepers to assist them with tasks such as installing mobile credits, trouble-shooting or phone repairs. Women from the Coop reported that they seek these services from male tele-boutique owners and local retailers with the understanding that the service provider is likely to look through their call log and their incoming and outgoing texts. Women reluctantly accept this invasion of privacy in exchange for receiving the mobile service.

Women from the Coop and in the villages often expressed a desire for more phone-related independence and the privacy that would result from it. *"I want to text family or people I know without giving my phone to my sons to do it"* or *"I don't go out much so sending messages is appealing. It's private. When you give your mobile to someone to send a message for you, you are giving them your privacy. It's better to send your own message and not depend on someone else."* They acknowledged, though, that their mobile use is tethered to their social network because that network provides them with a de facto set of ICT trainers, surrogates and proximate literates who support their phone use. This research corroborates findings by other scholars who found that the "availability of technical assistance is one of the important facilitating conditions in technology use" (LIRNEasia, 2009, p. 8 citing Ventakesh et al., 2003; Park et al., 2008). As I found in the Coop and in communities involved in the fogwater project, technical

assistance often occurs in social settings, and it involves family and friends (LINREasia, 2009).

11.4 Assessment of Methods

There were interesting implications to my choice of methods and theories that may be relevant to the larger ICTD community. This research was methodologically challenging because of its multi-disciplinary scope, requiring the incorporation of methods, frameworks and models that address issues associated with different scale (i.e., individual and local; social and natural; and ecological and global).

I found that a mixed methods approach had clear advantages. Employing mixed methods contributed to a rich, contextual understanding of rural Berber women's ICT use as well as the processes involved in developing and implementing the Fog Phone for the fogwater system. Ethnographic Action Research was useful in capturing detailed motivations affecting the use of mobile phones by an under-served population of rural Berber women. HCID principles were invaluable in the design of the Fog Phone. The Sustainable Livelihoods Framework (SLF) encouraged me to develop a more comprehensive and holistic view of the immediate community as well as generate a portrait of larger political and environmental forces that affect the community. The Stakeholder Analysis (SA) was an economical way to organize major and minor stakeholders and to better identify the benefits that might accrue to stakeholders. I expand on these ideas below.

11.4.1 Assessing the Usefulness of EAR

EAR was the dominant method for fieldwork in the Coop because it was the appropriate method to use to understand Berber women's communicative ecologies. By

using EAR, I was able to understand how women used their mobiles. The four phases of Ethnographic Action Research (observe, plan, do, reflect) were particularly useful in early stage research in the Coop where I sought to identify and understand the mobile utility gap. EAR was also vital in my investigation into the factors of a culturally, socially and technically appropriate IS to support the fogwater harvesting system. The 'do' phase of EAR invites the researcher and community participants to co-devise an action plan which I did through the co-creation of the mobile workshops and training sessions at the Coop. In the fog project, I operationalized the 'do' phase by embracing HCID principles and practices which were used in participatory design of the water posters and the water reporting protocol. Finally, I reflected on my role as a researcher, on community dynamics and gender issues in rural Berber communities and on the processes involved in designing and implementing the Fog Phone.

Ethnographic Action Research is susceptible to the same critiques as those directed at ethnography in general. With its qualitative emphasis on investigating and understanding participants who are located within a particular linguistic, historical and social milieu, and through its social change agenda, EAR is not necessarily focused on yielding quantitative data which challenges the positivist stance to research (Cornwall & Jewkes, 1995; Lincoln, 1995; Walsham, 2006). Furthermore, EAR's focus on understanding local, context-specific environments and relationships can hamper the generalizability of findings, and findings are difficult to replicate under other field conditions. Additionally, it can be argued that "the data which ethnographers use is a product of their participation in the field rather than a mere reflection of the phenomenon studied, and/or is constructed in and through the process of analysis" (Hammersley, 1992,

p. 2)

I found that while EAR was effective on site (in face-to-face, micro-level, personal and small-group interactions), it was less useful in helping me understand mid-level factors that affect Berber communities in southwest Morocco. EAR encouraged the collection of an abundance of detail but provided no clear path to utilize that information beyond the local, action-oriented project. I found, though, that the hyper-local information I gathered from EAR was useful as input into higher-order mid-and-macro-level analytical frameworks, including the Gender and Development (GAD) analysis, the Stakeholder Analysis (SA) and the Sustainable Livelihoods Framework (SLF).

11.4.2 Assessing the Usefulness of GAD

EAR methods were particularly useful in conducting the Gender and Development (GAD) Analysis. Ethnographic data from the Coop and communities involved in the fogwater project provided me with a broad foundation for considering the influence of gender-based roles, relationships, responsibilities and how they relate to women's participation in the Fog Phone. Crucial contextual information on women's and men's domestic and community roles in Agni Hiya were revealed through a GAD gender analysis which helped inform the design of the Fog Phone.

GAD, though, was deficient in two important ways. GAD is not designed to specifically address the use of ICT (although it can be manipulated to understand these conditions). Nor does GAD directly address issues related to natural resource management and use by marginalized women. Those issues are instead addressed by GED (Gender, Environment and Development).

Furthermore, while GAD highlights biases, discrimination and power differentials that disadvantage or marginalize women in developing communities, the 8 Tools of GAD do not offer prescriptions for eradicating divisions or altering power dynamics to make "new alliances out of old divisions, in order to build more inclusive, transformatory practices (Cornwall, 2003).

11.4.3 Assessing the Usefulness of SLF and SA

Because of its inward focus on participant and researcher processes, EAR methods alone were insufficient in understanding community-level dynamics and processes. The deep, contextualized information, however, was invaluable when it came to constructing the Stakeholder Analysis (SA) and the Sustainable Livelihood Framework (SLF), and I ultimately re-purposed EAR data to populate both those frameworks. Additionally, the SLF also provided me with a greater understanding of gender, culture and technology at the intersection of natural resource management.

My experience using SLF mirrors that of development scholars such as Rakodi and Lloyd-Jones (2002) who discuss the drawbacks of the framework's emphasis on analyzing an individual or household based on their consumption patterns. "Defining a household as poor in terms of consumption may not capture all deprived households and individuals" (p. 6). Furthermore, the authors point out that an individual or community's *perception* of poverty or ill-being are often affected by social relationships and are not confined to attributes of the assets and capitals embedded in the SLF. Additionally, the SLF does not necessarily capture all of the coping strategies that households incorporate to fend off or mitigate risk, which in the case of rural Berber communities I studied, had a profound influence on overall welfare. Another critique of the SLF is that it does not

account for opportunistic responses to changing circumstances. As the authors note, there is some doubt about the "extent to which poor households have sufficient control over their assets and environments to be able to pursue goal-oriented behaviour, suggesting that most can merely react opportunistically to changing circumstances" (p. 7). Opportunistic behavior was evident in the fogwater project (for example, in the rapid use of free water during the alpha test, or perhaps in participation in the design and development of the Fog Phone), making it difficult to differentiate between a possible positive change in assets or capitals or a short-term behavior shift.

11.4.4 Assessing the Usefulness of ICCD

I found that SLF and SA also had limitations. Neither the SLF nor SA framework allowed me to fully integrate top-level issues related to natural resource use and, more broadly, factors related to the intersection of ICT and climate change adaptation. These concepts are more fully integrated in the ICCD (ICT, Climate Change and Development) model. The ICCD model broadly illuminates the role of ICT to assist in climate change mitigation, monitoring, adaptation and decision-making. I found that combining EAR, SLF and SA methods helped operationalize the relatively new model in a community-level project.

Climate change impacts often occur at a local level, such as in communities involved in the fogwater project, but the ICCD model often emphasizes the use of ICT as decision-making tools at levels above the community (i.e. institutional, regional, sectoral, national and international). Additionally, much of the published ICCD research focuses on the use of ICT in direct action to mitigate, adapt and monitor the impacts of climate change. This research into the tools and processes involved in the Fog Phone for the

water project might be considered an 'off-label' or tangential use of the model because the Fog Phone was designed to manage and monitor water resources that are affected by numerous stressors, of which climate change is only one. Additional stresses on water supply and water quality are due to factors such as poor management and industrialization that are not directly related to climate change. Furthermore, the model may only be *indirectly* applicable because the Fog Phone does not provide climate change information per se. I contend, however, that ICCD research will benefit from the widest interpretation of the model. A narrow *understanding* of the ICCD model could serve to further isolate the discussion of pressing problems related to climate change in developing countries. A narrow *application* of the model does not serve those who are most vulnerable to climate change.

11.4.5 Assessing the Usefulness of HCID

Participatory and progressive HCID methods infused the design of the Fog Phone. I adopted Maunder et al.'s (2008) advice to give priority to the development of users, in this case rural Berber women involved in the water project, and to supportive structures within their living and working environments. Women from Agni Hiya were closely involved in the iterative design of the Fog Phone for the fog project. They identified the most salient water problems, and they provided feedback on the posters and SMS and voicemail usability issues. These efforts were consistent with the author's advice to develop the knowledge base and skills of the user in order to enable them to understand the prototype system, its benefits and how to effectively utilize it (Maunder et al., 2008, p. 6).

Participatory design sessions provided a space to develop technological capacity as well as motivation to adopt the Fog Phone. They also served as a forum to learn plumbing skills together. This combination of tactile and technical skills helped create investment and interest in the water system and the information management component. Furthermore, consistent with user centered and interactive design principles, stakeholders were consulted throughout the design process in order to ensure that the Fog Phone met their needs (Maunder et al., 2008; Stephanidis, 2001; Wong & Kodagoda, 2011). I gave priority to creating a congenial, supportive research environment that entailed meeting in gender-segregated focus groups where women would not be susceptible to criticism or judgment from male family members or neighbors.

The workshops and focus group meetings were also social events in Agni Hiya, occurring during a tea break or took on a party atmosphere. That speaks, again, to the importance of blending the instrumental with the social, in both face-to-face and technology-mediated contact.

11.5 Reflections on the Research Process

Ethnographic Action Research (EAR) requires the researcher to not only reflect on the research process but to reflect on their own role and relationships with members of the community under study. This section contains reflections on my role as a researcher, advocate, friend, information broker and animator.

11.5.1 Building Trust

I developed an environment of trust and openness between myself and research participants, engaging with DSH staff, the water manager and members from participating communities in honest, friendly relationships. I recognized that one of my

roles as a participatory researcher was to "play an active role in creating and maintaining a collaborative atmosphere in which all stake-holders can participate in the project in good faith and with mutual trust" (Park, 1999, p. 152). Collaboration added richness to the research, such as when women in Agni Hiya and I jointly produced the content for the water posters, or when DSH project managers and I worked closely to conceive of the water IS. In both cases, the result was more creative and effective than what I would have achieved on my own. Collaboration also contributed to a spirit of accountability between each stakeholder group (water users, the water manager and DSH project managers) and me. Being a passive observer or detached researcher was not an appropriate option for me as I investigated personal, social and cultural factors that might influence a study participant's contribution to the development of the Fog Phone. I maintain that my research benefited from the many sincere friendships that evolved in a sometimes frustratingly slow, social manner where the "work" of interviewing or training was delayed or given a lower priority than having a tea party or sharing family photos. Furthermore, as a privileged, Western researcher, a relationship established solely for the purpose of conducting research would not have been appropriate. I believe that the trust and friendship that developed between community members, the team of translators and me helped marginalized rural women gain the confidence and courage to participate in the research process.

While I was welcomed into homes and accepted at public gatherings, my presence and my research goals occasionally caused confusion. To ameliorate that confusion and to develop research relationships and friendships, I socialized, shared meals, cracked Argan nuts and occasionally performed domestic duties such as fetching water, doing the

dishes or learning to make couscous with women in Agni Hiya. These experiences helped build and strengthen personal bonds between the translators, research participants and me and were particularly effective ways for me to bridge language barriers with community members.

I also developed friendships with men in the communities involved in the water project in order to build trust in my work with their neighbors and family members. These conversations contributed to the development of the Fog Phone by providing me with information on social and cultural factors that might affect women's participation in system management. Respectful relationships with men in the community also helped mitigate suspicions about my research or my presence in villages and in homes.

11.5.2 Becoming an Information Vector

I unexpectedly became a primary information vector during the pilot test of the water delivery system and the accompanying Fog Phone tests. Community members identified me as a link to project managers and the local water manager, and I quickly became the 'water carrier' for information about system-wide problems. Because I was present in the community on a nearly daily basis during the launch of water service in June 2013, I was able to observe and discuss with residents myriad problems with the new pipes and taps. Women and men in the community used me as a conduit to relay issues to project managers and the water manager, and they provided specific suggestions on the kind of information they wanted to receive from managers such as the plumber's schedule, water shutdown notifications and alerts about water quality.

Additionally, during site visits to Agni Hiya, I engaged in detailed conversations with the chief project plumber and his assistant in order to understand the specifics of the

water delivery system at the community and residential level. I did not face any overt restrictions on my access to the plumber or plumber's assistant, so I took on the role of an information broker between female (and occasionally male) residents and the plumbing crew. These conversations allowed me to understand the mechanics of the water system as it pertained to water users. I was able to share this information with female and male residents during social and research-related visits. In some cases, it was difficult for women in the community to receive information directly from the plumber because men in the community sometimes prevented or discouraged women from being present while a plumber was in the house. On other occasions, when women were in the presence of local men and the plumber, the women retreated and were unable to see or hear conversations about the water system.

I also discovered that answering basic plumbing questions helped me build rapport and trust with both male and female community members. In addition to ICT skills, I led basic plumbing workshops with women in the community which helped them develop tangible skills to troubleshoot water-related problems. These training sessions also helped build their confidence and interest in participating in design of and research into the Fog Phone and, perhaps, taking on a community leadership role in the future.

11.5.3 Being a Project Animator

I found that I often played the role of project educator and animator, stimulating interest and participation in this research. I assigned myself this role, in part, as a way to bridge the substantial language and cultural gaps between community members and myself. Furthermore, the role of animator is consistent with Ethnographic Research Action methods. EAR required me to be immersed in the field in order to "animate

actions based on sound local knowledge (Tacchi et al., 2003, p. 10). This animating role of the researcher "is intended to ensure the active participation of users and stakeholders in the research process, and to build flexibility and responsiveness into the project" (Tacchi et al.). Similarly, I experienced what Cornwall and Jewkes (1995) describe as "researchers become learners and facilitators, catalysts in a process which takes on its own momentum as people come together to analyse and discuss" (p. 1668).

I relied heavily on translators to transmit technical and instructional information, but I supplied enthusiasm – whether it was trying a new feature on a mobile phone, or participating in a game of dismantling and re-assembling a faucet. I found that women who were initially reluctant to engage in my seemingly odd requests to, for example, handle plumbing tools or try placing a phone call often capitulated after some friendly cajoling from me to "ha-wuhl, ha-wuhl" (try, try). I fully acknowledge that early encounters with me were driven, in part, by an interest in pleasing the visitor and early enthusiasm could not be considered a commitment or guarantee of future participation. "Involvement in the research process is usually neither continuous nor predictable. Commitment and interest waxes and wanes over time" (Cornwall & Jewkes, p. 1673). That said, over time, the translation team and I witnessed greater interest in the research and the Fog Phone that appeared to be genuine (Figure 24). This manifested in more detailed reports about water issues during site visits in Agni Hiya. It was also demonstrated when women sought us out to make suggestions on fine-tuning the poster to include a greater variety of issues or recommendations. Additionally, women repeatedly shared suggestions on better ways to train participants to use the Fog Phone, and they provided guidance on how to engage women in the community who were

reluctant to participate in the Fog Phone, thus creating "communication loops" between community members, participants, translators and me (Byrne & Alexander, 2006, p. 122).

Figure 24: Gathering feedback during a participatory design session for the prototype Fog Phone for the fogwater project.

Additionally, I believe that I was sometimes a convenient cover story for women, particularly young, single women, to try a new tool or tone of voice that might otherwise challenge gender norms. My presence occasionally allowed women to act differently because I had created a research setting that was safe for them to experiment with new identities. I do not believe that any of our activities jeopardized or harmed women in the community and I am under no illusion that this research permanently changed the status quo. I placed great importance on being transparent but acknowledge that action research can be subversive (Coghlan & Brannick, 2005, p. 70). As Cornwall and Jewkes (1995) remark, "empowered communities may challenge established power structures" (p. 1673). I am fully aware that I introduced new opportunities to women that challenged

traditional or entrenched gender dynamics. I looked to women in the community to set the pace of our encounters and gave wide latitude to participants to engage on their own terms so as not to jeopardize their roles or responsibilities. I did not view women who participated in this research as victims, but we acknowledged (verbally and non-verbally) that their status was lower than that of men in the community. I viewed their collaboration in this research as an acknowledgement that their role in water stewardship was obviously changing, and along with that came some opportunities to, perhaps, re-consider other roles and responsibilities. Throughout my interactions in the communities, I kept in mind Wadsworth's insight to cultivate and be aware of "the countless tiny cycles" of participatory research. I found Wadsworth's observation that "change does not happen at 'the end'- it happens throughout" to be particularly perceptive (Wadsworth, 1998, p. 8).

Figure 25: A young Berber woman learns basic plumbing by taking apart and re-assembling a faucet.

CHAPTER 12

CONTRIBUTIONS AND CONCLUSION

My research was motivated by an interest in exploring the linkages between ICT use, climate change, natural resource management and women's participation as a mechanism for individual and community development in the Aït Baamrane region of Morocco. I pursued this interest by studying two similar communities of rural women who are culturally and economically marginalized, who reside in a drought-ridden region and who value their mobile phones. Using technology-focused ethnographic research methods, I first investigated the social, cultural and technical factors involved in mobile use by Berber women employed in the Coop. In that exploratory research, I developed a nuanced understanding of the utility gap but also found that there was no obvious ICT linkage between those women and natural resource management. I then applied and expanded my research to marginalized Berber women who were involved in a fogwater system. With that population, I explored the tools and processes involved in the design and application of a Fog Phone. I found that a culturally, socially and technically appropriate information system enabled women to report on the water system, thereby hopefully contributing to the operational sustainability of the fogwater harvesting system while still being actively involved in water stewardship. In addition to an exploration of gender and technology, this research explores how climate change and environmental vulnerabilities relate to women's lives and livelihoods, and it investigates the ability of rural Berber women to manage the environmental assets on which their livelihoods depend.

My work on this project has been published in ITID and EJISDC, and I have presented my research in this area to both scholars and policy makers at the ICTD 2012 and ICTD 2013 conferences (ICTD 2012, ICTD 2013), to mobile learning specialists at UNESCO (UNESCO Mobile Learning Week 2012) and to scholars in the Society for Applied Anthropology conference on Natural Resource Distribution and Development in the 21st Century (SfAA, 2012). Additionally, this work was featured in Proceedings from the Intelligent User Interfaces for Developing Regions 2011 conference (Dodson, Sterling & Bennett, 2013). This research was supported by a National Science Foundation Doctoral Dissertation Research Improvement Grant #SES-1353945 and by the American Institute for Maghrib Studies (AIMS).

Below, I explain the contributions that this research makes to scholarship, practice and policy.

12.1 Contributions to Theory and Practice

This research makes four contributions that span theory, practice and policy.

Contribution 1: A Prototype Water Information System for the Fog Project

This research contributes to the sustainability of the fogwater system by providing DSH and water users with a functional prototype Fog Phone that can help the organization achieve its mission to deliver potable water to rural households in an operationally sustainable way. Furthermore, this prototype information system honors women's central role in water stewardship, which may advance their standing in the community by increasing their agency. The Fog Phone is adaptable and flexible in large part because women were closely involved in its conception and design. The development and deployment of the Fog Phone helped build local capacity by involving

Berber women as infomediaries who transmitted local information about the water system to project managers. That infomediary role has room to expand as the Fog Phone expands to address other issues such as water conservation messaging, health information, mobile-learning and livelihood opportunities related to local natural resources. In general, the system may be useful in the future because the skills, the ICT and the platforms can be repurposed by DSH and expanded to serve other needs.

This research led to tangible benefits for study participants and stakeholders. In the pilot test, female water users benefited from an easy-to-use mobile-phone-based system to report on water system service problems. Project managers benefitted from an efficient, consolidated monitoring system and the local water manager benefitted from a convenient and culturally appropriate communication system that links to local residents. Female water users who participated in the study may have also received indirect benefits such as an enhanced sense of agency and increased self-esteem stemming from their participation in the Fog Phone.

The prototype IS is not limited to being an application only for a fogwater harvesting system. The information system linking multiple stakeholders can be generalized to other ICTD initiatives that have a reporting and monitoring component and that involve low-literate community stakeholders who have basic texting skills and who are equipped with simple feature phones. For example, in circumstances where a group of phone numbers can be collected, an information system similar to the Fog Phone can be used (and is being utilized) for transactional purposes such as the dissemination of market price information or to report on the availability of goods and services such as announcing the presence and location of health workers. Additionally, the prototype Fog

Phone IS can be adapted to serve projects where issues have been identified and agreed upon (such as water problems) by different tiers of stakeholders and where status reports and updates would help a project be more effective. For example, an IS of this type might be useful in citizen science and environmental monitoring initiatives that link rural community members with non-governmental organizations or researchers. Furthermore, this type of IS can be useful in projects where reporting and monitoring messages can be simplified into basic, standardized codes or common syntax that can be used by stakeholders to communicate status reports or project updates. Possible use-case scenarios might include integrating the components of the prototype Fog Phone IS in an early warning system to report on upstream water conditions, or for an NGO to aggregate field reports and to send alerts to distant communities about impending weather conditions. In these cases, it is beneficial to triangulate information through an organizational entity that can collate incoming information and disseminate bulk messages.

Contribution 2. Widening the Definition of the Utility Gap

This research contributes to practitioners' understanding of the mobile utility gap and its impact on the use of ICT by marginalized women in polyglot and oral-language dependent communities. I widened the definition of the utility gap by identifying complexities such as layered social, cultural and technical issues that complicate ICT use for semi-literate Berber women (Dodson, Sterling, & Bennett, 2013). This research underscores Warschauer's (2002) concern that a concentration on providing hardware and software could lead practitioners to pay "insufficient attention to the human and social systems that must also change for technology to make a difference" (p.3). He notes

that "content and language, literacy and education, and community and institutional structures must all be taken into account if meaningful access to new technologies is to be provided" (p. 3). This immersive ethnographic research contributes to our understanding of the widespread and persistent technological, social and linguistic barriers that limit the usefulness of text messaging and other mobile phone features for these women and others like them. Cost, gender hierarchies, fear of sophisticated devices, complex language environments and poor quality equipment all impede the use of mobile phones by these marginalized, low-resource women. Individually and in combination, these barriers to use can create a profound utility gap for low-literate, low-skilled women who possess and value their mobiles but struggle to use them.

The catalog of barriers that I identified in this research is not exhaustive, but it indicates that there are significant technical, social and cultural barriers to participating in the many communication benefits that mobiles provide. For low-resource illiterate women, the inability to access life-improving benefits such as sharing information in a cost-effective way or taking advantage of mobile-based development services can further marginalize them. These conditions are not specific to Morocco. There are approximately 500-million illiterate and low-literate women in the world today.

Warschauer (2002) points out the similarities between acquisition of literacy and access to ICT. Both are a set of social practices and both require a variety of "physical resources, relevant content, appropriate user skills, knowledge, and attitude; and the right kinds of community and social support" (p. 6). The author highlights six ways in which literacy acquisition and ICT access overlap. Both the acquisition of literacy and ICT use exist in gradations, both are social practices "involving access to physical artifacts,

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content, skills, and social support" and both are "a matter not only of education, but also of power" (p. 6). My findings on ICT use by low-literate Berber women echo these observations. Women's use of mobile phones was influenced by multiple linguistic, social, cultural and technical constraints that affected mobile use beyond the provision of handsets. The ICT-related interviews with Berber women and men helped illuminate the "complex array of factors encompassing physical, digital, human, and social resources and relationships" that affected use of mobile phones (Warschauer, p. 5). Furthermore, the technology inventory (Chapter 5) and the Sustainable Livelihoods Framework (SLF) (Chapter 7) also contributed to a "thick" understanding of the myriad physical, digital, human and social resources and relationships that affect Berber women's mobile phone use and their ability to make use of their devices and to engage in "meaningful social practices" such as personal communication and instrumental communication related to the fogwater project (Warschauer, p. 5).

Furthermore, this research confirms that while technology is important, *appropriate* technology is crucial. Sturdy components and functional technology are, of course, significant aspects of any ICTD initiative, but it is the human elements – those cultural, social and contextual factors –that give meaning to *appropriate* technology. In previous research on failure analysis, I found that development initiatives that blend appropriate technology with community participation tend to have more favorable outcomes (Dodson et al., 2012). That research also illuminated the extent to which effective ICTD projects are grounded in an understanding of individual and community subtleties that influence both ICT use and project acceptance. Undesirable outcomes can often be circumvented with community-level input and awareness of the cultural

cosmology (beliefs, structures, dynamics) that affect ICT access and use. Therefore, a nuanced and contextualized understanding of the myriad social, cultural and technical constraints as well as an awareness of the supporting structures that underpin the use of mobiles by low-income, semi-literate women is vital to the development and deployment of information systems in developing communities. Furthermore, ICTD initiatives for low-literate users in oral language communities will benefit from a nuanced understanding of the "rich pluralism of regional traditions, languages, dialects and cultures" (Morley & Robins, 1995). This understanding, along with an awareness of the mobile utility gap, can help mobile-based efforts in oral-language communities be more effective.

Many of these findings, obtained from a specific group of low-literate Berber women in an oral-language community, may also apply to other communities in developing countries where there is high mobile phone ownership but low usage of text-based phone features. The Berber women who participated in this study may appear to be "unique" users, but their experiences may be generalized to other predominantly oral-language societies. Barriers to using mobiles for advanced features that expand communication and save both time and money are often magnified in the context of oral-language dependent and polyglot communities where multiple alphabets are in use. This is not a rare phenomenon. As noted, most of the 7,000 languages spoken today do not have a written form (BBC, 2013; O'Neil, 2011; UNESCO, 2006; University of Pennsylvania).

Recommendations for ICTD Practice

Mobile phone use is a difficult task in settings where the primary form of communication is oral, where multiple dialects are spoken and where literacy levels are low due to cultural restrictions that limit women and girls' access to formal education. These constraints, as well as gender-based restrictions on communication, have implications for the design of wider ICTD and mobile-based development initiatives. One of the key challenges for ICTD practitioners is to address the issue of low adoption of many features and functions available on ICT. This research shows how adoption can be encouraged with simple, easy-to-understand messages that consider the importance of social contact and friendship alongside of instrumental benefits and technical support within the user's social surroundings (Kang & Maity, 2012). ICTD initiatives might benefit from addressing not only direct and visible benefits, but also intangible benefits such as friendship and social contact (Donner, 2009).

Along with the suggestion to balance social and instrumental uses of mobiles, I also clearly established the role of social influence and social networks in this research. I contend that programs such as gender-segregated community-based training sessions, peer-to-peer mentoring, engaging young women in the community to serve as promoters and advocates of an information system could be part of other mobile-based initiatives spanning health, education, environmental or livelihoods projects.

Issues of technical literacy also warrant deeper consideration when devising mobile-based literacy and education programs for low-literate users because low-quality devices can have an adverse impact on a user's ability to benefit from mobile services (Figure 26). Low-literate women are acutely aware that simple phones are not simple to

use. While text-based user interfaces (UI) may be a foregone conclusion, without local language support for illiterate users, text-based UIs will continue to frustrate millions of already marginalized, low-literate women in developing communities (Knoche & Huang, 2012). Furthermore, participants reported that smartphones and next-generation ICTs are not necessarily practical solutions to their problems of poor quality equipment because marginalized women in rural, conservative societies are often the last person in a family to receive upgraded equipment, and they often do not want it because of the steep learning curve that new equipment requires.

Figure 26: Young women consult over the design of the water posters.

Contribution 3. An ICCD Case Study Focusing on Complex Vulnerabilities

This research advances the ICCD model by contributing a case study portraying the linkages between ICT, climate change and development in a project to deliver fogwater to rural Berber communities that are vulnerable to climate change. The study contributes to the *adaptation priority* in the ICCD model that focuses on the role of ICT tools in contributing to the adaptive capacity and resilience of vulnerable populations, such as residents in rural, drought-stricken Aït Baamrane. ICTs have the potential to facilitate climate change adaptation "through increasing access to, and control over real-time data, information and knowledge' (Heeks & Ospina, 2012, p. 118). These priorities are reflected in the prototype IS. Furthermore, climate change adaptation requires "ICTs to be transformational as much as informational, developing collective as much as individual capacities" (Heeks & Ospina, 2012, p. 117). The prototype IS for the fogwater project helped develop technical skills of low-literate rural Berber women as well as community capacity. The study contributes to the adaptation research area of ICCD with a specific focus on attributes related to localization of ICT, gender and knowledge-sharing.

Adaptation requires an understanding of the nature of community capacity and resilience, and adaptation prioritizes participatory natural resource management and planning. This research contributes to adaptation through "the improvement of water resource management techniques, monitoring of water resources and awareness raising" (Heeks and Ospina, 2012, p. 24). The fogwater harvesting system directly addresses climate-change induced stresses on water resources in rural Aït Baamrane. The accompanying Fog Phone contributes to water awareness and water monitoring using at-

hand basic mobiles and a frugal design approach to the development of the Fog Phone to help manage the water project (Heeks & Ospina, 2012).

This research contributes to the state of knowledge at the intersection of gender, climate change, resource management and ICT. The impacts of climate change are often most acute at the local level in developing communities, and the negative effects of climate change are most often borne by rural women (IFRC, 2010, 2013; MercyCorps; USAID, 2014a). As stated in Chapter 2, The United Nations ranks women's access and control over resources such as water as crucial to the creation of a more equitable society, and scholars and practitioners have established that water projects in developing communities are strengthened when women's effort, knowledge and experience are included (United Nations, 2009). This ICCD case study advances one of the key tenets of the ICCD model, which is to deliberately and actively incorporate marginalized women because "women constitute key agents of change within communities, and their role is crucial in the promotion of ICT tools and approaches" (Heeks & Ospina, 2012, p. 6). Employed appropriately, ICT may enable women in Morocco and other developing countries to expand their participation in climate change adaptation initiatives and stewardship of natural resources. Because women in developing communities are particularly vulnerable to rapidly-depleting and compromised natural resources, they have important roles to play in terms of resource use, resource monitoring and resource stewardship. In turn, new skills and opportunities may create conditions that facilitate faster, more enduring, and broader economic benefits for themselves and their communities.

The ICCD model is predicated on the notion that ICT tools offer opportunities to create useful knowledge that fortify the ability of vulnerable populations to respond to climate change. This ICCD case study is "based on the recognition that information and knowledge are crucial enablers of action and change" (Ospina & Heeks, 2012, p. 1). It is consistent with ICCD research that recognizes the need to bridge knowledge and information-sharing gaps in order to mitigate, adapt to or monitor the effects of climate change (Ospina & Heeks, 2012). This research helps strengthen knowledge creation and information sharing between stakeholders involved in the fogwater project by enabling water users and water monitors to communicate with DSH. Specifically, this research focuses on ICT that enable stakeholders to inform, network, monitor and share knowledge about a project that was conceived in response to climate change.

Additionally, this research integrates emergent (scientific) and traditional knowledge, which are also core tenets of ICCD. Indigenous knowledge and practices are "fundamental in bottom-up/community-based strategies" (Ospina & Heeks, 2012, p. 3). Technical knowledge and indigenous practices co-exist in this research pertaining to the use of both traditional water sources and water derived from fog. In rural Berber communities involved in the fogwater project, traditional practices guide water collection and water use and both technical and traditional knowledge inform the use of ICTs in rural Aït Baamrane. For example, an indigenous understanding of water (i.e., community members often expressed the belief that rain is controlled by Allah, and when a new well needs to be drilled it is not abnormal to seek the guidance of a water 'shaman,' or 'wafaman' to identify underground water sources) combines with well-drilling equipment, meteorological forecasts and weather tracking. The prototype IS to help

manage the fogwater IS was designed to be socially, culturally and technically acceptable. I have shown how notions of acceptability incorporate both traditional and technological knowledge.

This research also contributes to the knowledge-sharing priority of ICCD research that is helping to build research capacities in developing regions. Younger staff members at DSH received training in the design and implementation of the Fog Phone, and the water manager and community members were introduced to data collection techniques and to participatory research and design practices. I also helped develop the research capacities of ICTD graduate students at the University of Colorado, Boulder.

Contribution 4. Research In A Geo-Strategically Important Region

This research contributes to an understanding of an under-resourced and marginalized population in the Middle East and North Africa, an understudied, politically important and environmentally fragile region of the world. The Middle East and North Africa (MENA) is largely missing from ICCD, ICTD, M4D and HCID discussions and from initiatives aimed at improving the lives of the under-resourced and marginalized communities located there. Women's illiteracy and lack of access to resources are acute problems in the Middle East and North Africa, one of the least gender-equitable regions in the world. This research contributes to an understanding of an understudied population in an understudied region of the world in a project aimed at extending the benefits of ICT to that population. Program officers, policymakers and practitioners can utilize this knowledge in ICT initiatives that try to widen access to the benefits of ICT.

In previous research, I established that most ICTD scholarship has been concentrated in Sub-Saharan Africa and India (Dodson et al., 2012; Gomez et al., 2012),

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where there are massive populations of poor people and fewer language and access barriers for Western researchers than in many Middle East and North African countries. This research in Morocco contributes to the presence of the Middle East and North Africa in ICTD, ICCD and HCID scholarship.

In addition, this research aligns with broader U.S. interests. The Middle East and North Africa (MENA) region is of strategic importance, and sustainable social and economic development in MENA is a global priority (USAID, 2004; USAID, 2011; US State Dept., 2013). Policymakers and program officers recognize the contribution that the provision of basic human needs has on peace, security and stability in developing countries, particularly those that have been rocked by recent political revolutions, as has been the case in North Africa.

For example, the United States Agency for International Development (USAID) is a division of the U.S. State Department and U.S. development assistance often parallels U.S. strategic interests. USAID's mission is to help end extreme poverty and to "promote resilient, democratic societies while advancing our security and prosperity" (USAID, 2014b). USAID's efforts explicitly and directly "enhance American – and global – security and prosperity" (USAID, 2014b). Furthermore, USAID's mission is to create a "safer and stronger" United States through sustainable development by using its $20 billion annual budget to fight poverty and encourage democracy by supporting civil society groups (specifically with ICT) (Nixon, 2014). Furthermore, USAID's Office of Middle East Programs (OMEP) focuses on programs in the Middle East and North Africa related to, among other priorities, marginalized women and water scarcity and the

promotion of the use of technology in regional development (USAID, 2014c). USAID's mission manifests in an investment in DSH's fogwater project.

The fogwater project has been recognized as being consistent with peace and security goals. It also contributes to top-level humanitarian objectives. The fogwater project and the supporting Fog Phone will service rural communes that are considered among the poorest in the Morocco, thus fulfilling two UN's Millennium Development Goals (MDGs) (United Nations)[4]. MDG 7 seeks to ensure environmental sustainability, reverse the loss of environmental resources and provide access to safe drinking water. These MDG 7 measures can help interrupt the cycle of poverty and family instability that is rampant in Aït Baamrane. This Fog Phone also addresses MDG 8, which encourages global partnerships to make available the benefits of new technologies, especially information and communications.

12.2 Future Work

The prototype Fog Phone was designed to support one of the largest fog harvesting systems in the world and the only one of its kind in North Africa. There is an expectation that the fog harvesting project and its supporting information system will be replicated in similar regions throughout Morocco and North Africa. The design of the Fog Phone is one component of a potential three-phased, multi-channel information system linking the three main stakeholders involved in the fog harvesting project. DSH had also identified the importance of sending and receiving real-time (or close to real-time) information about the status of the fog nets and the main water pipeline to and from the water manager.

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[4] The 8 Millennium Development Goals are: #1 Eradicate extreme poverty and hunger; #2 Achieve universal primary education; #3 Promote gender equality and empower women; #4 Reduce child mortality; #5 Improve maternal health; #6 Combat HIV/Aids, malaria and other diseases; #7 Ensure environmental sustainability; and #8 Global partnership for development. www.un.org/millenniumgoals.

A follow-on prototype IS, based on Android-based GPS-enabled mobile tablets, smart phones, laptops and PCs has already been developed and tested with the water manager to monitor and report on the fogwater collection and distribution infrastructure in text, map and photographic formats. This prototype can support a customized infrastructure tracking program to record and maintain system logs, generate system reports, send and receive emergency water alerts and transmit and archive system photographs. In the next phase, a communication channel would connect water managers and community water committee members through a mobile call and voicemail system.

This research can be expanded beyond the ICCD adaption research priority to apply to the monitoring priority that focuses on participatory monitoring to gather, analyze and disseminate climate-related information through tools such as SMS, tablets, internet. (Ospina & Heeks, 2012). Future work might also further explore citizen-based, collaborative monitoring efforts such as water consumption or water conservation information. Finally, the two rare natural resources (Argan trees and super-saturated fog) that exist in southwest Morocco are worthy of more study from many perspectives.

Lah ibark fik aman mrchne folkin.
"May Allah bless you. Water is available. It is good!"

SMS message sent to the Fog Phone, January 2014.

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