PHD THESIS

The Role of Human Infrastructure: Investigating Digital Interventions in the Global South

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The Role of Human Infrastructure: Investigating Digital Interventions in the Global South

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Dedicated to my mom, dad
&
wife

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ABSTRACT

Based on fieldwork in five distinct projects, this thesis investigates the role of human infrastructure in the context of digital interventions in the Global South. The settings are an agriculture voice message service for smallholder farmers in Bangladesh, an agricultural information service using phone text messages (SMS) also for farmers in Bangladesh, a for-profit service for farmers in Cambodia using digital applications, a digital mental health intervention for Rohingya refugees in Bangladesh and a study of the reordering of everyday life through digital technologies in Bangladesh during the Covid-19 pandemic. The focus on human infrastructure is inspired by research within Information & Communication Technologies and Development (ICTD), Computer-Supported Cooperative Work (CSCW), Human-Computer Interaction (HCI), Science Technology Studies (STS) and more. My findings contribute to research and practice by nuancing our understanding of the role of human infrastructure in digital interventions in the Global South. That is, I empirically and conceptually extend the discussion by pointing out how human infrastructure may be 'configured,' 'trained' and 'unravelled' in the context of digital interventions in the Global South. I show how one cannot take the human infrastructure for granted in the sense that it has to be both configured and trained and hence is not simply somehow there. Further, I discuss how a human infrastructure may unravel in the context of digital interventions in the global South and the consequences this may have for continued service provision. These contributions may be useful for both researchers and practitioners as it adds to our understanding of the key role of human infrastructure in digital interventions in the Global South and elsewhere.

Keywords: *Human infrastructure, infrastructure, ICTD, digital interventions, Global South, digital agriculture, mHealth, mental health, refugee crisis, COVID-19*

DANSK RESUMÉ

Baseret på mit feltarbejde i fem særskilte projekter undersøger denne afhandling, hvilken rolle human infrastruktur spiller inden for rammerne af digitale interventioner i det Globale Syd. Det drejer sig om henholdsvis en landbrugstjeneste baseret på talebeskeder for småbønder i Bangladesh, en landbrugsinformationstjeneste baseret på sms'er også i Bangladesh, en kommerciel landbrugstjeneste i Cambodia baseret på digitale apps, en digital intervention med fokus på psykisk sundhed blandt rohingya-flygtninge i Bangladesh og en undersøgelse af digitale omvæltninger i dagligdagen under COVID19-pandemien i Bangladesh. Afhandlingens fokus på human infrastruktur er inspireret af forskning inden for blandt andet Information & Communication Technologies and Development (ICTD), Computer-Supported Cooperative Work (CSCW), Human-Computer Interaction (HCI), Science Technology Studies (STS). Mine forskningsresultater bidrager til forskning og praksis ved at nuancere vores forståelse af den humane infrastrukturs rolle i digitale interventioner i det Globale Syd. Jeg søger med andre ord at udvide diskussionen, både empirisk og begrebsligt, ved at pege på, hvordan man kan tale om human infrastruktur som 'konfigureret,' 'trænet' og 'optrevlet' eller *unravelled* i forbindelse med digitale interventionsprojekter i det Globale Syd. Jeg viser, at man ikke kan tage den humane infrastruktur for givet i den forstand, at den både må konfigureres og trænes og dermed ikke er noget, der bare er der. Endvidere diskuterer jeg, hvordan en human infrastruktur kan *unravel* eller gå fra hinanden inden for rammerne af digitale interventioner i det Globale Syd, og hvilke konsekvenser det kan have for opretholdelsen af den pågældende tjeneste. Disse bidrag vil kunne være nyttige for såvel forskere som udøvende, idet de udvider vores forståelse af den humane infrastrukturs nøglerolle i digitale interventioner i det Globale Syd og andre steder i verden.

Keywords: *Human infrastructure, infrastructure, ICTD, digital interventions, Global South, digital agriculture, mHealth, mental health, refugee crisis, COVID-19*

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READING GUIDE

In Chapter 1 I provide a high-level overview of the role of the human ability to collaborate and systematically integrate efforts in the delivery of digital services in the Global South. As a result, this chapter briefly starts the discussion of the materiality of technology and the constellation of human actors and of how scholars have conceptualized 'infrastructure' and 'human infrastructure'. This chapter also presents the titles of the articles addressing the central research question and gives a brief summary of how each publication contributes to the human infrastructure.

In Chapter 2 I present the research that was conducted, with a particular emphasis on the methodology that was employed to generate data for analysis. This necessitates some reflection on my part regarding my position within the data generation process and how this has influenced my work. I have generated the data through the use of a variety of methodologies, including participant observation, qualitative methods such as semi-structured interviews and focus groups and a quantitative study that is quasi-experimental. This chapter also discusses how my studies used the aforementioned methodologies and why a complementary methodological process is useful for the thesis.

In Chapter 3 I discuss a dual reflection of human infrastructure. To begin, I review and reflect on the conceptualizations of infrastructure from various academic fields, including CSCW, HCI, ICTD, and STS. I intend to analyse how the term has been used analytically and as part of scholarly debates by examining different infrastructure-related perspectives. Following this, I focus on the concept of human infrastructure, with special attention paid to the scholarly research that has been conducted in this area. With the use of some reflection on infrastructure studies, and more specifically human infrastructure studies, I hope to gain a more nuanced comprehension of human infrastructures and how they relate to digital interventions in the Global South. This is done by describing the projects that serve as the basis for this thesis.

In Chapter 4 I provide a summary of each publication's findings as they pertain to the overall contributions of my thesis. Extending the discussion from Chapter 3, this chapter provides further context for the contributions made. Each of the five articles in this thesis presents a different aspect of human infrastructure, or might be interpreted as such, and discusses its significance in digital interventions in the Global South. This chapter arranges the publications according to the empirical fieldwork undertaken and data analysed for the thesis. The articles demonstrate how my research interests have shifted over the years, as reflected by my publications. Here, I make an effort to draw direct connections between the publications and the thesis's overarching theme of 'human infrastructure.'

In Chapter 5 I make an effort to summarise my thesis and conclude the contribution with a nuanced understanding of human infrastructure as it relates to digital projects and interventions in the Global South. Here, I look into the role of 'human infrastructure' in digital intervention projects in the Global South, using my research projects as a departure point, to determine if there is a unique relationship between the ICT in developing countries and the human infrastructures that support them, beyond technological system-level processes. The chapter also raises open questions that could be explored in future research.

CHAPTER 1: INTRODUCTION

Year: 2017. I was conducting fieldwork in a rural area of Bangladesh's Sirajganj district. Members of a farmers' self-help group gathered in the courtyard for a discussion on agricultural recommendations. A lead farmer of the group received an SMS on agriculture advice which is a regular part of an NGO-led development initiative. Other farmers in the group, who do not have access to mobile phones or can't read, were the intended recipients of his message. The lead farmer read the content of the SMS based agriculture recommendation and some of the group farmers were nodding and indicating that they would follow the advice. Some of the farmers attempted peering over the head of the leader to catch a glimpse of the phone's tiny screen to see the SMS and make their decision later. An NGO field worker was also present in the meeting to observe farmers' perception of the SMS recommendation. During the meeting, the NGO field worker's supervisor phoned him so he could convey farmers' feedback on the SMS recommendation. If any problem occurs with SMS reception or agriculture, the NGO's supervisor must notify the technology head of the project, who will then ask the IT system developers or the agriculture content developer to fix it.

This digital intervention in the Global South serves as an illustration of how it is not always realistic to expect technology to be placed into a particular situation and have the anticipated benefits instantly apparent. Farmers, farmer leaders, NGOs, SMS content creators, technology designers, technology manager and IT system developers etc. all worked together to put this technology into action. In this thesis, I will explore this integrated, collective and collaborative action of people in terms of 'human infrastructure'. I will consider the link between the materiality of technology and the constellation of human actors, relationships, activities, spaces and networks based on inspiration from the literature (Karasti and Blomberg, 2018; Kling and Scacchi, 1982; Lee and Schmidt, 2018; Lee, Dourish and Mark, 2006; Sambasivan and Smyth, 2010; Star, 1999; Star and Ruhleder, 1996). My work in this thesis demonstrates that if humanitarian development organizations and development partners want to create a digital intervention service in the Global South, they need to heed the 'human infrastructure' as part of system level 'processes' which is equivalent to technological 'processes'. ICTD, CSCW, HCI and STS researchers highlighted various 'human infrastructure' processes in the work based on the Global South and elsewhere. In this thesis, I will add to the literature on 'human infrastructure' in the Global South.

'Infrastructure' is envisioned as a system of substrates – railroad lines, pipes, electrical power plants and computer systems and wires (Star, 1999). Both technical and social infrastructures are intertwined. 'Infrastructural inversion' – a term initially introduced by Bowker (Bowker, 1994) to address the propensity of infrastructures to remain invisible backdrops to social action (Bowker, 1994). The idea could be interpreted as a gestalt switch, a figure-ground reversal, struggling against the tendency of infrastructure disappearing. Star and Ruhleder (Star and Ruhleder, 1996) used this term to reconceptualise the concept 'infrastructure' that focuses on the activities and work practices that warrant the functioning of infrastructure, rather than those it invisibly supports. Star and Ruhleder (Star and Ruhleder, 1996) questioned 'when' is infrastructure and 'infrastructure emerges' as a result of inversion. They outlined eight characteristics of effective infrastructure: it must be embedded; it must be transparent; it must have a reach beyond an event; it must be learned as part of membership; it must link to the convention of practice; it must embody a standard; it must be built

on an installed base; and it must be invisible unless it breaks. These characteristics may reveal the necessity of human connections, social activities and networks in the design, development and maintenance of the substrates. The actual phrase 'human infrastructure' was coined by a group of CSCW researchers to express the embedding of human beings in technological systems. They expressed that 'human infrastructure' can be defined as the arrangements of organizations and actors that must be brought into alignment in order for 'work' to be accomplished (Lee, Dourish and Mark, 2006). If we focus on the Global South, we can see that in digital intervention projects and services, a coalition of NGOs, social businesses, technology companies, government, private sectors (if needed) and different ranges of players may be essential to make the technology service 'work' (humanitarian development entities commonly define *work* as *activities*). In the Global South, 'human infrastructure' may be thought of as a foundation upon which a digital intervention project or service may be planned, developed and finally deployed.

Previous 'human infrastructure' scholarships focus primarily on workplaces and organisations. But some ICTD scholars applied a 'human infrastructure' lens to see the function of technology in the daily lives of the people of the Global South (Sambasivan and Smyth, 2010). Besides, some other ICTD, CSCW and HCI scholars applied the 'human infrastructure' lens on ICTD work practices, such as articulation work of human infrastructure to support offline internet service in Cuba (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018), a health record (EHR) system run by volunteers in India (Tang, Chen, Semaan and Roberson, 2015), frontline health workers' invisible work of maintenance in a community health system (Verdezoto, Bagalkot, Akbar, Sharma, Mackintosh, Harrington and Griffiths, 2021) by configuring offline, etc. Overall, these scholars, especially Sambasivan and Smyth looked at 'human infrastructure' from the angles of various systematic processes (*usage*, *maintenance* and *diffusion)* stressing that human infrastructure may be analogous to technological processes.

In my thesis, the central question is: *What are the relationships between digital intervention projects (or services) and their human infrastructure in the Global South?* This is so that I can contribute to the ongoing conversation amongst researchers about the 'processes' of 'human infrastructure'. This is addressed by applying the concept of 'human infrastructure' to a variety of humanitarian development projects and services intervened with information technologies. These projects and services deal with issues related to digital agriculture, mHealth[1] and ICT in refugee crises in the Global South.

My thesis takes an ethnographic, qualitative and quantitative approach to ICTD (Information & Communication Technologies and Development) in order to answer this question, and it empirically investigates the ways in which different 'processes' of 'human infrastructure' are connected to digital intervention projects and services in the Global South. As part of my PhD research, I have used a variety of methods, including participant observation, semi-structured interviews, focus groups and a quasi-experimental quantitative trial to investigate the role of 'human infrastructure' in the system-level processes of digital intervention projects and services in the Global South.

In order to add to the existing discussion of 'human infrastructure' processes in the digital intervention projects in the Global South*,* my thesis first looks into the *configuration process* of 'human

[1] mHealth (mobile health) is a term for the use of mobile phones and other devices in healthcare.

infrastructure' and describes how we *create (configure)* 'human infrastructure' in the digital intervention projects in the Global South by recruiting various human actors to design and implement solutions. Secondly, it shows how *building the capacity* of 'human infrastructure,' such as training for self-help group farmers, training for NGO project intermediaries, organising virtual and general training for staff, helped humanitarian development project in the Global South to execute digital interventions in the community. Third, it breaks Sambasivan and Smyth's focus on the 'processes' underlying 'human infrastructure'. Sambasivan and Smyth describe processes through three perspectives, *usage, maintenance work and diffusion.* This thesis combines these three into a single 'human infrastructure' process that is called 'usage' and adds a fourth under 'usage' dubbed as 'contingency work.' Finally, the thesis also shows how 'human infrastructure' *unravels* when the digital intervention project or service ends in the Global South.

Publications

The thesis includes five papers that each tackle a unique but interconnected element of 'human infrastructure' in digital intervention projects and services in the Global South. In keeping with the cross-disciplinary character of Information & Communications Technologies and Development (ICTD), my research draws from the fields of computer supported cooperative work (CSCW), human-computer interaction (HCI), development studies and information systems (IS). The concept of 'human infrastructure' is a unifying theme and together they offer empirical investigations of the synchronised, integrated, established, reorganised and prominent character of 'human infrastructure' in the provision of digital intervention services in developing regions of the world. From the perspective of human infrastructure, these are the papers of the thesis:

1. Lars Rune Christensen, Hasib Ahsan and Eshrat Akand. 2018. Krishi Kontho: an agricultural information service in Bangladesh. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (NordiCHI '18). Association for Computing Machinery, New York, NY, USA, 203–214.
   https://doi.org/10.1145/3240167.3240225

The first publication (Christensen, Ahsan and Akand, 2018) shows how an agriculture information service is synchronized to the rhythms of a human infrastructure – the farmers – and makes the service possible with agricultural practices.

2. Christensen, L. R., Ahsan, H., Rashid, M., & Das, B. K. (2019). Are You Magicians? The Collaborative Work of an Agricultural Information Service. ICTD '19: Proceedings of the Tenth International Conference on Information and Communication Technologies and Development (s. 1-10). Association for Computing Machinery.
   https://doi.org/10.1145/3287098.3287109

Read in a human infrastructure perspective the second publication highlights how the workings of an agricultural information service in Bangladesh are made possible through the integration work of a 'human infrastructure'. It describes how farmer self-help groups rely on word-of-mouth to disseminate information, how posters with agricultural advisory content may be strategically placed in villages and how agro-based SMS texts are best broadcast if they involve the elite of the community.

3. Ahsan, H., Christensen, L. R., & Kitura, K. (2021). Agribuddy: Infrastructuring for Smallholder Farming in Cambodia. I Proceedings of the 10th International Conference on Communities & Technologies: Wicked Problems in the Age Of Tech (s. 309) https://doi.org/10.1145/3461564.3461576

The third publication (Ahsan, Christensen and Kitaura, 2021) is concerned with the establishment of infrastructure, including human infrastructure in rural farming communities in Cambodia. The paper presents an analysis of the ICT-driven agricultural initiative that shows how it may be understood as infrastructuring for value chain, for microcredit and for capacity building. The paper considers the relational, connected, emerging and intentional character of the initiative.

4. Hasib Ahsan and Lars Rune Christiansen. 2022. The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic. In ICTD 2022, the 12th International Conference on Information & Communication Technologies and Development, University of Washington, Seattle, USA on June 27-29, 2022.

The fourth publication (Ahsan and Christensen, 2022) is on how the digital technologies allow for the rearrangement of human networks and infrastructure during a crisis. The authors arranged for research assistants to collect and gather data during the pandemic. The paper suggests that digital technologies have been important to the reordering of everyday life during the pandemic: videoconferencing has been instrumental in allowing urban residents to work from home, digital money has enabled workers in rural areas to continue financial transactions, and social media has been a source of news and rumours during the pandemic.

5. Christensen, L. R., & Ahsan, H. (2022). Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh. Medical Anthropology: Cross-Cultural Studies in Health and Illness. https://doi.org/10.1080/01459740.2022.2113396

The fifth publication (Christensen and Ahsan, 2022) shows the prominence of the human element in a digital health service where the 'human infrastructure' is very much part of the mental health screening process in a refugee camp.

CHAPTER 2: METHODS

Throughout this chapter, I will describe the research undertaken, with a focus on the methodology used to obtain data for analysis. At times, this involves a reflection on my own position during data generation, as well as how this has affected my work. I have used multiple methods to generate the data. The following table provides an overview of the projects, data generation approaches, methods and resulting publications[2].

Project	My role	Approach	Methods	Publication
Mobile based Climate Smart Agro Information Service for Farmers Project	Practitioner /Researcher	We employed an ethnographic methodology and conducted participant observation. Additionally, we conducted focus groups, followed by semi-structured interviews. Quantitative data was collected to compare the intervention's effects.	▪ Participant observation ▪ Semi-structured interview ▪ Focus group ▪ Quasi-experimental quantitative trial	Lars Rune Christensen, **Hasib Ahsan**, and Eshrat Akand. 2018. *Krishi Kontho: an agricultural information service in Bangladesh*. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (NordiCHI '18). Association for Computing Machinery, New York, NY, USA, 203–214.
Climate and Agriculture Information Service (CAIS) Project	Practitioner /Researcher	Here in this project, we used participant observation and other methods common to ethnographic research. In addition, we used focus groups and subsequent semi-structured interviews to generate information.	▪ Participant observation ▪ Semi-structured interview ▪ Focus group	Lars Rune Christensen, **Hasib Ahsan**, Mamunur Rashid, and Badal Kumar Das. 2019. *Are you magicians? the collaborative work of an agricultural information service*. In Proceedings of the Tenth International Conference on Information and Communication Technologies and Development (ICTD '19). Association for Computing Machinery, New York, NY, USA, Article 19, 1–10.
Agribuddy Project	Researcher	Our method was ethnographic, similar to the ones used in the prior two studies, and it entailed participant observation. Furthermore, we used both focus groups and semi-structured interviews to generate information.	▪ Participant observation ▪ Semi-structured interview ▪ Focus Group	**Hasib Ahsan**, Lars Rune Christensen, and Kengo Kitaura. 2021. *Agribuddy: Infrastructuring for Smallholder Farming in Cambodia*. In C&T '21: Proceedings of the 10th International Conference on Communities & Technologies - Wicked Problems in the Age of Tech (C&T '21). Association for Computing Machinery, New York, NY, USA, 309–318.
The COVID-19 study	Researcher	We took a qualitative position here as research	▪ Semi structured interview	**Hasib Ahsan** and Lars Rune Christiansen. 2022. *The Reordering of Everyday Life*

[2] Note that the fieldwork settings are described in the publications of the thesis. For a more detailed understanding of the fieldwork settings, please consult the papers attached.

		assistants conducted semi-structured interviews.		*through Digital technologies During the Covid-19 Pandemic*. In ICTD 2022, the 12th International Conference on Information & Communication Technologies and Development, University of Washington, Seattle, USA on June 27-29, 2022.
Rohingya mHealth Project	Researcher	We employed an ethnographic methodology and conducted participant observation. Additionally, we conducted focus groups, followed by semi-structured interviews.	▪ Participant observation ▪ Semi-structured interview ▪ Focus group	Christensen, L. R., & **Ahsan, H.** (2022). Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh. Medical Anthropology: Cross-Cultural Studies in Health and Illness.

Table 1 Methods used in the studies

This thesis, then, is based on the fieldwork carried out in various contexts in Bangladesh and Cambodia. In my various projects, one of the common approaches that I have adopted is the ethnographic approach. Ethnography is part of almost all the projects, making up this thesis, including the Krishi Kontho study (Christensen, Ahsan and Akand, 2018), Are you Magicians (Christensen, Ahsan, Rashid and Das, 2019), Agribuddy (Ahsan, Christensen and Kitaura, 2021), Rohingya mHealth (Christensen and Ahsan, 2022) and COVID-19 study (Christensen and Ahsan, 2021). The ethnographic approach is rooted in anthropology and the broader social sciences and is characterized by a commitment to 'grasp the native point of view, his relation to life, to realise his vision of his world' according to the seminal writings of Malinowski (Malinowski, 2013) – considered the founding father of anthropology. The British sociologist John Brewer states that, "Ethnography is the study of people in naturally occurring settings or fields by means of methods which capture their social meanings and ordinary activities, involving the researcher participating directly in the setting, if not also the activities, in order to collect data in a systematic manner but without meaning being imposed on them externally" (Brewer, 2000, p. 10). We may consider ethnography an approach or analytical stance, rather than just a set of methods. Among the methods typically used in ethnographic fieldwork we find participant observation and semi-structured interviews. Participant observation relies on the notion of observing the actors in their natural environment. In relation to John D. Brewer, Silverman (Silverman, 2008) states that 'naturally occurring' refers to situations that ordinarily happen in the world of the actors such as for example meetings between actors or the performance of their individual tasks. The signature of ethnography, according to earlier researchers (Brink and Edgecombe, 2003), is the study of naturally occurring human behaviour (such as that of actors) by first-hand participant observations within a culturally and socially defined context. By being immersed in the lives of our study's subjects as participant observers, we can pick up important insights about their culture and subculture. (Hammersley and Atkinson, 1997, p. 8). In my work in the Rohingya mHealth (Christensen and Ahsan, 2022), we shadowed the medical assistants during their house calls providing healthcare services to the Rohingya refugee community. We observed how medical assistants provided and used digital survey instruments to asses for example the mental health of refugees.

Scholars say that researchers should adopt an attitude of ‘respect’ and ‘appreciation’ towards the social world (Hammersley and Atkinson, 1997). We observed and tried to appreciate the situations of the housing conditions of the Rohingya beneficiaries, the camp condition and the beneficiaries' attitude towards the mHealth services. Data generated in the ‘naturally occurring’ situations in our studies gave us an insight into things that we could never have imagined. I can give a related example from our Rohingya mHealth studies (Christensen and Ahsan, 2022) where we observed our participants in their ‘natural settings’. We were surprised to see the housing conditions and the adolescent girls' and women’s life there. The camp accommodations were temporary with no permanent structures. These were constructed of tarps stretched on bamboo frames, and the flooring is composed of soil. Instead of a door, a house's primary entry often had a thick curtain. Empty bags were used as carpet substitutes. The lack of ventilation and poor lighting produced a suffocating and agitated environment. Teenage girls and women were the most susceptible under these circumstances. Due to the confines of their homes, they were unable to engage in socialising and have their privacy. In addition, we were informed that they were not permitted to leave their homes due to the ‘purdah’, which dictates that women should not expose themselves to males who are not blood or marriage related. Except for using the restroom and collecting relief items and using services, they remained inside the house. Without having an ethnographic approach and conducting participant observation, we would not have been able to fully appreciate the plight of the adolescent girls and women. In our other two studies, Krishi Kontho (Christensen, Ahsan and Akand, 2018) and Are You Magicians (Christensen, Ahsan, Rashid and Das, 2019), we were also committed to go out in the field to get close to the use of the SMS and voice-based agriculture information services in the community. Ethnographers point out that ‘getting close’ minimally requires physical and social proximity to the daily routines of people’s lives and activities (Emerson, Fretz and Shaw, 2011). To support this statement, we can provide an example from our Are You Magicians (Christensen, Ahsan, Rashid and Das, 2019) study. We could not have fathomed the importance of a the social and community driven approach to the dissemination of information in relation to the creation of the agriculture information system (driven by digital technology) without first immersing ourselves in the field and getting to know the community. We discovered that the farmers in the self-help groups were reaching out to those in their community who did not have access to cell phones by using non-digital methods to disseminate the information about agriculture. We were also surprised to see how a collaborative and coordinated approach by multiple NGOs, local government and the community operationalized the agriculture SMS system.

Figure 1 Krishi Kontho fieldwork pictures: flood affected areas and flood shelter (termed as cluster village) area

By engaging with these communities, we were able to generate data and get valuable insights. Again, the point here is to argue for the value of the ethnographic approach in my projects.

In addition, these two research initiatives were being carried out in northern Bangladesh, and one of our fieldwork experiences (Christensen, Ahsan and Akand, 2018) during a flood crisis (see figure 1) has taught us about the devastation that natural disasters can wreak on homes, farms, and people's means of subsistence. While agriculture voice messages and texting services were operational during the flooding, it was useless for farmers of the flood affected area to use them since their fields had been submerged. They were frantically making preparations to save their lives in the flood shelters that served as their temporary homes. These two studies were conducted in the context of humanitarian aid projects and getting 'access' to generate data during the flooding was very important for our understanding of the situation of our informants. According to Hammersely and Atkinson (Hammersley and Atkinson, 1997, p. 55), 'access' is defined as 'entry to the settings' and encompasses much more than simply 'permission' to do research. In our Krishi Kontho study (Christensen, Ahsan and Akand, 2018) the participation of key stakeholders was essential when planning fieldwork during the floods. This includes obtaining permission from farmers to visit their shelters and having nongovernmental organisation (NGOs) and their field facilitators provide logistics such as renting boats so that we could commute. Further, a letter to the local government was required to get approval for fieldwork during a flood. In addition, whenever we had a foreign researcher on our team in Bangladesh, we needed to get permission from the local police in order to do fieldwork. Since, the studies were conducted within the settings of humanitarian projects, the NGOs and their management helped us to gain the all-important 'access'. So not only during flood, but also in other situations and in in other studies, we had to manage 'access' for our field work. To gain access, we also found that the organizational 'gatekeepers' were important. A scholar mentioned that organizational 'gatekeepers' in industrial, urbanized settings tend to be more assertive and less accessible than those in community settings in rural areas (Van der Waal, 2009).

In contrast to the previously mentioned projects conducted in humanitarian aid settings, the Agribuddy study (Ahsan, Christensen and Kitaura, 2021) was conducted within a commercial organisation that provided the agricultural service on market terms in rural areas. The key 'gatekeepers,' the company's owners, first denied us access to their field since they were not familiar with our research. It may appear logical for a commercial business to attempt to protect their business knowledge and insight so that we as researchers do not publish studies that competitors might use to their advantage. However, we were given access after negotiation. To solve the issue of access, we contacted our friends and colleagues at the Impact Hub in Phnom Penh. The people at Impact Hub used to be familiar with us and our work. It was interesting to note that Agribuddy was a partner organisation of Impact Hub, Cambodia and received various forms of support from them. Agribuddy's management was approached by Impact Hub Cambodia to grant us access to their fields for research purposes. They also discussed the potential advantages of having Agribuddy analyse their farming operations objectively through the IT University of Copenhagen. Agribuddy's upper management was persuaded by the arguments and provided more than just permission to conduct our research in their business; they contributed toward one of my publications (Ahsan, Christensen and Kitaura, 2021). That is, in our other studies, we at least had a connection, either we worked in those projects as implementers or we were part of the design of the service. In previous works of ours (Christensen and Ahsan, 2022; Christensen, Ahsan and Akand, 2018; Christensen, Ahsan, Rashid and Das, 2019), we

were either directly involved in the implementation of the project or in the design of the service. So, access to the field was easy compared to Agribuddy.

Ethnographers also conduct *ethnographic interviews,* and the purpose of that is to explore the meanings that people ascribe to actions and events in their cultural world, expressed in their own language (Roulston, 2010, p. 10). Social scientists (Roulston and Choi, 2018) present *ethnographic interview*s as a type of semi-structured or 'open-ended' interviews in which researchers have identified topics of questions to ask individual participants. They also mentioned that to conduct ethnographic interviews, researchers need to analyse the field notes of observations and conduct multiple interviews with informants over extended periods of time (Roulston and Choi, 2018). In our studies, in conjunction with participant observation, we conducted semi-structured interviews. Semi structured interviews have been helpful to give explanations of what people do, to hear people's own explanations and perceptions of their own situation and what they do. Silverman notes (Silverman, 2004, p. 126), for interviewers in the interactionist tradition, interview subjects construct not just tradition but social worlds. For researchers in this tradition, the primary issue is to generate data which give an authentic insight into people's experiences (Miller and Glassner, 1997). The semi structured interviews conducted in the Krishi Kontho (Christensen, Ahsan and Akand, 2018), Are You Magicians (Christensen, Ahsan, Rashid and Das, 2019) and Agribuddy (Ahsan, Christensen and Kitaura, 2021) studies helped us grasp people's experiences from both the implementers' and the beneficiaries' perspective. Here, implementer means, the insight we received by interviewing the frontline staff and managements who were involved in for example agricultural service implementation. We also grasped the experience of the beneficiaries of the agriculture information services who represent the end level user of the service. Scholars say that conducting successful qualitative interviews (e.g., semi-structured interviews, focus groups etc.) and developing a trustworthy data set requires establishing a 'rapport' with the participants (Seidman, 2006, p. 98). Rapport means to establish a safe and comfortable environment for sharing the interviewee's personal experiences and attitudes as they occurred (DiCicco-Bloom and Crabtree, 2006). As researchers, it was reasonably straightforward for us to develop 'rapport' with the participants and schedule interviews in the aforementioned two studies (Christensen, Ahsan and Akand, 2018; Christensen, Ahsan, Rashid and Das, 2019) studies because the implementing organisations had been working with the beneficiaries for years. They were aware that researchers would come to interview them since they were the service receivers of the organisations. Because of this established rapport, we were able to ask questions on the effectiveness of the agriculture information systems, the recipients' use of agricultural advisories in the field and their overall impressions of the services provided. However, in the Agribuddy study (Ahsan, Christensen and Kitaura, 2021), our position as researchers was first unclear to the farmers. The farmers using the Agribuddy service depict it as a for-profit enterprise engaged in the business of selling fertiliser, seeds, loans, etc. So, whoever comes to talk about Agribuddy is immediately caught up in the paradox of farmers' ideas about making a profit, and they try to raise some complaints, such as the late delivery of fertilisers, the excessive price of fertilisers, etc. The Agribuddy field coordinator, the buddies, and the interpreter all attempted to get across that IT University of Copenhagen is doing research and that we need to hear from them in order to provide an assessment of the Agribuddy service. So, finally they started to talk about their experiences with Agribuddy service. Conventional social science perspectives also inform that a researcher's expertise in getting the data as part of a successful interview depends on whether there was a good rapport or not, whether the respondents talked a lot or not, and what they talked about, whether and how they divulged what the interviewer

was after (Baker, 1997). Many of the interviewees in the Agribuddy study (Ahsan, Christensen and Kitaura, 2021) spoke well in their native languages about their experiences, but many of the talks were lost in translation, leading us to believe that we couldn't generate more data from these interviews. I will discuss the challenges of translation inherent in our Agribuddy study later.

The rapport we experienced in the Rohingya mHealth trial was different (Christensen and Ahsan, 2022). At the outset of our study, it was difficult to establish 'rapport' with the Rohingya informants since they had recently escaped a conflict zone and were somewhat alien to the refugee camp they lived in. It often took time for refugees to open up and trust the people working inside the camp after fleeing violence and traumatic situations in their own country. As a result, it was initially challenging for us to generate data from the interviews as the refugee participants struggled to grasp our motivation and the nature of our study. When our project's medical assistants began visiting Rohingya households to conduct health screenings, a gradual but steady foundation of trust was created. In addition, we researchers sometimes accompanied our medical assistants on house calls to see how they performed their duties. So later, the Rohingya community authorised us to conduct interviews as part of the medical assistants' work. As researchers, we visited the refugee camps numerous times and gradually created rapport with the refugees in order to get their feedback on the mental health intervention and generate data. Thankfully, I was able to grasp the discussion of Rohingya refugees since the language is so similar to the dialect spoken in the Cox's Bazar region of Bangladesh. Also, many Rohingya spoke and understood Bangla, the official language of Bangladesh. The interviews were able to progress because of the mutual knowledge of languages.

Scholars mention that in the interview situations informants may be willing to divulge information and express opinions they would not be open about in front of others (Hammersley and Atkinson, 1997, p. 143). In other words, if they feel comfortable with the interviewer, they may be more open to sharing their thoughts. However, how the interviewer and interviewee interact to interpret the responses may be a crucial aspect of the interview. Some researchers mentioned that communicative circumstances enter the interview’s meaning-making activity (Holstein and Gubrium, 2008, p. 150). They provided an actual case study of conducting interviews to assess the quality of care and living in a nursing home. The residents not only put forth deep ideas and views on the matter at hand, they also kept tabs on their connections to the person questioning them (Holstein and Gubrium, 2008, p. 151). Let us give an example from one of our other studies in mHealth-based mental healthcare for Syrian refugees, in which we as interviewers were unable to determine why the referred young refugees were not attending counselling sessions with psychologists. In this research that is now being prepared for publication, we found that many of the young people who received text messages or phone calls reminding them of their mental health therapy appointments did not want their parents to know about it. During our participant observation, we were unable to fathom this reluctance. We could not even identify during the interview with the Syrian refugees. Possibly the informants did not feel at ease sharing the information with us, but they did want to tell the paramedics and project employees about the issue of not attending the counselling sessions. We can relate to the nursing home case study where the respondents monitor who the researchers are (Holstein and Gubrium, 2008). However, this crucial insight of the mHealth service is revealed in the semi-structured interviews with the project's paramedics who conduct the mental health screening: the decision to not notify the parents via text message or phone call of their child's scheduled session of mental health counselling therapy. After getting this information through the semi-structured interview with the

paramedics, the project stopped sending SMS reminders, this because people share phones, they are not personal or private. In the Syrian refugee camp setting, older family members like the father or mother are more likely to have a phone than the adolescent girl or younger ones. In addition to the screening, the young adults' parents' phone numbers are entered into the service's database in order to provide them with access to mental health services. So, if the project were to send an SMS or made a phone call, the admins would remind the refugees of their regular 'health awareness and hygiene meeting' to mask their appointment to see a psychologist. Our discussions with the paramedics revealed that having mental health concerns is still socially stigmatised among the Syrian refugees, and that the young people were hesitant to disclose their mental health circumstances even to their family members, which may lead to their missing out on counselling sessions. We did not hear about this problem until the young adults brought it up with the paramedics, with whom they had formed rapport.

Typically, the researcher will be the one to conduct the interview and will take precautions to protect the privacy of the interviewees. In such a setting, an informant may be more willing to share information that they would otherwise keep to themselves. Scholars say that this does not mean that this information is necessarily true or that the opinions they present are more genuine, more truly reflect their perspectives, than what they say on other occasions (Hammersley and Atkinson, 1997, p. 143). So, an additional factor that may need to be taken into account is the possibility that, in semi-structured interview settings, participants' actions and explanations for their actions, or descriptions of their actions, may not always match. People's explanations of why they do things or how they do things may not be taken at face value; rather, their explanations should be part of what needs to be explained (by the scholar). In our interviews with the Rohingya mHealth project's medical assistants, we encountered exactly that scenario (Christensen and Ahsan, 2022). Our project's medical assistants consistently described the mHealth-based mental health service as smoothly operating although it had some challenges at the beginning such as syncing with server issues, lack of internet connectivity etc. It was often hard to get them to talk about the challenges they were having with the mHealth information system and the difficulties they were encountering while using the mobile application for screening. The medical assistants believed that the researchers from the IT University of Copenhagen were the project's primary collaborator and, by extension, the project's ultimate authority. A critique of the project and its performance would be evident if they detailed the challenges of our mHealth system. They worried that if they come clean about the problems with the mHealth system, then they might lose their jobs because the project would not receive further funding. They aimed to present a very positive image of the project's progress. Arguably, the medical assistants here responded through the use of idealised narrative constructs, rather than by providing meaningful insights into their own subjective views and experiences (e.g., mHealth challenges inside the camp) (Miller and Glassner, 1997). Denzin (cited in Miller and Glassner, 1997) notes that what the subject tells us is itself something that has been shaped by prior cultural understanding. We agree with Denzin's perspective, and to a degree our long-term observations have shown that medical assistants have gained cultural awareness in Bangladesh where NGOs and development partners sometimes attempt to emphasise the positives more than their typical humanitarian intervention difficulties.

Focus groups were another method we utilised to generate data. Their wide range of applications shows their versatility (Wilkinson, 1998). For a researcher, focus group methodology is a way of generating qualitative data that engage a small number of people in an informal group discussion

‘focused’ around a particular topic or set of issues (Wilkinson, 2004). Since many of our intervention projects involved the development of information and communication technology (ICT) tools and apps, we found that focus groups were an effective way to hear first-hand accounts of people's experiences with these interventions from those people themselves. Scholars also mentioned that focus groups are conducted to have different perspectives and experiences that participants reveal during the informal interactive discussions (Morgan and Hoffman, 2018). I agree that the perspectives and experience sharing in the focus group interactions are not ‘naturally occurring’ (Silverman, 2004) but it may be referred to as natural phenomenon since those are real world conversations although occurring in a more organized manner. Scholars (Morgan and Hoffman, 2018) point out that the focus group interaction is ‘naturalistic’ rather than naturally occurring, because the researcher provides the topics that is the subject of the interaction. Another scholar says that (Wilkinson, 2004) focus groups are more naturalistic than interviews, which is almost closer to everyday conversation that includes various ranges of communicative processes (e.g., storytelling, arguing, challenging, disagreement etc.). From my own experience with the Krishi Kontho research, we gained some added knowledge while listening to people talk and chat in focus group interviews. We learned that listening to battery powered radio was the primary form of amusement for rural households and these places were not connected to the national energy grid. Some of the tea stalls in the village market are equipped with solar panels to power their TVs and the male farmers socialise there during evening. One of the women was making fun of the male farmers, saying that they could go to the market during evening and enjoy drama and news on television, but the women are not socially allowed. Although we did not directly ask any of these questions, we were able to glean the information that male farmers may have more options for entertainment than female farmers. These are the kind of interactions that do not happen in solo semi structured interviews but might be overhead during participant observation or in focus groups. From the natural flow of the conversation, we were able to deduce that the farmers in the study region would pick up some information about cutting-edge agricultural methods from the news or agriculture programmes broadcast in the area. These insights were due to the natural flow of the focus group discussion.

Some social scientists say focus groups provide another means of acquiring information and might be characterised as a group interview (Stringer and Aragón, 2020, p. 148). In three of our studies, we usually conducted each of the focus groups with 6-8 persons with variations in terms of age, status and communities. The researcher acted as a moderator and could generate data by raising discussion topics. Focus groups provide a way of generating data very quickly from these numbers of participants. In a focus group, participants often challenged each other on contradictions between what they claimed to believe and how they actually behaved (Kitzinger, 1994). For example, in our Agribuddy study, one of the farmers in focus groups (we also interviewed him later) was still to trust the Agribuddy agriculture service. When the moderator asked about what they thought about registering to Agribuddy service, a farmer responded that he would see the success of Agribuddy with his neighbouring farmers first and then he might decide to join. In this regard, it is worth noting that the 'seeing is believing' attitude is especially common among farmers in the Global South. Those that implement agricultural initiatives with farmers refer to this as a ‘plot demonstration’ so that farmers who didn't sign up for the service may observe the outcomes and be encouraged to do so for the next crop season. For example, in one of our previous precision agriculture projects, we utilised the 'plot demonstration' method to win over the confidence of farmers who had not yet signed up for the 'precise agriculture service’. (Pronk, Hengsdijk, Ahsan and Michielsen, 2019). We also conducted

multiple focus groups in our Krishi Kontho (Christensen, Ahsan and Akand, 2018) and Are You Magicians (Christensen, Ahsan, Rashid and Das, 2019) studies, to understand the experience of farmers' cultivation practices, agriculture information needs and perception of the service. As researchers, it often helped us to follow the interactions and arguments about the 'issues' we raised during focus groups as moderators. Here we also noticed that focus group participants did not always agree with each other, questioned each other, misunderstood one another and tried to justify their own points of view (Kitzinger, 1994). We can cite an example from the Are You Magicians (Christensen, Ahsan, Rashid and Das, 2019) study where a participant raised questions about the agriculture information service. On one occasion, the project's weather forecasting system did not work and the SMS advisory on heavy fog approaching came out wrong. But farmers took precautions to save their plants from fog since they received the SMS advisories from the project. This information came out through focus groups that informed us about the occasional challenge of the agriculture information service. So, focus groups may provide some unexpected insights and many of these insights are unlikely to have arisen in semi-structured interviews because the agreements and disagreements between peers are more visible in the conversation of the focus groups. So are power structures, who talks, who talks first, how much, and who stays silent can all be tell-tale signs of power relations within a group made visible in focus groups, as we shall see next.

Morgan states that the majority of the published research articles using focus groups combined them with other methods such as individual interviews (Morgan, 1996). So, focus groups studies use follow up interviews with individual participants to explore specific opinions and experiences and to produce personal narratives (Duncan and Morgan, 1994). Focus groups, if we compare them to semi-structured interviews, have the advantages of displaying the social dynamics of group and displaying also for the researcher arguments and power dynamics within the group. In three of the studies (Ahsan, Christensen and Kitaura, 2021; Christensen, Ahsan and Akand, 2018; Christensen, Ahsan, Rashid and Das, 2019) attached with my thesis, we conducted focus groups. In one such focus group, we experienced that one or two members among the focus group participants talked much more than the other participants. We figured out that those one or two participants were leaders in their farmer cooperative groups. So, out of respect to their group leaders or due to long practiced cultural characteristics, other participants remained silent at the beginning. So, we as moderators had to intervene in the discussion and assisted the other participants to speak and share their experiences and perception around the focus group topics. We observed another dimension of the social dynamics. The implementing NGOs such as Christian Aid, Welthungerhilfe and other NGOs of the projects picked those farmers who worked as group leaders with them in the previous projects or worked with other NGOs before. So eventually, these lead farmers were privileged as they received an ample number of trainings from different NGOs that increased their communication and leadership skills. And since they were picked by the NGOs, they automatically gained 'elite' status in the eyes of the community members which is kind of a 'social capital' for them. In this sense, in focus groups, it can on occasion be hard to generate data and follow experiences of the individual participants as many of them remain silent due to social and power dynamics in the community. This assumes that each person has one 'true' set of attitudes that may revealed only in the presence of a researcher in a one-to-one interview, rather than in a group setting with peers (Morgan and Hoffman, 2018). Sometimes, focus groups introduce an element of bias due to the influence of group leaders. That is why we conducted follow-up interviews with some selected participants in order to get data on personal experiences and narratives.

Focus groups also unfolded some consequences of patron-client relationships (Hall, 1974). In a paper, some development scholars (Lewis and Hossain, 2008) quoted a BRAC (one of the largest NGOs in Bangladesh and the world) study which was conducted in the 80's in Bangladesh. The study revealed that in Bangladeshi villages, resources were not reaching the poor and landless. Instead, being controlled and enjoyed by a small number of powerful men, who had developed good connections with the local government officers. Our focus groups in Krishi Kontho (Christensen, Ahsan and Akand, 2018) discovered this connection, patron-client relationship and power structure in our study settings. In our focus groups, we identified that the village government agriculture extension officers[3] tended to visit and help the big farms as they received incentives from them. The small farmers were unable to provide incentives and that could be a reason for not getting regular extension support from the government agriculture extension officers. This was an unexpected but very valuable insight that arose from the focus groups. We did not receive this information during the semi-structured interviews conducted with NGO field officer and participants. They were hesitant to mention this service lack as they need to remain on a good footing with the government agriculture extension officers for their project operations. By bringing this insight, we also should not generalise the service of the government agriculture extension officers. One of our past research (Ahsan and Sadek, 2015) conducted in Bangladesh revealed that government's agriculture extension officers are very few in numbers and they have few resources to support all the farmers in the community. Additionally, due to financial restraints, the Bangladeshi government cannot hire more agriculture extension officers.

It may be important not to overplay differences between focus groups and semi-structured interviews. Scholars (Morgan and Hoffman, 2018) suggest that they are best seen as complementary rather than competing methods. In our different studies, semi structured interviews were useful to follow-up our focus groups. Focus groups helped us create opportunities to hear from participants whose thoughts and experiences are worth pursuing further. This means focus groups are especially useful for investigating the extent of both consensus and diversity among the participants, as they engage in sharing and comparing among themselves with the moderator in a facilitating role.

Now I will share how using interpreters during focus groups affected our data generation. It was previously mentioned that our focus groups and semi-structured interviews in our Agribuddy study (Ahsan, Christensen, & Kitaura, 2021) initially resulted in little information being gathered. Since the Agribuddy study (Ahsan, Christensen and Kitaura, 2021) was conducted in Cambodia and we did not know the local Khemer language, we had to engage an interpreter who was fluent in both Khemer and English. Scholars say that working in different cultural settings requires not only proper understanding of the language, but the researcher also needs to make sense of the social group and phenomenon under study to be able to communicate conceptually and analytically to an academic audience (Bujra, 2006, p. 172). A major problem we encountered during the Agribuddy study (Ahsan, Christensen and Kitaura, 2021) was that our informants, the farmers, would talk for three minutes, and the interpreter would sum it up in thirty seconds. As a result, we missed out on a great deal of important data. Moreover, during the focus groups, the interpreter brought her own assumption to our research on Cambodian agriculture. While it was our intention to moderate the focus groups regarding farmers' perspectives about Cambodian agriculture and their use of the Agribuddy service, the interpreter

[3] The Bangladesh government has around 18,000 agriculture extension officers (They are titled as SAAO) who are placed in village settings and are responsible for helping farmers in cultivation practices.

frequently chimed in with her own opinions and echoed those of the farmers she was translating for. Here, the research may have become subject to triple subjectivity - the interactions between research participant, researcher and interpreter (Temple and Edwards, 2002). As researchers, we had to explore the social location of the interpreter and tried to dig it down from the Agribuddy study. Temple and Edwards (Temple and Edwards, 2002), suggested that, in such situation of triple subjectivity, interpreter might be questioned as a 'key informant' to learn about the interpreter's personal history and how he or she relates to for example the farmer groups we were working with. Since the interpreter was neither a member of the farming community nor a former agricultural worker, she was not clearly a 'key informant' in our Agribuddy study (Ahsan, Christensen and Kitaura, 2021). This raises doubts about the interpreter's quality as a 'key informant,' at least with regard to her knowledge of farming and the farmers' situation. We had a casual conversation with the interpreter about her thoughts about Agribuddy, but since she was neither a user of the service nor a part of the farming community, we did not put much weight on her perspective. We reasoned that we would be able to generate adequate quality data from the focus groups if we could find an interpreter with expertise as an interpretation and a background in qualitative research, or an interpreter who represents the farming community and the user of the service. So, in terms of the social location, our interpreter played mostly the role of a translator only. To minimise the challenges of translation and to get more understanding on Agribuddy service, we had to set-up three semi structured interviews with Agribuddy staff, including the management. In those semi-structured interviews, many of our questions and misunderstandings were resolved, and we gained a much deeper understanding of the Agribuddy ecosystem. The interview participants could speak English; therefore, we did not need to include our interpreter for translation. In my experience, engaging an interpreter as part of the data collection process can be fraught with difficulties, not least because of the previously described phenomena of 'triple subjectivity.' (see also Temple and Edwards 2002).

In the Agribuddy study, we required the services of an interpreter, whereas in the study resulting in the COVID-19 paper (Ahsan and Christensen, 2022), we required the services of research assistants to carry out the semi-structured interviews. Due to COVID-19 situation, we had to remotely organise the interviews for our COVID-19 study in Bangladesh. Because we, the researchers, were unable to travel to Bangladesh due to restrictions on movement linked to the pandemic, the interviews and data collection were handled by local research assistants. Furthermore, the travel restrictions went beyond international travel. Even if a Bangladeshi citizen lived within the nation, he or she would be unable to move freely from one region to another due to internal travel restrictions (Khatun, 2021). Therefore, we had to choose and engage research assistants who resided close to the interview participants due to the mobility constraints and internal travel restriction for Bangladeshi citizen. As a result of the pandemic, then, we had to employ local research assistants to generate interview data from Bangladesh. Some researchers have pointed out that in cross-cultural studies, within social sciences, researchers do not have guidance on how to find, recruit and work with the research assistants (Stevano and Deane, 2017). Scholars also suggest that establishing affiliation with a local research institute for collaboration may be crucial for the ability to find research assistants and also to get to know the local research environment (Molony and Hammett, 2007; Stevano and Deane, 2017). We attempted to team up with a research organisation, but everyone's travel was limited because of the pandemic. Because of this, we decided on a new tack. In the past, we have collaborated with a wide range of non-profits and social entrepreneurs in Bangladesh to perform a number of research project and initiatives. We were already on good terms with them and had built up some

rapport. Research assistants are often employed by the NGOs and social enterprises to collect quantitative data through surveys. As part of our preparations, we contacted a former manager of survey enumerators working for a social enterprise. We hired that person as a coordinator to oversee the hiring and supervision of research assistants. Several meetings with the coordinator led to the selection of six research assistants with experience in survey data collection to work with our newly hired coordinator. Molony and Hammet suggested that research assistants' experience and personality is also important in relation to the physical and social environment(s) in which the research is to be conducted (Molony and Hammett, 2007, p. 295). We also wanted to hire research assistants who live in close proximity to the study's participants, who are familiar with the area and who won't spend too much time commuting. Some researchers suggested the importance of having methodological expertise while conducting cross-cultural studies and suggested that prospective research assistants who have previously worked with questionnaire-based structured interviews need to be informed and trained in qualitative methods (Molyneux, Goudge, Russell, Chuma, Gumede and Gilson, 2009). Research assistants in our study were chosen based on their prior experience as enumerators and their familiarity with focus groups. In spite of their varied academic credentials, none of them had received training in qualitative research methods before. We recruited them with the help of our coordinator and then spent two days of online training on qualitative interview techniques. It was a non-intervention ICTD study (Dearden, 2012) and with their consent, we used the zoom platform to train the research assistants. We developed the semi-structured interview guideline in the local language and discussed how to ask the questions and recording the interview sessions. This process helped to collect data from the field. The research assistants going to participants' homes and conducting interviews helped us get the audio recorded data, photos and videos. The photos and videos contributed to an understanding of the physical setting of the participants under lockdown. As a preventative measure against COVID-19 cotangent, both the interviewer and the interviewees donned face masks, used hand sanitizer and kept their distance from one another during the interviews. Molony and Hammet notes that the relation between researcher and research assistants is shaped by a range of wealth and power asymmetries that are rooted in a broader set of international historical relations, but it is essentially one of employment (Molony and Hammett, 2007). Since the research assistants conducted the work in order to have some income during the pandemic, a relationship akin to that of employer and employee existed. Since the interviews were released as a delivery of our interview assignment, they did not have the same publication and research interests as us. However, if we had done the interviews on our own, we may gain further knowledge. But in light of the pandemic, hiring them and collecting data is all that could be done.

Figure 2 COVID-19 study: Our interviewees with mask and social distancing

We also adopted a quantitative approach in addition to the ethnographic and qualitative methodologies. Some researchers mention that when used in combination, both quantitative and qualitative data yield a more complete analysis, and they complement each other (Creswell, Fetters and Ivankova, 2004). Arguably, we may call Krishi Kontho as mixed method study as we performed quantitative and qualitative inquiries (Christensen, Ahsan and Akand, 2018). Our points of view are in line with those of other researchers who have suggested that mixed-methodologies research is described as "research in which the investigator gathers and analyses data, integrates the findings, and draws inferences utilising both qualitative and quantitative techniques or methods in a single study" (Tashakkori and Creswell, 2007). Research on Krishi Kontho was carried out as part of a humanitarian development initiative. Baseline surveys, a type of quantitative survey instrument, are sometimes employed at the outset of humanitarian development projects, before any form of intervention has taken place. Swedish International Development Authority (SIDA), a well-known humanitarian development organisation, defines baseline study as the gathering of primary and secondary data that identifies and analyses the socioeconomic conditions in a specific location and time period (Freudenthal and Narrowe, 1992). According to them, the project's success may be measured against predetermined standards by gathering baseline data. Additionally, baseline inquiry is conducted to keep an eye on things and assist with the project's overall activity planning (Freudenthal and Narrowe, 1992). Furthermore, the World Bank also states that one cannot estimate its performance into the future without first establishing a baseline, and baseline is the first measurement of indicators (Kusek and Rist, 2004). Prior to the beginning of the agricultural voice message field trial in the Krisho Kontho (Christensen, Ahsan and Akand, 2018), we established a baseline of the previous year's crop yields, production costs and pest & disease infestation. The baseline was constructed so that results from the field trial could be compared to those obtained from a point of comparison established prior to the study. Our Krishi Kontho study's project partner, Christian Aid, collected information on farming practices, crop yields and other agricultural indicators, in addition to demographic and socioeconomic data. This is routine data collection done as part of their regular and ongoing efforts to help local farmers and in the selection of project farmers. For the sake of the Krishi Kontho research, we chose to use a subset of the Christian Aid-gathered baseline indicators. In order to compare the outcomes of the field trial to pre-trial stage, we constructed a Krishi Kontho baseline. We used the same indicators from the baseline survey in an endline survey to evaluate the impact and outcomes of the field experiment. A combination of quantitative data and qualitative methodologies, including focus groups and semi-structured interviews, was utilised to assess the results of the field experiment[4].

The Krishi Kontho study (Christensen, Ahsan and Akand, 2018) employed a non-randomized intervention and a quasi-experimental approach to collect data at the beginning and end of the study. We followed the ‘nonequivalent-group design’ (Reichardt, 2009, p. 55) which included the collection of a pre-trial observation in both groups. Intervention (termed ‘treatment’ as well) is administered to one group and finally both groups are assessed on post measures. Researchers mention that quasi-experimental design is used when it is not logistically feasible or ethical to conduct a randomized control trial (RCT) (Harris, McGregor, Perencevich, Furuno, Zhu, Peterson and Finkelstein, 2006). We were unable to conduct a large-scale randomised controlled trial (RCT) for the Krishi Kontho

[4] The analysis of data generated using different methods (participant observation, semi-structured interview, focus groups and quantitative field trial) are described in the papers attached with this thesis.

investigation due to time and financial constraints. We assigned two groups of farmers, each with 100 members (the 'control group' and the 'intervention group'). Farmers in the 'control group' did not receive any voice SMS messages about agricultural practices but instead continued to use their customary methods, such as seeking advice from their fellow farmers or local input shops. Farmers in the 'Intervention group' received voice SMS messages with agricultural recommendations. In order to conduct an effective impact evaluation, we conducted an endline survey and gathered data on key performance indicators, such as crop yield and production cost for both 'control' and 'intervention group' of farmers. Therefore, I concur that there was a selection bias in our quantitative analysis due to the lack of random assignment of farmers. Some scholars mentioned that science often progresses best when it employs a diversity of methods that have corresponding diversity of strength and weakness (Reichardt, 2009, p. 46). In Krishi Kontho, while quantitative methods were helpful in describing the scope of a phenomenon, they were less successful when attempting to characterise it. The quantitative method helped to measure the change in crop yield and production cost based on before and after the Krishi Kontho field trial. For example, the 'intervention group' of farmers saw on average 12% higher production than previous year. And even the production cost was on average 6% less than previous year (Christensen, Ahsan and Akand, 2018). Our use of semi-structured interviews and participant observation in the Krishi Kontho study (Christensen, Ahsan and Akand, 2018) allowed us to go more deeply into the nature of the phenomena we were studying. For example, through participant observation, focus groups, and semi-structured interviews, we found that farmers who placed a high value on receiving voice messages in a timely manner were able to better structure their cultivation practices. In addition, during the semi-structured interviews, farmers voiced a need to be provided with market price information, which they said they desperately needed but was not receiving from the Krishi Kontho service. So, the qualitative data and ethnography could offer the tale and understanding of the phenomenon and perspective which we lacked in quantitative data.

CHAPTER 3: REFLECTIONS ON HUMAN INFRASTRUCTURE

Technology cannot be 'airdropped' into a situation with the guarantee of positive results (Donovan, 2017)

The purpose of this chapter is twofold. I begin by reviewing and reflecting upon the different ways in which infrastructure has been conceptualised across a range of scholarly perspectives. In reviewing different perspectives on infrastructure, I want to assess the ways in which the concept has been used analytically and been part of scholarly debates. Subsequently, I turn to the notion of human infrastructure and give emphasis to recent scholarly activity in this area. Based on reflections on infrastructure and especially human infrastructure studies, I seek a more nuanced understanding of human infrastructures in their relationships to digital interventions in the Global South. In doing so, I draw on the projects that form the basis of this thesis.

3.1 Infrastructure and human Infrastructure

Now, I will trace some influential lines of thought that have helped shape the concepts of *infrastructure* and *human infrastructure* that are key to my thesis. I will begin with the concept of infrastructure as it has been presented in the broader literature of e.g., CSCW, IS, STS and then go on to focus on the use of the concept of human infrastructure not least in ICTD. That is, while I do not attempt a comprehensive review of the vast literature on 'infrastructure' in the computing-related literature, I do attempt to trace some influential lines of thought and how these may inform our understanding of human infrastructure.

During the last decades, the fast spread and pervasiveness of large-scale IT-based installations has led to a surge in the interest in computing infrastructures. Simultaneously, the value of such studies as an approach to learning about IT infrastructures has been increasingly acknowledged and gained importance in Computer-Supported Cooperative Work (CSCW), Information System (IS) and Science and Technology Studies (STS) (Karasti and Blomberg, 2018; Lee and Schmidt, 2018) Thus, the concept 'infrastructure' has been used in a variety of contexts, many of which depend on computer technology (such as the ICTD). But I will start with the conception of 'infrastructure' first.

The concept 'infrastructure' itself has been used in several contexts, across a wide range of fields. According to Schmidt and Bansler, disparities in the use of the concept have become a source of confusion (Schmidt and Bansler, 2016). As the concept of 'infrastructure' has become increasingly used as an analytical tool, as more scholars have entered the field, a wider range of perspectives and approaches have been brought forward. Initially, the term was used to refer to the system of public works in a country, state, region or city such as water and sewage, electrical power, railroad etc (Bowker, Karen Baker, Florence Millerand and Ribes., 2010). Later, in the 1970s as an analogy, the concept was expanded to a socio-technical system such as postal service, banking, aviation etc. (Lee and Schmidt, 2018). Infrastructure is also conceived as a relational term (Karasti, Baker and Millerand, 2010; Star, 1999) and it emerges in relation to organised practices where they are connected to particular activities. Human actors and networks may be significant for connected activities and

organised practice (Star and Ruhleder, 1996, p. 113). Later In my thesis, I will go through how the term ‘human infrastructure’ is being employed in both CSCW and ICTD research as a means of expansion of ‘infrastructure’. Before getting into that discussion, let us trace the history of the term ‘infrastructure’ in computing-related discourse.

Early on, Rob Kling, Walt Scacchi and Tom Jewett used and introduced the term ‘infrastructure’ as a key analytical concept in the area of ‘social studies of computing’ (Jewett and Kling, 1991; Kling, 1987; Kling and Scacchi, 1982). Their study's overarching goal was to pinpoint the sociology of technology; specifically, they were curious about the normative uses of computers, the social effects of widespread computer usage and the factors that drive the adoption of new computer-based technologies. For their research, they wanted to view computing technology and computer systems not as something that (magically) appears from nowhere, but as something that is inherently 'social,' both in its creation and its use. They mention that examination related to new computing development ignored or simplified the concept of the ‘social’ (Kling and Scacchi, 1982; Lee and Schmidt, 2018). Kling and Scacchi introduced the notion of ‘infrastructure’ to treat organizational and practical aspects of computing (the social) at the same level as computing equipment to bring to attention the invisible work and the hidden costs required. A formal definition is presented by them: “Infrastructure refers to those resources which help support the provision of a given service or product. The infrastructure for providing computer based services includes resources such as skilled staff and good operations procedures, as well as physical systems such as reliable ‘clean electrical energy and low-noise communication lines (cited in Lee and Schmidt, 2018).”

Also, widespread use of the term ‘infrastructure’ in the context of computing may be traced back to around 1990 when the term ‘information infrastructure’ first arose. Kling and Scacchi had no relationship with this use of the term ‘information infrastructure’. Rather, in light of TCP/IP's ascent to the status of de facto Internet standard in late 80s, technologists, administrators and government officials have discussed and expressed an interest in building 'services' atop the underlying computing and communication infrastructure. In order to help scientists who work in different geographical locations to communicate with each other, share data and use digital libraries, US National Science Foundation (NSF) ideated an information infrastructure named ‘national collaboratories’ (Wulf, 1989). Later the concept ‘national collaboratory’ was replaced by ‘collaboratories’ (National Research Council, 1993, p. vii). They ideated to develop multiple scientific collaboratries to share network and computing resources, software and infrastructure.

In addition to NSF, The White House Office of Science and Technology Policy (OSTP) advocated privately run information infrastructure to allow schools, businesses and the government to share high quality information at affordable prices, that is an addition apart from the need of the scientists (OSTP, 1992). Later, in 1991 a plan of action titled ‘National Information Infrastructure (NII)’ was released which had a meaning of more than physical infrastructure. The term ‘information infrastructure’ in its definition, included information (content) itself, the people's access to applications and software, the network standard for privacy of people and the private sector individuals who create information, develop applications and provide services (IITF, 1993). So, ‘National Information Infrastructure (NII) conceived as a set of *services* providing content.

Furthermore, for infrastructure studies, the analytical strategy of 'infrastructural inversion' is very important. The analytical move was initially formulated by Bowker to address the propensity of infrastructures to remain invisible backdrops to social action (Bowker, 1994). The idea could be interpreted as a gestalt switch, a figure-ground reversal, struggling against the tendency of infrastructure disappearing in analysis (Simonsen, Karasti and Hertzum, 2020). Star and Ruhleder (Star and Ruhleder, 1996) used this term to reconceptualize the concept 'infrastructure' as Star elaborated it as a conceptually based notion with methodological consequences (Karasti and Blomberg, 2018; Kling and Scacchi, 1982). Infrastructural inversion struggles against the tendency of infrastructure to sink into the background and brings it into foreground. It focusses on the activities and work practices that warrant the functioning of infrastructure, rather than those that it invisibly supports (Star and Ruhleder 1996, p. 113). To illustrate 'infrastructural inversion', consider the example of the Worm Community System's (WCS) 'collaboratory' research conducted by Stat and Ruhleder (Star and Ruhleder, 1996). The Worm Community System (WCS) was developed to support biologists from global communities to share in partnership with computer scientists who were building an electronic shared laboratory and publishing space for them (Schatz, 1991; Star, 1999). But few biologists actually ended up using the system. 'Infrastructure' issues such as incompatible platforms, a recalcitrant local computer centre and bottlenecked resources were identified as the root cause of the problem, rather than the interface of representation or the representation of the work processes inherent in the system (Star, 1999). So, WCS in its design was a 'closed system'. It could run only a very constrained selection of workstations and operating systems. But on the other hand, World Wide Web (WWW) can be accessed from various terminals and it is inexpensive and Internet computer support is readily available in most academic institutions. To understand the failure and experience of WCS, Star and Ruhleder invoked the notion 'infrastructure' mentioned by Kling and his colleagues (they cite Jewett and Kling, 1991; Kling and Scacchi, 1982). Kling and his colleagues inverted the usual relationship between infrastructure and superstructure by shifting their focus from computing system to practical organizational embeddedness and dubbed it 'infrastructure' while still maintaining the computing system as focal entity (cited in Lee and Schmidt, 2018). However, Star and Ruhleder went further, noting that the nature of tools and technology used in large-scale, powerful infrastructure tools, such as the example 'national information infrastructure (NII),' is ambiguous for diverse groups. De facto standardisation of a single powerful group obscures the nature of ambiguities. The focus needs thus be shifted from seeing 'infrastructure' just in terms of large-scale technological installation to also including serious political and social concerns as well as classification schemes and standards. If this does not happen, powerful stakeholders will suppress the less powerful stakeholder in a system which may fail. So, to shift focus, Star and Ruhleder used the analytical move of 'infrastructural inversion' (Bowker, 1994; Star and Ruhleder, 1996). For them 'infrastructure' is something that emerges for people in practice, connected to activities and structures (Star and Ruhleder, 1996). That is, an analytical move based on the idea of 'infrastructural inversion' was offered as a means of bringing to the foreground activities and conflicts of interest that may otherwise go unnoticed or, in their words, become 'invisible.'

We may say that infrastructure emerges analytically as a result of inversion. Star and Ruhleder started questioning: 'When' is an infrastructure? They formulated these dimensions of 'infrastructure' which is an *integration* of resources in 'local practices' (Sambasivan and Smyth, 2010; Star, 1999; Star and Ruhleder, 1996):

- *Embeddedness.* Infrastructures are bound up with a host of pre-existing structures, both technical and social, which they depend on for identity and function.
- *Transparency.* Infrastructures support tasks invisibly by being ready-to-hand and without needing to be assembled or reinvented for each task.
- *Reach or Scope.* Infrastructures are not limited or confined to a single event or site of practice. They may be either spatial or temporal.
- *Learned as a part of membership.* The elements of infrastructures, such as artifacts and organizational relationships, are internalized by the people that use them.
- *Linked with conventions for practice.* Infrastructures interact with the shared norms of a community of practice, both shaping them and being shaped by them.
- *Embodiment of standards.* Where conventions conflict between different infrastructures, interconnections are made through reliance on negotiated standards.
- *Installed base.* New infrastructures are built upon older ones and upon existing systems of support, funding, training and expertise.
- *Visible upon breakdown:* Infrastructures tend to be invisible to those using them unless and until they break down.

According to Atsuro Morita, infrastructural inversion is not only a strategy deployed by the researcher (Morita, 2017). During moments of breakdown, many people are directly affected by the unpredictable behaviour of infrastructure. As a result of unusual events like breakdowns and accidents, the workings of infrastructure may become clearly visible to the observer. Under such circumstances, they, too, may begin exploring its ramifications (Star, 1999). So, 'infrastructural inversion' is not only an analytical strategy but also something practitioners may experience.

Having traced the concept of infrastructure, including the analytical strategy of infrastructural inversion, I will now turn to the related notion of 'human infrastructure'. As mentioned above, I will give emphasis to recent scholarly activity in this area. Based on reflections on infrastructure and especially human infrastructure studies, I seek a more nuanced understanding of human infrastructures in their relationships to digital interventions in the Global South. I will base the discussion on an understanding of my own project work as well as the literature.

3.2 Human infrastructure

The notion of human infrastructure, then, takes on a pivotal role in this thesis. To grasp the notion we can as a starting point turn to the work of Lee and colleagues (Lee, Dourish and Mark, 2006). The trio performed a distinct infrastructural inversion – not just to inform the relationships between social groups and materiality – they wanted to think about social groups as infrastructure. They used the term 'human infrastructure' to refer to arrangements of organizations and actors that must be brought into alignment for work to be accomplished. Over the years technological infrastructures support large-scale distributed scientific enterprises and they are referred to as 'collaboratories' (Finholt, 2003), 'eScience' (Hey and Trefethen, 2005), 'grid computing'. Lee and colleagues referred to these as 'cyberinfrastructure' (Lee, Dourish and Mark, 2006). Earlier, Berman has stated that most critical to the success of 'cyberinfrastructure' is 'human infrastructure'. Collaborative efforts by people are essential to cyberinfrastructure's software, tools and applications. The personal networks,

knowledge and relationships of the human infrastructure take a long time to build and are critical to the usability of the resources (Berman, 2001).

In ICTD, Sambasivan and Smyth (Sambasivan and Smyth, 2010) have used the concept of human infrastructure to provide inspiration on how the concept may be of benefit to the field. Based on field work in India, Sambasivan and Smyth offer ICTD researchers and practitioners an analytical lens to understand "shared social norms and practices, flows of information and materials and creative processes that underlie existing information and communication access" (Sambasivan and Smyth, 2010, p. 1). Furthermore, they provide a discussion of the systemic processes (*usage, maintenance, and diffusion*) and properties that may constitute a human infrastructure. Below I will attempt to extend our knowledge of such systemic processes inspired by Sambasivan and Smyth's categories and in that manner contribute to a further nuanced understanding of human infrastructure in ICTD. However, before I do so let us take a closer look at the notion of human infrastructure and how it has been used in selected studies in the Global South.

The notion of human infrastructure has been key in a number of studies in the Global South, including in an intriguing analysis of the DakNet project in India (Pentland, Fletcher and Hasson, 2004). The original purpose of the DakNet project was to bring affordable digital connectivity to outlying communities by establishing widespread high-speed wireless broadband infrastructure. This was done by delivering telecommunications hardware via human-powered modes of transportation including ox carts, buses, motorcycles and more. In DakNet, humans were crucial since they were the ones to transport the necessary technical infrastructures. Furthermore, the MOSES project (Smyth, Etherton and Best, 2010) draws attention to the infrastructure lens as it demonstrates how a video-sharing kiosk system was implemented in Liberia as part of a peer-learning process for post-conflict reconciliation. The findings of the MOSES study indicate that despite the villagers' computer literacy, it was the pre-existing relationships among the user groups that allowed them to learn the Kiosk's interface. Their family and friends and members stepped in to teach them how to use the Kiosk and guide them through their exploration of its features. Also, again from India, the 'digital green' program (Gandhi, Veeraraghavan, Toyama and Ramprasad, 2007) taught farmers how to make agriculture videos with the goal of spreading their knowledge to other farmers. The video-based agriculture extension knowledge was widely disseminated through farmer cooperative groups, farmer relationships in the community and personal links. Video-based agriculture extension relied more on the existing human infrastructure.

We may have heard that the reporting of data based on people's responses is supposedly an important part in the digital intervention project in the Global South and that needs to be error free. According to results from a tuberculosis (TB) programme in India (Patnaik, Brunskill and Thies, 2009) voice call centre human operators in data collection were preferable and feasible ways to capture high accuracy data, especially in healthcare. This conclusion was reached by testing three distinct user interfaces within the research project: electronic forms, text messages, and telephone calls to a live operator. In contrast, another research out of India investigated at the function of human intermediates in a video-based healthcare awareness campaign for mothers (Ramachandran, Canny, Das and Cutrell, 2010). Through the use of these short videos, healthcare workers (intermediaries) increased their knowledge base and served the pregnant women and their families in the village better. There are some other HCI, CSCW, and ICTD literatures where human infrastructure in the Global South is described.

‘Intermediation’ is a common and important process to access ICT where there is literacy gap for people in the Global South. In partnership with two local NGOs in India, Medhi-Thies et al. designed, developed, deployed and evaluated a mobile based social networking system named KrishiPustak for low literate farmers where intermediation played a role. The NGO agriculture extension workers worked as human mediators to help low literate farmers to access the agro-based social networking system. These human mediators also registered farmers, trained them on-the-spot and also helped to access the system (Medhi-Thies, Ferreira, Gupta, O'Neill and Cutrell, 2015). A study from Cuba (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018; Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018) showed the importance of human infrastructure in ‘offline internet service’ in a restricted internet access environment. The service provides a critical opportunity to understand human effort that constitutes socio-technical system (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018). The distribution of offline digital contents, such as movies, music, TV shows, educational programs etc. service through USBs, CDs, hard drives, heavily depends on three groups of people, a) the masters who gather and compile the digital content, b) the packagers who deliver, edit and produce additional content, c) the people who consume, share and create their own content. A telemedicine study from India (Chandwani and Kumar, 2018) shows the importance of different stakeholders to run rural and urban hospitals. The study was inspired by Sambasivan and Smyth’s article (Sambasivan and Smyth, 2010) and their findings show how other human infrastructure such as coordinators, support staff, patients etc. facilitate telemedicine service apart from the doctors. In mental health, a helpline study from India (Pendse, Lalani, Choudhury, Sharma and Kumar, 2020) shows how volunteers' diverse identities and backgrounds can be seen as 'expertise' within the mental health support service. Their study find that help-line volunteers navigate individual boundaries and interpersonal boundaries to support the caller. This service is invisible, but it may be termed labour which creates value. Another study in Kenya on the use of mobile phones by the visually impaired finds that accessibility turns into ‘social’ if the support system works. It overlaps with the concept of human infrastructure as ‘social system’ is a combination of human actors, relationships, activities, spaces, networks and goals (Barbareschi, Holloway, Arnold, Magomere, Wetende, Ngare and Olenja, 2020). However, an HCI study in Kashmir, India focused on uncertainty and disruption in education, demonstrating that human infrastructure, such as local teachers, can be leveraged to access content, and that community ties, neighbourhood ties, and extended family ties may help to share devices and learn during disruption. (Wani, Singh and Singh, 2022).

Having considered some of the literature related to the theme of human infrastructure in the Global South, let us return to an analytical lens inspired by Sambasivan and Smyth (Sambasivan and Smyth, 2010). To reiterative, Sambasivan and Smyth (Sambasivan and Smyth, 2010) provide a discussion of processes (usage, maintenance and diffusion) that may be key for human infrastructure. I will attempt to extend our knowledge of such systemic processes by drawing on the projects that form the basis of this thesis. I seek a more nuanced understanding of human infrastructures in their relationships to digital interventions in the Global South.

3.3 Process of Human Infrastructure in technology supported interventions in the Global South

Like any other community in the world, the people from the Global South may need to be involved in daily activities, such as in work, livelihood, health, entertainment, food production etc. For all these,

they may depend on human relationships and interaction. Or what we might call human infrastructure (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018; Lee, Dourish and Mark, 2006; Sambasivan and Smyth, 2010). However, as we discussed before, the notion of human infrastructure has received perhaps less attention that it ought to (Mark, Al-Ani and Semaan, 2009).

Based on their field study in Bangalore on media sharing and intermediation, Sambasivan and Smyth (Sambasivan and Smyth, 2010) denoted several processes in the human infrastructure. They analysed their Bangalore cases by categorizing three 'processes' i.e., 'usage', 'maintenance work' and 'diffusion'. In addition to that I will add three more categories. That is, it may be relevant to also consider how a human infrastructure may be 'configured', 'trained', and 'unravelled'. Adding the latter three categories to our understanding of processes within a human infrastructure may prevent us from taking it for granted. A human infrastructure is not just somehow there, and we cannot take it for granted in our analysis. Inspired by the work on human infrastructure, and especially the work of Sambasivan and Smyth (Sambasivan and Smyth, 2010), I will present the following framework:

1. *Configuring the human infrastructure (creating it),*
2. *Training of the human infrastructure,*
3. *Usage of the human infrastructure in interventions,*
    a. *General usage*
    b. *Maintenance*
    c. *Diffusion*
    d. *Contingency work*
4. *Unravelling the human infrastructure (ending it).*

Table 2 below presents four interrelated perspectives of human infrastructure – an analytical framework. I will use this framing to try to further understand some of the projects I have been involved with over the years and that form the empirical basis of this thesis.

Perspectives	Examples	Projects
Configuring the human infrastructure	Voice message for agriculture information for farmers - Hired and configured lead NGO project manager for overall coordination. - Recruited partner NGO staff for field implementation. - Recruited technology staff for design and development of the service.	Mobile based Climate Smart Agro Information Service for Farmers Project
	SMS messages for agriculture information dissemination - Configured and hired human actors from NGOs and technology partner. - Gathered and configured self-help group farmers in the community to disseminate the content of the messages. - Involved religious leader (Imam) to disseminate content of the messages. - Involved government agriculture officer for SMS content validation.	Climate and Agriculture Information Service (CAIS) Project
	- Recruited community lead farmer as buddy who holds smartphone and app to provide agriculture service among farmers - Agribuddy recruits and buddy connects other human infrastructure, millers, input sellers, micro-credit loan providers, pesticides sprayers.	Agribuddy project
	Mobile app-based screening and web dashboard educed mental health counselling.	Rohingya mHealth project

Perspectives	Examples	Projects
	- Configured and hired human actors from NGO, technology staff and university researchers - Medical assistants are recruited for mobile based screening. - Mental health counsellors are recruited for referral handling. - Rohingya community leaders were involved to ease community access.	
Training of the human infrastructure	- Training 500 self-help group lead farmers to re-tell agriculture SMS contents among other group farmers and non-project beneficiary farmers. - Training project's staff on participatory rural appraisal (PRA), well-being analysis, social and resource mapping and participatory needs assessment to select farmers for the project.	Climate and Agriculture Information Service (CAIS) Project
	- Training farmer producer groups' (FPG) 'resource farmer' on group facilitation to discuss agriculture voice message content to other farmers. - Training project staff to conduct needs assessments and select farmers for the project.	Mobile based Climate Smart Agro Information Service for Farmers Project
	- Training intermediaries: Buddy's knowledge on agriculture extension regarding crop cultivation, pest/disease management and fertiliser application. - Training on using digital app to connect value chain players with farmers.	Agribuddy project
	- Training intermediaries: Medical Assistants' mHealth training and mental health screening training. - Mental health counsellors' training on using dashboard.	Rohingya mHealth Project
	- Providing virtual training to local research assistants and research coordinator during COVID-19 pandemic to conduct interview with the respondents and collect data from the field.	COVID-19 study
How usage was enabled by the human infrastructure	- General usage: Project's chili and maize farmers were the receivers and users of the agriculture voice messages. - General infrastructural maintenance: Lack of electricity forced farmers to charge their phones in charging services in the market run by small shopkeepers. - Diffusion: Agriculture content receiving farmers shared with other non-project beneficiary farmers.	Mobile based Climate Smart Agro Information Service for Farmers Project
	- Self-help group farmers and farmers were the user of the content of the agriculture SMS and applied in their farm and in the field. - Non project beneficiaries may be the users of the contents of the agriculture SMS messages as the project field officers crafted and posted handwritten posters and used mosque public announcement system to disseminate SMS contents.	Climate and Agriculture Information Service (CAIS) Project
	- Buddy used Agribuddy system as intermediary and primary proxy user of the app. - Farmers acted as the secondary user since they were service receiver and content user.	Agribuddy project
	- Medical Assistants were the primary users of the screening app and they acted as intermediaries. - Diffusion: On the job training helped the medical assistants to spread the service and screen more people in the camp. - Psychologists were the primary user of the web-based health information system on mental health. - The Rohingya beneficiaries acted as a secondary user of the mHealth service as they were screened and treated.	Rohingya mHealth project

Perspectives	Examples	Projects
	- Research assistants used audio recorders to record interviews, cameras to video tape and capture photos of the location and surroundings during COVID-19 pandemic.	COVID-19 study
Unravelling the human infrastructure	- Funding constraints and fixed time duration of the project unravelled the human infrastructure. Medical assistants, psychologists and other projects staff had to leave job and moved elsewhere.	Rohingya mHealth project
	- Voice and SMS service stopped after the end of the project as community and self-help groups did not have capacity to run by themselves.	Mobile based Climate Smart Agro Information Service for Farmers Project & Climate and Agriculture Information Service (CAIS) Project
	- The buddies and staff of Agribuddy are not unravelled since the services is based on business and commercial value chain. There is no donor or aid dependencies.	Agribuddy project

Table 2 Perspectives on human infrastructure in relation to selected projects

Now, I will focus on the perspectives on infrastructure seen in table 2 in an effort to give a nuanced picture of the workings of a human infrastructure. I will give examples from both the literature and my own project work.

3.3.1 Configuring the human infrastructure (creating it)

Our fieldwork findings in different projects (Ahsan, Christensen and Kitaura, 2021; Christensen and Ahsan, 2022; Christensen, Ahsan and Akand, 2018; Christensen, Ahsan, Rashid and Das, 2019) show that we create or configure human infrastructure in digital intervention projects in the Global South. As mentioned in the section before, Sambasivan and Smyth (Sambasivan and Smyth, 2010) may have taken human infrastructure somewhat for granted in the sense that they did not account for the making of the infrastructure. They mentioned in their paper that the human infrastructure lens focuses their attention on the 'existing' dependencies, condition and knowledge which will shape technology in the Global South (Sambasivan and Smyth, 2010). That human infrastructure is configured is apparent not only in our own research (Ahsan, Christensen and Kitaura, 2021; Christensen and Ahsan, 2022; Christensen, Ahsan and Akand, 2018; Christensen, Ahsan, Rashid and Das, 2019), but also in other studies as well. For example, a study from Cuba shows that in a restricted internet service, offline internet could be established and sustained by three groups of existing people. An offline internet service named EP 'created' three types of human actors such as the masters, the packagers and the people, organised them to run the service (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018). Another study on human infrastructure created and involved help-line volunteers to provide informal technology mediated mental health support TMMHS) in India (Pendse, Lalani, Choudhury, Sharma and Kumar, 2020) but this was voluntary support. Here, we are breaking the lens of Sambasivan and Smyth (Sambasivan and Smyth, 2010) on existing human infrastructure and may say that human infrastructure may need to be created to implement digital intervention projects in the Global South as each project involves specific human resources to address 'humanitarian

development problems'. For that reason, projects may need to recruit, create and configure various types of human resources based on their work background and domain expertise. These digital intervention projects ultimately become collaborative in manner and different human resources perform coordinated and articulated work to implement the activities in the community. Our field observation noticed that multiple human agents from NGOs, governments, social enterprises, academia and from the community contribute to the design and implementation of digital intervention services. For specific digital intervention projects in international development, organisational and stakeholder partnerships are formulated to address issues related to various needs, such as healthcare, food security, education etc. The lead partner organisation usually takes the initiative to formulate the consortium. However, the organisational partners are required to apply for donor or external funding through the process of 'request for proposal (RFP)' calls (Gibson, Shivakumar and Andersson, 2002, pp. 79-82). Usually, aid projects are implemented by either recipient governments under a bilateral agreement with the donor country or through an 'implementing partner' of the donor—frequently a non-governmental organisation (NGO) (Smillie, 1995). In some cases, donors and aid agencies also reach out to these organisations and create partnerships to address community development challenges by catalysing aid (Stubbs, Kentikelenis and King, 2016). Sometimes, one single partner applies for these grants for small scale projects. Not only donor agencies, but sometimes private sectors and foundations also provide aid to address the Global South challenges. In India, to implement a telemedicine service, National Institute of Medical Research (NIMR) formed a consortium with local hospitals in Orissa and received funding from the Government (Chandwani and Kumar, 2018). Another remote medical consultation service from Ghana showed that adoption of two different ICT interventions was heavily dependent on seven partner organisations (Luk, Ho and Aoki, 2008). Therefore, relationships among organisations and aid are interlinked in digital intervention projects in the Global South.

Now let us come back to the point of configuring human infrastructure. Firstly, during the funding application period and after the confirmation of the funding from the donor, all the organisations recruit a pool of human actors to implement projects. If we take an example of an agriculture project – agriculture scientists, agriculture extension experts, project managers and NGO officers are recruited. To give a generic example, if the project is an ICT based agriculture project, then the technology partner in the consortium involves human actors like mobile app developers, web application developers, system designers, digital content creators etc. (Ahsan and Sadek, 2015; Patel, Chittamuru, Jain, Dave and Parikh, 2010; Pronk, Hengsdijk, Ahsan and Michielsen, 2019; Toyama, Gandhi, Veeraraghavan and Ramprasad, 2009). An example, from Kenya, Catholic Relief Services (CRS) developed and implemented FarmBook, an e-business planner for farmers (Tata and McNamara, 2018) that involved ICT applications developers to create the service and field extension officers to implement the service. Prior research also shows that networks of technical personnel can address technical problems and fill the technology gap of non-technical personnel (Surana, Patra, Nedevschi and Brewer, 2008). So, human infrastructure can be worked in different ways. We may call these technology and ICT application developers and designers 'digital producers' (Heeks, 2018, p. 146). But digital intervention projects in the Global South may require more drivers (other human actors and networks) to make a digital initiative happen. When recruiting and configuring different personnel from the project consortiums partners, human infrastructure plays its part in executing a digital intervention project in the Global South. We are reiterating that 'human infrastructure' may be created in the digital intervention projects in the Global South.

Now let us see how human infrastructure is created in our digital intervention projects. In the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018), with funding, the lead organization, Christian Aid Bangladesh's program manager formed a partnership with local NGO, GUK and the technology partner mPower to execute agriculture voice messages in the farming community. Then the local NGO, GUK recruited field officers and registered interested farmers who were willing to receive agriculture voice messages. The technology partner, mPower, first appointed various human actors to design and implement the agriculture voice message service. They recruited designers to identify farmer's information needs. Then the agriculturists developed and validated voice message contents. mPower's technology team developed the SMS portal and uploaded the voice message. The IT support personnel was regularly involved to fix bugs and troubleshoot the server. mPower's project manager finally operationalised the service with the help of partner NGO staff and farmers. Since these people are recruited for this project only, we may say that 'human infrastructure' is configured or created to implement agriculture voice message.

The 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) crafted and sent SMS messages to farmers. They almost had similar process like 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) in forming the consortium with multiple partner organisations. They also recruited tech and non-tech personnel to design and implement agriculture SMS service. But during the implementation process, the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) formed and involved some other types of human actors. They involved lead farmers from the self-help groups[5] to disseminate SMS messages orally to other farmer member of the groups who did not have phones to receive SMS. The project also included governmental agriculture officers to validate agriculture content to gain trust of the farmers. Further, to spread SMS advisories to non-registered or other farmers in the community, the project requested the local religious leader (Imam) to use Mosque's public announcement (PA) system to disseminate the content orally. Using PA system for non-religious activities created some issues which is discussed later in the 'usage' section.

The Agribuddy Project (Ahsan, Christensen and Kitaura, 2021) is not donor dependant but runs on the form of commercial value chain. As a company they recruited buddies[6] who use an app to provide microcredit loan application service, agriculture extension messages service, market information service etc. to farmers. Agribuddy created this intermediation process to ease access for farmers to the value chain facilities, to address lack of bearing the cost of owning a technology (smartphone) by farmers and lack of literacy (Sambasivan, Cutrell, Toyama and Nardi, 2010). By selecting and training 'buddies' from the community, Agribuddy connects the human infrastructure of millers, input sellers, micro credit loan providers, pesticides sprayers so that farmers could store, sell, and protect their crops.

In the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022), we find another type of intermediation through medical assistants in a mHealth based mental health service. Here, the

[5] Self-help group farmers in the project, and each group has 25-30 farmer members who voluntarily came forward to form a group for agriculture service. Apart from SMS messages, they used to receive agricultural training from the NGOs.

[6] Buddies are farmers who work as intermediaries for the Agribuddy service and work as the hub of agriculture value chain players.

technology mediates human action on the one hand and on the other hand it is also adapted by human action (Tang, Chen, Semaan and Roberson, 2015). The project implemented by the IT University of Copenhagen and a local partner, Friendship, recruited medical assistants to screen Rohingya beneficiaries at doorsteps. To handle referral cases from the screening, the project recruited psychologist to run mental health counselling sessions. Unlike other projects mentioned above, they also included the technology development resources to design the mHealth platform. However, according to prior CSCW literature, in conventional healthcare organisations' electronic health record (EHR) systems largely focus on technical infrastructure with little attention to how the EHR system can support the human infrastructure via communication, coordination and collaboration (Pirnejad, Stoop and Berg, 2006; Reddy and Dourish, 2008). Whereas the Rohingya mHealth Project (Christensen and Ahsan, 2022) is a non-conventional healthcare system that depends a lot on medical assistants (paramedics) to screen patients. Additionally, the project included Rohingya community leaders, 'Majhi'[7] to build rapport with the Rohingya community so that they are willing to receive the service.

Having considered how human infrastructure is configured or created, I will move on to consider how it may be trained to improve its capacity.

3.3.2 Training of the human infrastructure

In this sub-section I am shifting to another perspective of human infrastructure which is 'training'. In international development projects, training is an important activity to develop and strengthen the skills and abilities of the human actors of development organisations to execute projects. For example, training health workers for primary healthcare (Austin-Evelyn, Rabkin, Macheka, Mutiti, Mwansa-Kambafwile, Dlamini and El-Sadr, 2017), training teachers to use multimedia tools in schools (Mtebe, Mbwilo and Kissaka, 2016), training agriculture extension workers on pest and disease management of crops (Konam, Namaliu, Daniel and Guest, 2008) etc. Various development organisations also plan and deliver training for community members and beneficiaries as a means of preparing them to react to development initiatives. For example, integrated pest management training for farmers, child nutrition and feeding training for new mothers (Duncanson, Burrows and Collins, 2014) and whole ranges of other different trainings to strengthen the capacity of the community members.

In their article, Sambasivan and Smyth (Sambasivan and Smyth, 2010) mention that human infrastructure could be leveraged to create and distribute expertise and literacies (Sambasivan and Smyth, 2010), especially in large scale deployment. They also suggest that training and capacity building could be a future opportunity in the ICT based services in the Global South. We may respond to their statement that in the development sector, NGOs and development partners strengthen the capacity of human actors by conducting various kinds of training. Today, we notice that the digital intervention projects in the Global South organise rigorous training for human actors on accessing mobile applications, SMS and voice messages. In many cases, training often takes place in a haphazard way and it depends on everything from luck to personal connections (Star and Ruhleder, 1996). The haphazard and inconsistent training of human actors may make a project unsuccessful. In the following section I am going to categorise and discuss the types of training of the human actors in the

[7] A Majhi represents Rohingya people who act as leaders in every block of the Rohingya camps. He is the person to go who can build communication and relationship with the Rohingya people inside the camp.

project we studied. It will serve as a reflection on the role of training in the digital intervention project in the Global South.

a) Self-help group (SHG) and farmer producer group (FPG) training

Here, I am going to present the types of training conducted in various projects for different human actors, such as self-help group (SHGs), farmer producer groups, intermediary training, virtual training etc. Self-help groups (SHGs) are a common form of community-based groups in many developing countries[8]. Governments, donors and non-profit organisations are increasingly delivering interventions through locally organized SHGs. One important characteristics of self-help group is the idea of mutual support – people helping each other (Khasnabis, Motsch, Achu, Al Jubah, Brodtkorb, Chervin, Coleridge, Davies, Deepak and Eklindh, 2010).

In the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019), along with their implementing NGOs, the donor cum primary implementing organization Welthungerhilfe developed the capacity of farmers from the Char[9] and Haor[10] regions to follow agriculture advisories. The project facilitated the creation of farmer self-help groups and trained its members to use digital agricultural advisory services. Each self-help group was represented by a 'lead farmer,' with a total of 500 lead farmers representing their particular villages. These groups often focused on sharing best practices and creating new knowledge and acting as a forum to enable members and stakeholders to come together to explore new possibilities, solve problems and create new, mutually beneficial opportunities (Anil, Tonts and Siddique, 2020). In 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019), all these 500 lead farmers were trained to share knowledge and act on agriculture SMS messages delivered from the project. The messages were customised and adapted to the lead farmer's group. The lead farmers retold the content of the SMS messages to other farmers of the self-help group in their meetings. Using 'word of mouth', the lead farmer trained other peer farmers to act on their agriculture practices. In contrast, the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) did not have self-help groups but it had farmer producer groups (FPG) based on crop types (i.e., maize groups and chili groups). The project organised farmers and gathered them into a group. The leader of the group was titled 'resource farmer' and those resource farmers were trained by the project on how to facilitate the discussion of the content of mobile voice messages in the group. As mentioned in the methods chapter, the paper based on the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) had both control group (no voice message on agriculture) and intervention group (voice message receiver). Only the intervention group farmers used to receive voice messages and it helped them to discuss the content in their group meeting and act on the content. In these trainings, hard copy printed materials were not used. The discussion and sharing of the voice message contents worked as

[8] The term 'Developing Country' is substantially problematized in ICT4D field (Khene and Masiero, 2022).

[9] Char is a tract of land surrounded by the waters of an ocean, sea, lake or stream. In the dynamics of erosion and accretion in the rivers of Bangladesh, the sand bars emerging as islands within the river channel (island chars) or as attached land to the riverbanks (attached chars).

[10] A marshy wetland ecosystem in the north-eastern part of Bangladesh which physically is a bowl or saucer shaped depression that looks like inland seas during the monsoon floods.

knowledge materials. However, the project missed an essential capacity-building activity, namely the distribution of market price information to farmers via voice messages.

b) Training intermediaries

'Agribuddy project' (Ahsan, Christensen and Kitaura, 2021) in Cambodia trains 'buddies' and they are the resource farmers from the community. In the previous section, I mentioned that the buddy works as a field-level intermediary who acts as a farmer connector to the players of the agriculture value chain, such as linking farmers to micro-finance organisations, input companies, crop processors etc. Buddy uses a digital application to connect these farmers to the network. Through the Agribuddy digital app forum, buddies also contribute to agriculture knowledge for farmers. Farmers who own smartphones can post their questions on crop cultivation, pest, disease, fertilizer applications etc. and a buddy can respond to their questions. If Agribuddy registered farmers cannot use or access the digital platform, then in person knowledge sharing is provided by the buddy. The Agribuddy services build the capacity of 'buddies' to become an intermediary and local resource in the community. Also, the 'buddy' strengthens Cambodian farmers' capacity to produce crops and sell their products through the Agribuddy network. If we investigate the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022), we have medical assistants on the ground as intermediaries as well. Various training was provided to these medical assistants to screen Rohingya beneficiaries to identify mental health issues by using a mHealth application. Prior to this, Friendship, the partner NGO, had taught these medical assistants to use mHealth apps for chronic disease screening and mother and child health screening during their house calls. The mental health domain and use of mHealth applications in screening were new and additional topics that the medical assistant had to learn. Therefore, the project organised fundamental and refresher training on mental health screening algorithms, how to ask questions during mental health screening, and how to use and send the screening data to a central server for the psychologist to view. These frontline medical assistants' capacities to screen mental health issues were developed by the project. In addition, project psychologists were trained to access screening data from their web dashboard and to diagnose the patient. By giving medical assistants and psychologists with specialised training, the Rohingya refugee camp got better equipped to offer mHealth-driven mental health services for the refugees. A review study on mHealth highlighted the importance of training frontline health workers (FHWs) to adopt mobile phones (Agarwal, Perry, Long and Labrique, 2015). Several studies showed that mHealth training is comprised of an introduction to the functions of a mobile phone, pictographic instructions on how to use a mobile phone, orientation to any additional software being used and addressing technical difficulties (Agarwal, Perry, Long and Labrique, 2015; Andreatta, Debpuur, Danquah and Perosky, 2011; Tomlinson, Solomon, Singh, Doherty, Chopra, Ijumba, Tsai and Jackson, 2009). These studies also show that CHWs often face challenges, including maintenance of skills and knowledge needed for the complexity of tasks performed in the field and inadequate access to training materials (Gopalakrishnan, Buback, Fernald, Walker, Diamond-Smith and in addition to The, 2020). The Rohingya mHealth project's (Christensen and Ahsan, 2022) initial training on mHealth based mental health also had challenges. The project management from the partner organisation included a software user trainer to train the medical assistant on how to access the mobile app. The project management did not notice that the software user trainer may not have the knowledge on mental health issues and public health issues. So, the software user trainer conducted training on accessibility of the app only. Although the medical assistants have a degree in primary care, they did not have training on mental health issues. The

partner organisation did not include a psychologist and public health expert as master trainers to train the medical assistants. Because of the lack of proper training on mental health issues, during their home screening they used to ask mental health question (SRQ-20) in a very straight forward way to the beneficiaries. But the SRQ-20 mental health screening questions needed to ask in a very conversational manner so that beneficiaries understand the question properly. The home screening experience and feedback forced the project management to create a multidisciplinary training team. The team consisted of application developers, psychologists, public health experts and project personnel. They also developed a training package consists of screening app (mHealth app) user manual, screening app (mHealth app) training manual, primary content on mental health issues, presentation slides etc. A study on community health workers' performance and potential shows that services drop if training is not provided on the new mHealth solution (Feroz, Jabeen and Saleem, 2020). They also identified that weak technical support from CHWs brings challenges to mHealth implementation. In the Rohingya mHealth project (Christensen and Ahsan, 2022), the technical support did not bring issues, but the training on the complexity of mental health issues was not there at the beginning.

c) Virtual training

The COVID-19 pandemic shows how much we depended on the human infrastructure for research and how we can leverage the capacities of research assistants to collect data. The COVID-19 study's (Ahsan and Christensen, 2022) semi-structured interview data collection was carried out by research assistants who resided in the local community. There were travel restrictions for the authors to collect semi-structured interview data. So, we selected research assistants who lived in the same community from where we intended to collect the data. We organised training sessions on the Zoom platform and trained on how to ask semi-structured interview questions, take permission to audio record the interviews, take photos of the environment, etc. Another research coordinator was appointed who coordinated the research assistants for the selection of the interviewees from the community. A study on Syrian refugee caregivers in Lebanon during COVID-19 lockdown included research assistants to collect survey data via WhatsApp and regular phone calls. They were also trained by the research coordinators on the Zoom platform and conducted live role plays on interview protocols, how to deal with potential problems of not reaching the caregivers, how to act on phone disruption etc (Miller, Arnous, Tossyeh, Chen, Bakolis, Koppenol-Gonzalez, Nahas and Jordans, 2020). In our COVID-19 paper, poor internet connectivity at the village level did not allow us to arrange an online video call with the participants. Or even calling them directly would lack richness of data as we did not have rapport with the community. So, the training was conducted mostly how research assistants can collect data from the ground during COVID-19 pandemic.

d) General training for staff

Training programs are often incorporated into the operation of agencies, institutions and for people who are responsible for implementing services (Stringer and Aragón, 2020, p. 282). Development organisations organize training for their staff as well. The 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) and 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) developed the technical skills of the project staff on different methods, such as conducting participatory rural

appraisal (PRA) technique (Chambers, 1994; Narayanasami, 2009), well-being analysis (Narayanasami, 2009, p. 205) , social and resource mapping process (Narayanasami, 2009, p. 41), agriculture value chain analysis (Hellin and Meijer, 2006), etc. The staff received training to implement the project's activities and to recruit farmers to join farmer producer groups. The project staff were trained over the course of several days on topics including matching potential farmer groups with pre-selected value chains (such as maize, chilli crops, etc.); agreement with farmers to form a group and determining its internal administration and governance structure; selecting lead farmers and resource farmers from the group in a participatory way; training and orienting lead farmers and resource farmers; and selecting women farmers and leaders as lead farmer roles. These trainings boost the project staff's ability to instruct farmers, hence enhancing farmers' skills, technology utilisation, and agricultural knowledge. Additionally, the NGO officers and field coordinators received training on agricultural information messaging. The primary objective of these two projects was to deliver SMS and agriculture voice messages respectively to farmers on crop practices, weather warnings, etc. The staff was trained on the contents of SMS and agriculture voice messages so that they could relay them to the farmers when necessary. These field officers are the farmers' point of contact in the event of a technical difficulty in receiving agricultural information through SMS text or agriculture voice message. In the event of a technical issue, the field officers notify their superiors and attempt to resolve the situation through them.

3.3.3 Usage of the human infrastructure in intervention

In this subsection, I will explore the 'usage' perspective of human infrastructure that Sambasivan and Smyth brought up (Sambasivan and Smyth, 2010). As part of deconstructing their human infrastructure 'process' lens, my discussion includes 'general usage', 'maintenance work,' 'diffusion' and 'contingency work' in a single 'human infrastructure' 'process' defined as 'usage'. My fieldwork revealed various aspects of 'usage' in digital intervention projects in the Global South, which enabled me to deconstruct their usage and add or merge other components.

a) General usage

For smallholder farmers in the northern area of Bangladesh, several human actors created a pre-recorded voice message service as part of the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018). The 'Mobile based Climate Smart Agro Information Service for Farmers Project' is an example of a consortium partner project that includes human actors, human resources and networks that enabled technology. According to my categorisation of the consortium members, the initiative was supported by the Christian Aid (NGO) organisation and its management. The manager and field officers of the local NGO partner GUK chose farmers to trial the agriculture voice message service. First, the mPower design team held interactive workshops with various stakeholders to generate ideas for the technology they would be developing. The application and voice messaging site were built by software engineers and bug testing resources. And last, the agriculturists worked on the content of the audio messages. The mPower project manager then began sending out voice messages after recording their contents. So, the internal network, work habits and relationships of these employees allowed for the timely delivery of agriculture voice messages to farmers. Farmers' access to and use of these technologies were facilitated by the coordinated efforts of a variety of human actors and enablers. The 'Climate and

Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) added some additional forms of human actors for implementing SMS services in the community. Unlike 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018), the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) also has donor managers, NGO staff, project managers, technology designers and developers to develop crafted agriculture SMS services for farmers. It was also an integrated *work* among the consortium partner organisations and human actors. 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid, and Das, 2019) sent SMS advisories on various crops, while 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan, and Akand, 2018) sent voice messages for two crops. To implement the service on the ground, the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) involved self-help group's lead farmers (with phones) to receive SMS and retell the content of the SMS to other self-help group farmers in farmer group meeting who do not own a phone. I am quoting one of the SMS messages from our paper on 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid, and Das, 2019) here –

> *A cold wave with heavy fog may occur in your area in the next 2-3 days. During that time, to protect your tomato plants from fungal attack spray fungicide (Dithene M-45) onto your plants. Use 20 mg in 10 liters of water for every 5 decimals of land.*

In the paper, we termed this self-help group discussion 'word of mouth' dissemination. So, the self-help group farmers were the enablers of the SMS as well. MOSES project (Smyth, Etherton and Best, 2010) in Liberia showed same types of learning (here, Kiosk as technology) about usage and existing human relationships played a large role for peer learning. In the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid, and Das, 2019) the 'human infrastructure' did some more ICT enabling activities to spread the agriculture SMS content to other non-project beneficiaries[11] (unregistered farmers of the project), such as creating posters on the SMS content by the lead farmers and NGO officers and placing them in the village's central spots. Public announcement systems within the mosque were still another means of spreading information. The mosques in rural Bangladesh are especially important because of the country's large Muslim population. The NGO field officers approached the Imam for permission to utilise the mosque's public address system to broadcast SMS messages. On the first day he said it was OK, but by the next day he said it wasn't. To them, only the preaching of God's message belongs in a mosque. We find a different view about Imam from a Bangladeshi research (Rifat, Toriq and Ahmed, 2020) that reveals that Imams are not limited to religious service. Their findings from urban areas show that Imams want to learn science, which is feasible thanks to the internet. But the local Imam described in our 'Are You Magicians?' paper (Christensen, Ahsan, Rashid and Das, 2019) believes mosques should only be used for Islamic preaching. He even said only 'Allah' could forecast (as many of the agriculture SMS messages were crafted based on the weather forecast). So, beliefs and religious sentiment in relation to technology use varied greatly if we compare our findings with Rifat et al. (Rifat, Toriq and Ahmed, 2020). Building rapport might sway the Imam's mind. On reflection, in our Are You Magicians paper (Christensen, Ahsan, Rashid and Das, 2019) we may have neglected to consider the Imam as a potential enabler (human infrastructure) during the design phase in relation to agriculture SMS

[11] Non-project beneficiaries means farmers who are not registered to receive SMS from the project but reside in the same community with the project beneficiaries.

dissemination and consequently failed to fully collaborate with him. To make a technology (agriculture extension messages) happen, relevant human infrastructure may need to be involved at the right moment.

The Agribuddy project (Ahsan, Christensen and Kitaura, 2021) in Cambodia had another dimension. The 'buddy', a farmer from the community, played the part of field-level intermediary as described above. And he was the hub that linked farmers, banks, agro-input manufacturers, crop processors, millers, wholesale buyers, etc. Our field study found that most farmers were illiterate and did not have access to smartphones. The 'buddies' with their smartphone applications facilitated registration to the Agribuddy service, helped them with credit applications and facilitated the selling and transporting of other produced crops after harvesting. The human infrastructure was centred around the buddy in that project. It should be mentioned that the farmers in Agribuddy were the beneficiaries of the technology service, but they were not the users of the technology. Like the Agribuddy project (Ahsan, Christensen and Kitaura, 2021), in the Rohingya mHealth project (Christensen and Ahsan, 2022), the Rohingya community was never the user of the technology, but they were the beneficiaries of the mental health service. Here, the human infrastructure centred around medical assistants who screened (using an android application) the Rohingya people on mental health during house calls. For further diagnosis and referral, the psychologist (counsellor) used the web dashboard. Compared to the projects in Bangladesh discussed above, the Rohingya mHealth project (Christensen and Ahsan, 2022) also had donors, implementing NGOs, technology developers and action researchers (I was part of the design of the service as a Co-PI along with the PI of the project from IT University of Copenhagen).

Some of the above digital intervention projects in the Global South denote that there were some end level technology users, content users (such as SMS and voice message content user). The human infrastructure of the digital intervention projects in the Global South may ensure the implementation of the technology. In some other projects mentioned above, such as in Rohingya mHealth (Christensen and Ahsan, 2022) and Agribuddy project (Ahsan, Christensen and Kitaura, 2021), the end mile beneficiaries are the service receivers. They are neither technology users nor content users. But they are service receivers such as micro-credit loan applications, mental health screening etc. The technology users are the intermediaries (for example, the buddy in the Agribuddy service, the medical assistant team and the psychologist (counsellors) in the Rohingya mHealth project). Their intermediation and other human actors or stakeholders in the project created services for the beneficiaries who are part of the human structures. So, in terms of *usage* for the end mile of the digital intervention projects, the projects have two different streams, 1. technology and content user, 2. technology-mediated service receiver. In a study from India, Tapan Parikh and Kaushik Ghosh termed the partial or non-physical access to computing devices users *secondary users* (Parikh and Kaushik, 2006). They mentioned that '*secondary users* must interact with information resources via a proxy primary user who has the required access rights and skills. The proxy's filtering and funnelling decisions limit the secondary users' information-seeking behaviour. They also added that the secondary user might also have an unequal power relationship with the proxy. Therefore, secondary users might never know the full scope of actions and knowledge available to them'. If we take this lens in our Rohingya mHealth project (Christensen and Ahsan, 2022), the beneficiaries are secondary users whom we may call technology-mediated service receivers. The proxy primary users (medical assistants) are the health service provider in a mHealth service inside the camp who refer and connect

the Rohingya beneficiaries for the psychologist's counselling sessions. The discussion of the power relationship between the medical assistants and beneficiaries do not comply here. The technology-mediated service receivers (Rohingya beneficiaries) do not have the literacy to screen their mental health condition. Only trained medical assistants or paramedics can screen people using the mental health algorithm. In the digital intervention project like the Rohingya mHealth project (Christensen and Ahsan, 2022), the beneficiaries are aware of the project screening activities on mental health. According to Parikh and Kaushik (Parikh and Kaushik, 2006), it is commonplace that the beneficiaries may not understand or care about a digital application process. During our fieldwork, one of the relatives of a mental health beneficiary was asked about her perception of her family member's screening. Her response was, "Doctor Apa (Doctor sister) opened the mobile, asked question and she wrote something. Then she sent my son to another doctor (counsellor). They do it for our benefit." The observation indicates that the medical service was important to them, but they do not always care whether anyone screens with digital applications or do it manually. In the Agribuddy project's (Ahsan, Christensen and Kitaura, 2021) intermediary case, the farmers are the secondary users as they must depend on 'buddy' for microfinance loan applications and other services related to their crops. There was a power relationship among the primary users (buddy) and secondary users (farmers).

b) Maintenance and repair work

Maintenance and repair are core practical problems in the ICTD and broader information science fields (Jackson, Pompe and Krieshok, 2011). In ICTD, a technology and tool's main use may be to help human actors deliver project work and intervention. Heidegger (Mingers, 2001; Riemer and Johnston, 2017) had an influential distinction on tools as 'present-at-hand' and 'ready-to-hand'. The ICT devices and software applications used in our different projects aimed to echo with Heidegger as a view to achieving and providing services to the beneficiaries. These are the equipment to be used and they are 'ready-to-hand'. These technologies and applications tend to break down (Star, 1999) and those need to be fixed by human actors in order to run smooth operations of projects. So, this maintenance and repair of the technologies may refer to Heidegger's 'present-at-hand' concept as the technology or tools immediately lose their usefulness. From different digital intervention projects' evaluations and assessment, it can be seen that long-term sustainability remains weak (Heeks and Molla, 2009; McNamera, 2003). And problems of sustainability occur because of repeated failures to account maintenance and repair as a central activity inside the project (Jackson, Pompe and Krieshok, 2011).

i) Hardware maintenance work

ICT tools and logistics are essential in humanitarian projects, mainly when frontline project staff and intermediaries use mobile devices and applications for screening. The tab and smartphones used in our projects needed troubleshooting and maintenance. These projects are designed so that the technical human resources within the project do the troubleshooting and maintenance of the devices used by the frontline staff. In the Rohingya mHealth project (Christensen and Ahsan, 2022), the medical assistants used Huawei 7 inch tablets for household screening. Like many other digital intervention projects, they experienced hardware issues. There were some cases when their phone display cracked, camera stopped working due to hardware issues, phone battery became damaged etc. In any hardware issues, the medical assistants needed to report and hand over the device to the project coordinator. For smooth screening operations, the project coordinator used to replace non-

functional tab (relates to present-in-hand as per Heidegger) with surplus tabs from the store. The project's NGO partner had centralised human resources (technical staff) at the head office in Dhaka to deal with hardware issues. Dhaka is around 400 km away from the project location Cox's Bazar and it would take three to four weeks to fix technical issues with a tab. In case of any hardware replacement of the tabs, the head office hires enlisted professionals from vendor companies. An ICTD study on repair and maintenance work from Namibia suggested that repair must be centralised to a single location where quality control can be ensure by technology professionals (Jackson, Pompe and Krieshok, 2011). They compared two empirical project cases of maintenance and repair work. One case used a centralised system for their technology repair work and another one had volunteer driven maintenance. They suggested to have the previous (centralised) for an ICTD study based on a project. We got a completely different observation from the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) and 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018). The lead farmer, resource farmer and general farmers who had 'mobile feature phone', used to repair their phone in the village market or at the city market in case of emergencies. Their phones were not provided from the project, and they were the owners of the phone. Both the projects did not invest or build the capacity of a local technician although agriculture SMS and voice messages were the main service in these two digital intervention projects in the Global South. The projects did not even form any partnership with local shops. The maintenance and repair work should be key concern, otherwise development actors may fail to address their objectives (Jackson, Pompe and Krieshok, 2011). In a CSCW article based on their Namibian ICTD study, Jackson et al. mentions that the first and most obvious of the concerns is the need for better bridges between development initiative and repair work and workers (they called them repair worlds) of the regions in which these projects are situated (Jackson, Pompe and Krieshok, 2012). Otherwise, it will be an uneven development.

ii) Software maintenance work

In the Rohingya mHealth project (Christensen and Ahsan, 2022), the partner organisation's technology department was authorised to handle mobile and web application's malfunction issues. In case of any update of the application or error issues of the application, the medical assistants inform the project coordinator, and the project coordinator channels the issue to the software team in Dhaka. The team there fixes the errors and bugs and updates the applications. Once the repair is done, the medical assistants can download and update the application from the server using their username and password. They can start their screening operation then. From their ethnographic study in Rural Namibia, Jackson and his colleagues (Jackson, Pompe and Krieshok, 2012) shared a prescribed lesson that in ICT based development projects, software platform choices should bear medium-to-long term maintenance and repair realities in mind. But they doubt that projects do. The 'Rohingya mHealth Project' (Christensen and Ahsan, 2022) had those realities in mind and recruited software maintenance people for that. We find an alternative maintenance work in the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) and 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018). A web application was built by a technology team working on two separate projects. The team was tasked with configuring the dates of SMS and agriculture voice messages in order to ensure that they are automatically delivered. The projects' technical team used to monitor the SMS and voice panel whether the system was working or not. So, beneficiaries or the NGO field officers did not need to

report regularly on the malfunction of the SMS and voice messages as the technical team would monitor that.

iii) General infrastructural maintenance and repair

Sambasivan and Smyth (Sambasivan and Smyth, 2010) also mentioned that technological environments in low-income communities are often prone to disruptions such as irregular electricity (Sambasivan and Smyth, 2010). In the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) study area, Gaibandha char region does not have electric distribution power lines and power supply infrastructure. It brings the challenge for mobile phone charge. Few affluent families use solar energy and install the solar home system for the basic consumption of electricity. The off-grid non-affluent people who own mobile phones, charge their phones in the village market situated in mainland area. Some village shopkeepers discovered that they could earn money by renting out phone charging services for those who do not have solar home system. Human infrastructure evolved to solve the charging problem. One single time full battery charge can run for three to four days. In her ethnographic study in Nairobi, Wyche (Wyche, 2015) showed a similar approach where barbershops made extra income by offering to charge handset batteries. Interestingly, despite the danger for theft, many still continued to leave their phones. Theft-related questions were included in our fieldwork for the "Mobile based Climate Smart Agro Information Service for Farmers Project" (Christensen, Ahsan and Akand, 2018). The respondents, however, did not worry about leaving their phones with the shopkeepers at the village market. Due to the shopkeeper's familiarity with the locals, they used to feel comfortable. And, in reality, they did not face any missing cases. We saw a similar phone charging issue with the 'Climate and Agriculture Information Service (CAIS) Project' Christensen, Ahsan, Rashid and Das (2019) beneficiaries as they were from the char area (river island). Examining these agriculture projects through the notion of 'maintenance' would capture all the work it takes to keep everything running (Ellacott, 2017). Otherwise, the work on mobile charging points would remain hidden in the background (Star and Strauss, 1999).

c) Diffusion

ICT diffusion and utilization can transform developing countries in ways that improve their competitive advantage (Udo, Bagchi and Kirs, 2008). Rogers (Rogers, Singhal and Quinlan, 2014) defined diffusion as the process by which an innovation moves within a social system over time. He considered the innovation's perceived costs and benefits, its testability, a person's familiarity with it, its difficulty of use and its compatibility with pre-existing social, economic and environmental systems. (Elia, Mutula and Stilwell, 2014; Rogers, Singhal and Quinlan, 2014). The 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) and 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) attempted to benefit farmers by providing agriculture information through voice messages and SMS messages. Not all farmers in the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) had mobile phones and did not receive messages, but the lead farmers had mobile phones. These lead farmers shared the received SMS texts with other farmers in their self-help groups. So, SMS contents were conveyed to other farmers in the self-help group. After the end of the project, it was unclear whether they embraced SMS text and utilised the knowledge in their farming

practices. Handwritten posters and public announcement systems were employed to spread SMS messages, as stated in the 'usage' section. These mediums of delivering messages through human infrastructure (e.g., NGO field officers, lead farmers, resource farmers[12], etc.) indicate that non-beneficiary project farmers had broader reach, but we could not determine if they all adopted SMS contents and the ICT systems. The project did not track random viewers of agriculture SMS information through posters and PA system. But the project aimed to disseminate its content in village areas. Non-project beneficiary farmers may not apply agriculture knowledge in the field since they were not part of the project's capacity building initiatives (Peansupap and Walker, 2004). Non-beneficiary farmers were not trained on how to share SMS messages, how to use them for key farming practices and how to monitor their own agriculture field and compare it to others to measure yield increase. Besides, trust in agriculture information may be vital for farmers. Non-beneficiary farmers who weren't trained in capacity building may not use SMS technology because of the lack of trust on the information as they were not part of the project. A study shows that usually the peer farmers have been demonstrated to be a scalable, accessible, trusted and locally relevant source of knowledge (Mamykina, Manoim, Mittal, Hripcsak and Hartmann, 2011) for other farmers. A voice-based agriculture information service from India's post-study shows that information sources matter to farmers. They significantly follow if peer farmers share the information compared to other authorities (Patel, Shah, Savani, Klemmer, Dave and Parikh, 2012). So, in the 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) the diffusion process ensured the reach of agricultural information to farmer communities in the village areas, but it was not clear whether the non-beneficiary farmers used the information or not. Diffusion took place in a different fashion within the context of the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022). The performance of the medical assistants improved once they received training on the job. Furthermore, they spread information regarding the screening to the Rohingya beneficiaries and screened a greater number of persons within the camp.

d) Contingency work

The 'human infrastructure' supported contingency work in our different projects by restructuring project activities in crisis and risk situations. A contingency plan can be considered a backup plan for when things don't go according to the main plan or project work. So, contingency planning involves defining action steps to be taken if an identical risk event should occur (PMI, 1996). International development projects and digital intervention projects in the Global South may also respond to risk and crises by taking significant steps. It is a process that anticipates potential crises and then develops strategies, arrangements and procedures to address humanitarian needs (Richard, 2007). The contingency planners work to prepare the organisation to be better able to mitigate any disruption to normal business activities, such as natural occurrences (e.g., hurricane, fire, or earthquake) (Fischer, Halibozek and Walters, 2019). As mentioned before, in 'Rohingya mHealth Project' (Christensen and Ahsan, 2022), medical assistants use a mobile app to screen mental health condition of the Rohingya beneficiaries. Beneficiary is referred to mental health counsellor if the screening score crosses a threshold value. During referral beneficiary handling, the counsellors are required to check the mental health screening score and data of the particular beneficiary from their web dashboards. Internet

[12] In humanitarian development projects that deal issues with agriculture, sometime denote the farmer group leader as resource farmer.

connectivity is required to use mobile application (from medical assistant) and for checking the dashboard (for counsellors). When the project started mHealth implementation back in September 2019, due to security concern, the Bangladesh government instructed mobile operators to shut down 3G and 4G networks in the Rohingya camp areas in Cox's Bazar (PTI, 2019). 3G and 4G networks were the only option to access the internet. So, the mental health based mHealth service experienced an infrastructural breakdown (Star, 1999) as neither medical assistants or counsellors could access the applications. The project human resources (the frontline field staff, medical assistants, counsellors etc) had to adjust with contingency work plan. The medical assistants started to use 'offline' mode during screening and saved the data in mobile memory card. Once they were within a close proximity of Wi-Fi network, they used to send those saved screening data to the database of central server. As the mental health counsellor needs to check screening score and data during counselling sessions, hard copies of the data were provided to them. Hard copy printing became contingency work for the field coordinator of the NGO, Friendship. The project had to come up with this hybrid work process due to internet shutdown. A qualitative study from Bangladesh (Morshed, Dye, Ahmed and Kumar, 2017) on a state-imposed internet ban on social networking cites (applications like Facebook, messenger, WhatsApp etc.) analysed a forced non-use pattern and highlighted that some groups of people look for adjustment and workarounds to access internet. Some groups of people started using an IMO application as a substitute to messenger. People who were doing Facebook based online business, moved their page to another website. So, people made contingency plans there to deal with the problem. For future studies, the authors suggested that technical means and human factors like sympathy, responsibility and collaboration are needed to ensure a seamless internet service in the face of bans. In response to their future suggestions, we may say that the digital services of the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022) had human factors which drove responsibilities to provide mental health service. To run the service, they collaborated to come up with printed screening documents and hybrid service idea at the time of internet ban. As mentioned, the medical assistants used offline mode for data collection. We find a study from Cuba on how human infrastructure collaborated with 'offline' information network. Cuba's El Paquete Semanal project (Dye, Nemer, Mangiameli, Bruckman and Kumar, 2018) showed how offline information networks through human infrastructure helped distribute digital content among Cuba's citizens. In a highly restricted internet access environment, three groups of individuals used to collect digital content (music, movies, TV content etc.) on hard drives, USBs and CDs and distribute it among Cuba's citizens weekly so that they can consume information and entertainment. This is another type of contingency when technical and democratic infrastructure fall apart.

3.3.4 Unravelling the human infrastructure (ending it)

Most international aid projects in the Global South are financed by multilateral development agencies (World Bank, United Nations, European Union, etc.) or by the bilateral system (USAID, French Cooperation, DFID, CIDA, etc.) (Diallo and Thuillier, 2004). These projects are generally delimited in time, lasting anywhere from six months to five years or more. This typically means the projects end when the financing ends. Earlier in this chapter, it was mentioned that the digital intervention projects in the Global South with aid money configures its human resources. So, at the end of the aid, we may say that because of the nature of time-specific digital intervention projects, the employment contract with human resources ends. Eventually, that was the end of human infrastructure in those projects. For example, the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022) had the Novo Nordisk

Foundation (NNF) fund to design and implementation of the mHealth service for one year. The medical assistants were key for the doorstep screening of beneficiaries. Along with medical assistants, the job contract of the project coordinator, psychologists (counsellors) and project officers ended, and the budget constraints was the reason for not scaling. Later, one year extension (second round) and budget from the aid agency helped the project to retain the staff to provide the mental healthcare service. The second round of the project ended in 2021. The project staff changed their jobs and moved to other projects and institutions. The mHealth-driven mental health service had to be stopped as the local partner was not successful in receiving funding from other aid or donor sources. The mobile application, data, server and technology are still there. But those became non-functional because of the absence of human infrastructure. Similarly, in the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) and 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019), the job contract of all the project officials, including the frontline staff and project coordinators, ended after the end of the project. In these two projects, the voice and SMS service stopped because of the end of the contract of this staff. Services of these two projects did not scale as the self-help group farmers, lead farmers and farmer producer group leaders or the communities were not enough to run the voice and SMS technology by themselves. The capacity of the local human infrastructure was not based on the technology development and execution in the absence of the other human infrastructure. Even the local community were not willing to register and purchase the service from the technology company. My field observation shows that farmers tend to expect to get an agriculture extension message for free, even if it comes through any digital channel. However, a study (Dodson, Sterling and Bennett, 2012) reviewed different ICT based development projects based on three salient factors: 1. development objective (Is there any development goal?), 2. development perspective (Were the projects top-down or bottom-up), 3. development focus (Were the projects community-centric?). They concluded that those ICT based development project contributed to unsatisfactory development results. If we take those three salient factors, we may say that our projects were designed based on a top-down approach where donors would come with funding. Implementing NGOs and organisations recruited human resources to execute the project on the ground, but the sustainability and scale were not thought out properly. That is why the project had to pack up after a certain period when there was a lack of funding. Digital green project can be termed a successful case of scale as they developed agriculture extension based on a participatory process for content generation and created a locally generated digital video database (Toyama, Gandhi, Veeraraghavan and Ramprasad, 2009) and the community did not need to depend on others to create the contents.

Both the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018) and 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019) did not generate sufficient funds to maintain operations and keep their respective human infrastructure employed. Almost no farmers were willing to pay for agricultural information since they already receive so little free advice from government-hired agriculture extension officers and so little free advice from the input retailer from whom they purchase their fertiliser, pesticides, seeds, etc. So, they were not habituated to pay for information. Neither initiative, though, provided a clear plan for managing the technology and fresh agricultural content. The financially sustainable approach was missing, unfortunately. In order to continue their work, development organisations usually seek fresh funding for ongoing initiatives. These two projects, however, did not get the extension they needed. Furthermore, no commercially viable agriculture

company was included to absorb the technology and operate things themselves. So, their human infrastructure was unravelled because of the lack of sustainable business case. But there are exceptions in agriculture projects like this who tried to make the service sustainable. A precision agricultural service called GeoPotato (Pronk, Ahsan, Rahman, Kessel and Hengsdijk, 2017) was implemented in Bangladesh (a three-year initiative beginning in 2016) in collaboration with one of the world's leading fungicide manufacturers, Bayer Crop Science. mPower, a tech startup, works with Bayer Crop Science to register farmers using an ICT-enabled registration system and to guarantee that precision farm advisories are delivered by SMS and include references to Bayer fungicide. Bayer is investing over $41,000 (USD) in the 2021-2022 season[13] so that they may send out 50,000 GeoPotato alerts to farmers (This latest data is collected by interviewing field manager of mPower). So, GeoPotato project could retain the 'human infrastructure' to some extent.

However, the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022) was unable to keep its human infrastructure in place because of financial limitations. Nonetheless, the implementing NGOs kept some employees and redistributed them to other mHealth initiatives within the camp, ensuring that some of the Rohingya refugees receive mental health screenings through those medical assistants. We may argue that preserving human infrastructure depends on receiving sufficient financing from donors in such settings.

The 'Agribuddy Project' (Ahsan, Christensen and Kitaura, 2021) is kind of different from the 'Mobile based Climate Smart Agro Information Service for Farmers Project' (Christensen, Ahsan and Akand, 2018), 'Climate and Agriculture Information Service (CAIS) Project' (Christensen, Ahsan, Rashid and Das, 2019), and the 'Rohingya mHealth Project' (Christensen and Ahsan, 2022). The agriculture service was built on the concept of a commercial value chain, and human resources such as 'buddies' were employed there until they left for other opportunities or retired. Instead of relying on the funding from donors, the initiative is supported by fees paid by farmers to Agribuddy for their services. However, we may say, human infrastructure in commercial enterprises running ICT based services among farmers may unravel if anyone leaves the job or migrates.

[13] Potato crop season is around 3 to 4 months.

CHAPTER 4: RESEARCH FINDINGS AND CONTRIBUTIONS

In this chapter, I will situate the findings of each publication within the overall contributions of my thesis. This chapter therefore also expands on the contributions discussed earlier in chapter 3. The five publications in this thesis present different aspects of human infrastructure, or can be read as doing so, while relating them to their role in digital interventions in the Global South. The publications are arranged in order of the empirical fieldwork conducted and the data analysed for the purposes of the thesis. As a result, my publications reflect my focus as it has evolved as part of my research activities over the years. Here, I attempt to connect them explicitly to the theme of 'human infrastructure' as the overarching theme of the thesis. Table 3, below, contains an overview of the publications, their research aims and their perspectives on human infrastructure.

Publication	Research aim	Perspective on human infrastructure
Krishi Kontho: An Agricultural Information Service in Bangladesh.	How can an agricultural information service be developed to support the temporalities, rhythms of agricultural practices, in rural Bangladesh and beyond?	From an infrastructure perspective, the paper shows how an agricultural information service may be synchronised to agricultural practices that rely on a human infrastructure in the Global South.
Are You Magicians? The Collaborative Work of an Agricultural Information Service.	How is an agricultural information service worked into a rural community?	Details how the workings of an agricultural information service in Bangladesh are made possible through integration work that relies on a human infrastructure.
Agribuddy: Infrastructuring for Smallholder Farming in Cambodia.	How may infrastructuring for value chain, for microcredit, and for capacity building contribute to smallholder farming in the Global South?	On the establishment of a (human) infrastructure in Cambodia to connect smallholder farmers to a wider market.
The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic.	How was everyday life during the Covid-19 pandemic in Bangladesh reordered through commonplace digital technologies and services?	Focuses on how human networks and human infrastructure are arranged to generate data during a crisis.
Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh.	How may the assessment of the mental health of refugees be a matter of both numeration via a screening tool and attunement to moods?	Shows the prominence of the human element in a digital health service – the human infrastructure is very much part of the screening process. Inseparably so, as numeration and attunement to moods intersect in the datafication of mental health.

Table 3 List of publications, research aim and perspective of human infrastructure

4.1 Krishi Kontho: an agricultural information service in Bangladesh

This first paper was published in the proceedings of the 10th Nordic Conference on Human-Computer Interaction (HCI) – NordiCHI'18 in October 2018. The paper is co-authored by Associate Professor Lars

Rune Christensen from IT University of Copenhagen and Eshrat Akand from Christian Aid, Bangladesh. (Christensen, Ahsan and Akand, 2018)

This paper delivers an example of an agriculture information service in rural Bangladesh where 30 pre-recorded voice and text messages are pushed to the mobile phones of smallholder farmers (chilli and maize farmers) at intervals choreographed with the life cycles (soil preparation, seeding, fertilisation, irrigation, pest, and disease control, harvesting, drying etc.) of their crops and cultivation practises. During an eleven-month field trial of the 'Mobile-based Climate Smart Agro Information Service for Farmers Project,' the authors of this research conducted field visits and discovered that the service has the potential to increase crop yields by 12 percent while decreasing production costs by 6 percent due to reduced fertiliser and pesticide use (accepting the limitation of small field trial with two crops to reach to a conclusion). Moreover, the farmers found the service helpful and were able to supplement their own agricultural expertise with the advice provided by the agriculture voice message service. The service overcame the barrier of low literacy by offering agriculture advisories through voice messages rather than, say, text. This research included a variety of methods. The research method included a combination of a quasi-experimental trial, qualitative data gathering and participant observation.

This paper draws on human-computer interaction (HCI) literature which served as both an inspiration and a source of ideas. HCI concepts such as rhythms (Begole, Tang, Smith and Yankelovich, 2002; Jackson, Ribes, Buyuktur and Bowker, 2011) were used to describe temporal orders, 'in due time' (Møller and Bjørn, 2016) was used to describe an activity's completion and 'temporal coordination' (Bardram, 2000) to understand cooperative work for designing a tool. If we look at this through the lens of 'human infrastructure,' the paper would conclude that the coordination and cooperative efforts of human infrastructure manifested in the synchronisation of an agricultural information services to farm practises. For example, the NGO management coordinated with technology designers and developers to develop the agriculture information service. Then NGO field officers coordinated with farmers to form a group of farmers (25-30 members in each group) based on selected crops to run the agriculture information service. So, the paper also describes various coordinated and collaborative activities on the back of a synchronised agriculture information system with farmers, and it added to the literature on 'infrastructure,' more specifically 'human infrastructure in ICTD,' as discussed by Star and Ruhleder (Star and Ruhleder, 1996), and Sambasivan & Smyth (Sambasivan and Smyth, 2010). First, I show that in order to implement the agriculture information service in a collaborative manner, the partners of the project needed to 'configure' human actors by recruiting a pool of 'human actors' including technology designers and developers, agriculture content developers, content validators, software developers and NGO staff. Second, the NGO staff selected and registered farmers for the field experiment after they had received multiple rounds of participatory 'training' within the project. Farmers for example received training on how to respond to voice messages they receive at various stages of the crop cycles. Thirdly, after breaking Sambasivan and Smyth's (Sambasivan and Smyth, 2010) process of 'usage' from their framework, the discussion of the thesis adds that in this paper human infrastructure, such as farmers, technology staff, management staff, and NGO field officer use agriculture voice message service in different ways. Apart from general use of the voice message in their phones, farmers also relied on those cheap mobile phones for other purposes, such as communication to relatives, friends and peers etc. So, when the phone is broken and needs technical 'maintenance', they take them to a mobile repair shop in the

closest village or city on the mainland where skilled workers get them up and running again. Farmers also rely on the village tea stalls run by independent businessmen to keep their phones charged and the thesis adds that this is also part of the maintenance of their phones. In addition to sending the agriculture-related information, the technical team and IT professionals are responsible for maintaining and repairing server difficulties. Finally, the thesis adds that the human infrastructure 'unravel[s]' when the project's money runs out and the hired workers lose their jobs and look for new ones. In this manner, then, the configuration, training, usage and unravelling of human infrastructure had a significant part to play for the duration of the project that is described in the paper.

4.2 Are you Magicians? The Collaborative Work of an Agricultural Information Service

This second paper was published in the proceedings of the Tenth Conference on Information Communication Technology for Development (ICTD) ICTD'19 in January 2019. Associate Professor Lars Rune Christensen co-authored the paper from IT University of Copenhagen, with Mamunur Rashid from Welthungerhilfe, Bangladesh, and Badal Kumar Das from mPower, Bangladesh. (Christensen, Ahsan, Rashid and Das, 2019).

This paper investigates the integration of an agricultural information service called 'Climate and Agriculture Information Service (CAIS)' into a rural community in Bangladesh. As this research is on the process of integrating the service into a larger socio-technical ecosystem, it becomes clear that 'human infrastructure' is what made the integration work possible. The service assisted smallholder farmers by collecting weather forecasts from the public domain for specific village locations, associating agricultural advice with the weather forecasts and sending text messages to the farmers with the weather forecasts and agricultural advice. Typically, government agricultural extension agents (also known as SAAO) are expected to visit farmers to give agriculture advice. However, SAAOs are scarce and have limited resources to visit smallholder farmers in rural areas due to a lack of road communication and transportation. Consequently, smallholder farmers in these remote rural regions (riverine islands) lack access to such agricultural information and advice.

The analysis was made possible through an investigation in a rural area of Bangladesh. The results of the article indicate that the service's success in the region hinged on the concerted efforts of human actors beyond its original design and brief introduction. That is, the 'human infrastructure' in the project played a significant role. Firstly, human actors from NGOs and technology company were recruited for this particular digital intervention project. They were responsible for designing and implementing the technological service, as well as creating and validating the SMS contents. Human actors from NGOs and technology company developed and executed the technological service, and they also created and validated the SMS contents. The NGOs' field staff rounded up enough farmers to form 500 self-help groups of 25-30 members each. One of the farmers volunteered as lead farmer to take the reins as group coordinator. The paper lists several human elements and activities required to maintain local service delivery. As a new addition to the 'human infrastructure' literature, it can be argued that digital intervention projects in the Global South may actively recruit and configure human infrastructures. Second, the article demonstrates the motivation of both lead farmers and other farmers to spread the news via word of mouth in order to take action based on the SMS messages. To better organise farmers into self-help groups, NGO field staff received (PRA) training on how to recruit and integrate farmers into groups. The NGO staff trained the lead farmer, and the lead farmer then

relayed the information from the SMS to the other farmers at the self-help group meeting so that the other farmers may use the information. Consequently, the study explains how human actors are developed through training, capacity-building and the exchange of information. Third, the study indicates that many different human actors, such as farmers in self-help groups, lead farmers, NGO staff, technology staff and the Imam, are connected to the 'use' of the agriculture information system in some way, either as end users, as those responsible for its 'maintenance' or 'repair,' or as someone who helped spread (diffusion) the message on agriculture advice. The result of the fieldwork indicates that the lead farmers need to visit a repair workshop for hardware maintenance of the mobile phones, while the technology team gets involved when necessary for SMS application maintenance and server difficulties. To reach farmers who weren't involved in the project directly, NGO field staff and lead farmers made posters with the SMS content and put them in a centralized spot in the village. When it came to disseminating the SMS message, however, NGO workers tried to include the community's most influential figure—the mosque's imam—by broadcasting it over the mosque's public announcement system. The thesis was subsequently extended into the literature on human infrastructure where it brought the findings of this paper and have shown that human infrastructure aided to implement an integrated agriculture SMS advisories into a rural community. Human infrastructure is the lens through which this thesis examines the roles of various human players in the use of agriculture information, the maintenance of a technological device, and the repair of SMS apps, as well as the function of human actors in the dissemination of the information. In conclusion, I argue that the human infrastructure of the digital intervention project in the Global South 'unravel[s]' when the project's funding runs out and the employees lose their jobs and seek new ones. We see a similar perspective from the article on Krishi Kontho (Christensen, Ahsan, and Akand, 2018). Employees of the consortium members and farmers may be employed temporarily for the length of the digital intervention project in the Global South.

4.3 Agribuddy: Infrastructuring for Smallholder Farming in Cambodia

The third paper is a peer-reviewed conference paper, published in the proceedings of the 10th International Conference on Communities and Technologies (C&T' 21) held in June 2021, Seattle, U.S. The paper was invited for presentation (virtually). Associate Professor Lars Rune Christensen from ITU and Kengo Kitaura from Agribuddy co-authored the paper (Ahsan, Christensen and Kitaura, 2021).

The paper is based on research conducted primarily with farmers and stakeholders of the Agribuddy enterprise in the Siem Reap province in Cambodia. The paper aims to analyse Agribuddy's ICT-driven agricultural initiative to integrate and create rural infrastructure in Cambodia. The paper was inspired by infrastructural studies and employed Karasti and Blomberg's (Karasti and Blomberg, 2018) five dimensions of information infrastructure: 1) relational, 2) invisible, 3) connected to, 4) emerging and accreting to, 5) intervention and intentionality. These five dimensions are synthesised based on Star and Ruhleder's (Star and Ruhleder, 1996) eight dimensions of (information) infrastructure that include (1) embeddedness, (2) transparency, (3) reach and scope, (4) learned as part of membership, (5) links with conventions of practice, (6) embodiment of standards, (7) build on an installed base, (8) and visible during breakdown. The paper was also inspired by a ninth one added by Bowker and Star (infrastructural inversion) (Bowker and Star, 1999). Through an infrastructural inquiry in Agribuddy initiative, the paper used these dimensions from infrastructural studies in an analysis that portrayed the Agribuddy in this way: 1) infrastructuring for a value chain that is crucial to move quasi-sustenance

farmers' product into commercial agriculture through an integrated value chain. Agribuddy service and its human intermediary 'buddy' seeks to integrate key stakeholders such as farmers, banks, input manufacturers, crop processors and wholesale buyers to link farmers to viable commercial agriculture. The papers also viewed the Agribuddy service as 2) infrastructuring micro-credit as it facilitates lending in collaboration with commercial financial institutions. Here the 'buddy,' in coordination with supervisor process loan application and handle loan amount so that farmer does not use the loan amount for other purposes. The loan repayment is controlled by Agribuddy by channelling revenue from crop sales to the lender. The paper also viewed Agribuddy service as 3) infrastructuring for capacity building since moving from sustenance farming to small scale commercial farming may require building capacity in the farming communities. The Agribuddy app has a digital forum where farmers and buddies may ask questions and post responses about various agricultural topics such as pests, diseases and fertilisers etc. As a result, both parties' knowledge of farming and their ability to practise it are enhanced. In parallel to digital platform, the 'buddy' may share knowledge face-to-face with the farmers since the buddy often belong to some of the same communities.

The papers also used the lens of 'installed base' (Star and Ruhleder, 1996) and denoted that the Agribuddy initiative is built on existing actors from various stakeholders and *connected* them in different ways such as introduction of the 'buddy', microfinance scheme and capacity building of farmers. While bringing the *connected*, the paper also talked about the *relational* character of the service such as scaling to other areas and regions, and multiplying the connections by adding more farmers, recruiting more buddies, lending more money, harvest more crops etc. According to the article, Agribuddy's scaling depends on commercial success with an economy of reputation in the market, therefore the emerging dimension may be marked by uncertainty, ups and downs and occasional disconnects. In terms of intentionality and intervention, the paper shows that the Agribuddy enterprise may harbour clear intentions, not of exploitation, but of commercialisation of smallholder agriculture in a socially responsible way in the context of a market economy. The paper's field findings also identified 'control' over the partners, such as farmers, buddies, banks, input suppliers etc. but the authors argue that Agribuddy needs to do some policing (which is relative to control) of the partners in order to scale the service.

By putting the human infrastructure in ICTD lens in use here it may first be said that in Agribuddy the intermediation process through the 'buddy' is configured which may be said that human infrastructure is created here. Farmers do not use the Agribuddy mobile app by themselves. Initially a network of buddies, a human infrastructure, is created by the Agribuddy company to connect all the value chain stakeholders through the ICT system. Secondly, to run the service of Agribuddy, the human infrastructure, the buddies were trained to use the app and Agribuddy also developed their agriculture extension knowledge as a local resource within the village community. These buddies strengthen Cambodian farmers' capacity to produce crops and sell their products through the Agribuddy network. Thirdly, if I consider 'human infrastructure in an ICTD' lens here, there are different types of users ('usage') of the same digital service. Buddy as intermediary is the technology and content users. On the other hand, farmers are the end user of the Agribuddy digital service. The farmers seek information through buddies and buddies as intermediary ensures loan and other value chain service using the Agribuddy app. Lastly, the 'unravel' part of 'human infrastructure in ICTD' within Agribuddy is not similar to donor driven services as it is a commercial service and continues. If the main human infrastructure 'buddy' migrates or leaves Agribuddy, then the 'unravel' lens can be applied.

4.4 The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic

This fourth paper was published at the 12th International Conference on Information & Communication Technologies and Development (ICTD 2022) at the University of Washington, Seattle, U.S. on June 27-29, 2022. The paper is co-authored with Associate Professor Lars Rune Christensen (Ahsan and Christensen, 2022)

Twenty-two semi-structured interviews and supplementary photographs and videos were collected as empirical material for the study, which took place across several locations in Bangladesh during the COVID-19 pandemic. Since the authors were unable to visit Bangladesh because of the COVID-19 lockdown, the bulk of the interviews (twenty interviews) were performed by research assistants whom the authors recruited and trained on an interview protocol. The research assistants were an essential part of the 'human infrastructure' the researchers depended on to collect field data for this study. Participants were chosen depending on their accessibility to the research assistant. Research assistants were able to conduct in-depth interviews with people from various walks of life, from university professor in the city to a rikshaw puller or a small businessman in the countryside.

To analyse the reordering of everyday life in the Global South during the pandemic, the paper employed the concepts of 'life world' (Husserl, 1970), 'being in the world' (Heidegger, Macquarrie and Robinson, 1962), 'natural attitude' (Schutz, 1976), and the idea that repetition may defer trauma and shock (Dorfman, 2014). The study examines how commonplace digital technology rearranged daily life in Bangladesh in the early stages of the Covid-19 pandemic. The paper criticizes the idea of 'digital resilience' and 'e-resilience' (Heeks and Ospina, 2019) and prefers to talk of 'reordering' instead. The findings of the paper suggest that people in the Global South partly could reorder their lives through digital technologies, for example a university professor was able to build an improved daily routine with online teaching and a nice home life during pandemic. Whereas a Rikshaw puller received loans using digital payment system during his hard time to earn his bread and butter. Also, digital money was used a great deal to pay for goods from a distance for many. It was also seen that rumours and information concerning COVID-19 and others spread rapidly through social media. The paper, then, focuses in part on how digital technologies allows for the rearrangement of human networks and infrastructure during a crisis.

Putting the 'human infrastructure in ICTD' lens in the paper, the thesis has mainly emphasized those human infrastructures (research assistants) and networks (organisations) necessary to conduct the interviews in the field. First, the thesis shows how the capacity of the local human infrastructure (research assistant) may be strengthened virtually by training them during a pandemic or crisis situation in the Global South when it is difficult to travel and gather data. The COVID-19 paper demonstrates how the researchers used a virtual platform to 'train' the research assistant interview techniques. The researchers relied on their old connections in the local community in Bangladesh to help them find suitable research assistants to train and conduct interviews for their research. Second, the thesis also finds that the data collection work conducted by the research assistants as 'contingency work', that is one of the major points discussed in Chapter 3. Usually, researchers aimed to conduct interviews by themselves, but in this COVID-19 paper, the researchers had to make a contingency plan to collect data. The contingency plan guided them to taught human infrastructure (research assistants)

on how to 'use' interview protocol and relevant devices (i.e., recorder, camera, etc.) to gather qualitative data for the researchers.

4.5 Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh

This fifth paper was published in Journal of Medical Anthropology: Cross-Cultural Studies in Health and Illness. The paper is co-authored with Associate Professor Lars Rune Christensen from IT University of Copenhagen (Christensen and Ahsan, 2022).

The paper draws attention to the duality of mental health assessment in a Rohingya refugee camp in Bangladesh. A digital screening tool based on WHO Self-Reported Questionnaire (SRQ-20) was designed and used by medical assistants as a screening tool to quantify the severity of mental health issues and on a scale from one to twenty – where a score of seven or above was the cut-off point for referral to treatment. This study found that medical assistants in Rohingya camps relied not just on the numerical score of the WHO standard screening test SRQ-20, but also on their senses and bodily experience while making home calls to the refugees. By conducting ethnographic fieldwork, following the medical assistants during house call for mental health screening, observing them and interviewing them, the paper draws attention to the fact that medical assistants practice 'numeration' and 'mood' to capture the dual quality of mental health assessment. WHO's SRQ-20 quantifiable measurement has been used as 'objective' measures, and more 'subjective' attunement (Heidegger, 1962) to moods and atmospheres mediated through bodily experience. That is, neither numeration nor attunement to moods stand alone in the medical assistants' assessment of the mental health of refugees in Kutapalong camp. Previous studies (Christensen, Ahsan and Mandal, 2020; Tay, Islam, Riley, Welton-Mitchell, Duchesne, Waters, Varner, Silove and Ventevogel, 2018) provided extensive documentation on how the Rohingya refugees' exposure to extreme violence in Myanmmar and the harsh conditions of their refugee camps in Bangladesh contributed to their mental health problems, but the paper argues that little attention has been paid to how mental health is understood by those working with the refugees i.e., the medical assistants (part of a human infrastructure). The study introduces the concept of 'numeration-attunement' to the area of medical anthropology by referring to the service provided by medical assistants in regard to the mental health of refugees.

Arguably, the article also shows the prominence of the human element in a digital health service. The medical assistants' attunement to the moods of the refugees is very much part of the production of the screening data. Hence, the human infrastructure (that the medical assistants are a key part of) plays an undeniable role in the datafication of mental health in this case. Furthermore, psychologists, counsellors, technology developers and management may be said to also be part of the human infrastructure in this case.

On reflection we can also see how the aforementioned human actors, like the medical assistants, are configured or created as part of the whole service. First, the IT University of Copenhagen and the Bangladeshi NGO Friendship raised the necessary funds from the Novo Nordisk Foundation to hire and organise this 'human 'infrastructure' in order to launch the service. Second, the medical assistants acted as intermediaries in the screening process by utilising the SRQ-20 and their own intuition insight to determine whether or not the patients would benefit from screening and needed referral. They

received training on how to operate the SRQ-20, but not on how to 'subjectively' tap into people's emotions and vibes. Not everything is trained during the project initiation as some skills are more fundamentally part of what it means to be human. Thirdly, if we apply the human infrastructure's 'usage' lens from the thesis, the medical assistants were the major 'user' of the of the screening app and acted as intermediaries between the Rohingya refugee and counselling for referrals. The Rohingya refugees were part of the screening process as they were the ultimate beneficiaries to be screened but they were not the users of the mobile app. They were the secondary users as mentioned in chapter 3, because they received the screening service. The thesis also showed that (and also described in chapter 3) 'hardware maintenance' of the tablet used by the medical assistants was done by the human infrastructure. In case of any damage or malfunction of the tab, the technology trouble-shooter person used to fix it for the medical assistants. Similarly, the developers (human infrastructure) used to fix bugs and errors of the digital SRQ-20 screening app as part of software maintenance. The thesis identified the 'diffusion' process when the medical assistants received on the job training and refresher training and their performance went up. As described in chapter 3, the fieldwork demonstrated the necessity of the 'contingency work' procedures for the medical assistants in the event of an internet outage. They needed a strategy for screening patients in 'offline' mode and storing the results on a mobile memory card. If they were within range of a Wi-Fi network, they would upload their screening information to a central server. It may be said that human infrastructure had to plan for 'contingency work' in a digital intervention project in the Global South. So, to analyse the human infrastructure 'user' and 'usage' of the paper, the thesis identified general users, both hardware and software maintenance work done by human actors, diffusion process for the medical assistants and contingency work during mental health service delivery. Last but not least, human infrastructure may unravel as the NGO may fail to keep the medical assistants for mental health screenings due to budget constraints.

CHAPTER 5: CONCLUSION

In this thesis, I have attempted to contribute with a more nuanced understanding of human infrastructure in relation to digital projects and interventions in the Global South. Taking my research projects in the Global South as a point of departure, I have explored the role of human infrastructure in digital interventions. Asking, *what are the relationships between digital intervention projects (or services) and their human infrastructure in the Global South?*

To begin, in Chapter 2 I described the methods of the studies. I described the research undertaken in my project, with a focus on the methodology used to obtain data for analysis. This involved reflections on my own position during data generation. I accounted for the multiple methods to generate the data, including qualitative and quantitative approaches such as participant observation, focus groups, semi-structured interviews, and a quasi-experimental field trial with a quantitative component. Participant observation was conducted in order to observe key human infrastructures in their natural environment. In addition, as presented in Chapter 2, semi-structured interviews with a wide range of human actors, including project beneficiaries, project staff, technology designers and management, were required to complement my participant observation. The purpose of these semi-structured interviews was to learn about the interviewees' own explanations, first-hand experiences and overall impressions of the digital intervention services. My fieldwork additionally made use of focus group discussion as a supplementary data collection method. Since the digital intervention projects organised beneficiaries into groups for more efficient service delivery, I've used 'focus groups' in parts of my research to understand the common perspectives discussed in a group, their consensus and difference in opinions regarding the digital services. In one of the studies (Christensen, Ahsan and Akand, 2018), I was required to conduct a quasi-experimental field trial and gathered quantitative data. However, in a non-intervention study on COVID-19 (Ahsan and Christensen, 2022), I used semi-structured interview data but the data was collected by the local research assistants. In the methods chapter, one important lesson is that researchers may explore diverse methods to better understand the role of human infrastructure and the practices they use in digital intervention projects in the Global South.

The purpose of chapter 3 was twofold. First, to review and reflect upon the different ways in which infrastructure has been conceptualised across a range of scholarly perspectives. In reviewing different perspectives on infrastructure, I wanted to assess the ways in which the concepts had been used analytically and been part of scholarly debates. Second, I turned to the notion of human infrastructure and gave emphasis to recent scholarly activity in this area. Based on reflections on infrastructure and especially human infrastructure studies, I strived for a more nuanced understanding of human infrastructures in their relationships to digital interventions in the Global South. In doing so, I drew on my projects that is the basis of this thesis. More specifically, I discussed and expanded the concept of 'human infrastructure in ICTD' drawing not least on the work of Sambasivan and Smyth (Sambasivan and Smyth, 2010). To do so, I traced some influential concepts of infrastructural studies, such as 'infrastructural inversion' as an analytical lens (Star and Ruhleder, 1996) and 'human infrastructure' (Lee, Dourish and Mark, 2006) as a concept. Sambasivan and Smyth among others was inspired by the idea of 'infrastructural inversion' and the concept of 'human infrastructure' in their ICTD study where they discussed systematic 'processes' (usage, maintenance, and diffusion) as well as 'properties' of human infrastructure (Sambasivan and Smyth, 2010). My discussion attempted to expand their view

on systematic 'processes'. Using my own projects as exemplars, I argued for a fuller view of systematic processes that may constitute human infrastructure to include 'configuration', 'training', 'general usage', 'maintenance', 'diffusion', 'contingency work', and 'unravelling'. One of the key takeaways from this chapter is that human infrastructure in various ways is part of digital interventions in the Global South and needs to be taken into full account in order to (analytically) understand these projects and (practically) fulfil their potential benefits.

In Chapter 4, I situated the findings of each publication within the overall contributions of my thesis. That is, I attempted to connect each of the five publications explicitly to the theme of 'human infrastructure' i.e., the overarching theme of the thesis. Each publication was framed or read as presenting different aspects of human infrastructure. Chapter 4 expanded on the contributions of chapter 3. I will now summarise the contributions of the thesis below.

5.1 Summary of Contribution

This thesis, then, makes several contributions to both research and practice. To begin with, it makes a number of *conceptual* contributions, particularly by adding to the literature on infrastructure studies. Second, it makes contributions *empirically and analytically* to the study of human infrastructure practices in interventions in the Global South and their implications for technological support. Third, the publications have contributions that may be appreciated independently of the theme of human infrastructure. A short recap of my contributions is given below, followed by some suggestions for future research.

In terms of conceptual contributions, the thesis adds to the literature by underlining that human infrastructure may be 'configured' or 'created'. In an analysis, underlining that human infrastructure is configured or created is an antidote to taking the human infrastructure somehow for granted. On an empirical and analytical level, the thesis has highlighted, for example, that projects may employ a wide range of human resources and arrange their interconnections in order to bring about the community-wide implementation of a digital service. In a given project, a technology and design team may be employed to design the technical system of the digital service as well as to develop and manage its associated content. Furthermore, a project operation team and community groups may be created to manage the digital service locally.

Another conceptual contribution of the thesis is to insists on the notion that human infrastructure may be 'trained' as part of digital interventions in the Global South. In an analysis, underlining that human infrastructure may be trained is yet again an antidote to taking the human infrastructure for granted, including its skills and competencies. Moving to an empirical and analytical level, the thesis has highlighted, that the recruited human actors and resources must carry out their duties and responsibilities to implement the project and provide the services with skills and competencies that may be learned through training. For example, self-help farmer groups and farmer producer groups may be educated on how to relay agriculture information messages to other farmers, while project 'intermediaries' may be taught to use digital applications to better serve project beneficiaries. Furthermore, local research assistants can be taught 'virtually' to gather data during a disaster (pandemic) when researchers cannot physically go to the Global South. In addition, project employees may be trained to establish beneficiary groups and implement digital service activities. This insight is

related to Sambasivan and Smyth's (Sambasivan and Smyth, 2010) idea that human infrastructure may be 'capacity building resources.'

Last but not least, the notion that human infrastructure may be transient is underlined using the notion or concept of 'unravelling'. This again gives empirical and analytical focus to impermanence and the work of keeping the infrastructure in place. For example, if funding for projects dries up due to budget constraints, partner organisations on projects may lose their ability to keep valuable employees and those employees may go elsewhere for employment. The human infrastructure unravels. In contrast, a digital intervention service like Agribuddy that operates on a for-profit basis may be able to keep its employees and keep going. In this manner, empirically speaking, the business model, or the lack thereof, may have implications for the stability of the human infrastructure and be instrumental in determining the point in time of its unravelling.

As indicated above, the publications of the thesis each have their own research contributions that can be appreciated by reading them individually and by consulting chapter 4 for an overview. In order not to reproduce chapter 4 or the publications at length, it may suffice to reiterate that they each can be read as related to the theme of human infrastructure as previously stated and as individual publications. Thus, the publications, contribute on two levels 1) as individual pieces of research that can be read individually, and 2) as an ensemble of papers with a body of knowledge that in this thesis has been related to the theme of human infrastructure in digital interventions in the Global South.

To reiterate, then, read as an individual piece of research the paper entitled "Krishi Kontho: An Agricultural Information Service in Bangladesh" (Christensen, Ahsan and Akand, 2018), address the research aim of understanding 'how can an agricultural information service be developed to support the temporalities, rhythms of agricultural practices, in rural Bangladesh and beyond?' Second, related to the common theme of human infrastructure the study of the paper contributes by showing how an agricultural information service may be synchronised to agricultural practices that rely on a human infrastructure in the Global South. The paper entitled "Are You Magicians? The Collaborative Work of an Agricultural Information Service" (Christensen, Ahsan, Rashid and Das, 2019) has a stated interest in 'how is an agricultural information service worked into a rural community?' And details how the workings of an agricultural information service in Bangladesh are made possible through integration work that relies on a human infrastructure. The paper entitled "Agribuddy: Infrastructuring for Smallholder Farming in Cambodia" (Ahsan, Christensen and Kitaura, 2021) address the research aim of understanding 'How may infrastructuring for value chain, for microcredit, and for capacity building contribute to smallholder farming in the Global South?.' And states how an establishment of a (human) infrastructure in Cambodia connects smallholder farmers to a wider market. The paper entitled "The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic" (Ahsan and Christensen, 2022) shows 'how was everyday life during the Covid-19 pandemic in Bangladesh reordered through commonplace digital technologies and services?' By focusing on the theme of human infrastructure, the study illustrates how human networks and human infrastructure are arranged to generate data during a crisis. The paper titled "Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh" (Christensen and Ahsan, 2022) shows the research aim on 'how may the assessment of the mental health of refugees be a matter of both numeration via a screening tool and attunement to moods?' The paper connects to the common theme of infrastructure and demonstrates the prominence of the human element in a digital health

service, where the human infrastructure is very much part of the process. Inseparably so, as numeration and attunement to moods intersect in the datafication of mental health.

5.2 Direction of Future Research

My thesis contributes to the relationship between 'human infrastructure' and digital intervention services in the Global South. It has also highlighted the human infrastructure perspective in relation to technological processes in the digital intervention service in the Global South. Throughout the thesis I described and explained the human infrastructure processes, but I would like to see other scholars join in to continue to explore human elements in the digital intervention service in the Global South. I would like to outline some open questions and areas I could not dig into. Additional empirical studies may add more to the body of knowledge to the human infrastructure processes in the Global South's digital intervention services.

Why and how might the local elites such as religious leaders in the Global South participate in digital intervention projects as human infrastructure? What possible outcomes are there?

A religious leader (Imam) was asked to relay agriculture SMS messages from the mosque's public announcement system, as part of the Climate and Agriculture Information Service (CAIS) Project (Christensen, Ahsan, Rashid and Das, 2019), but he declined since, as he saw it, a mosque is a place solely for the prayers of Allah (God). In our research, we were unable to delve deep enough to ask other imams whether or not non-spiritual or important messages might be communicated in the mosque. It may be helpful to consider how leaders from various religious communities view digital services when developing and implementing projects in the Global South. If there is any doubt as to whether or not religious leaders should be considered stakeholders before implementing a digital solution, that perception may be helpful. The scholarly findings may add to the literature of ICTD, HCI and beyond.

How can we better understand how community beneficiaries can act as intermediaries, especially in smartphone app based digital intervention services?

In terms of mental health screening and the commercial value chain in agriculture discussed in chapter 3, the Rohingya mHealth project (Christensen and Ahsan, 2022) and Agribuddy service (Ahsan, Christensen and Kitaura, 2021) demonstrated the role of intermediaries where the beneficiaries were mostly the service recipients, not the users of the smartphone apps. Today, many donor-driven projects develop digital service considering smartphone applications. For example when community health workers (CHW), who are not even paramedics, collect data on health using smartphone apps (Ginsburg, Chowdhury, Wu, Chowdhury, Pal, Hasan, Khan, Dutta, Saeem, Al-Mansur, Mahmud, Woods, Story and Salim, 2014), and when resource farmers are used to provide agricultural extension services through online/offline apps (Ahsan and Sadek, 2015) etc. Since the number of community-level smartphone users in countries of the Global South are increasing rapidly (Correa, Pavez and Contreras, 2020; Stork, Calandro and Gillwald, 2013), it may be interesting to study how community beneficiaries perceive smartphone applications created by digital intervention services. And how beneficiaries adjust to utilising the applications if they begin to assume the position of intermediaries through the use of the device and apps? In such a scenario, it would be intriguing to investigate how

digital intervention projects and services enhance the education, literacy and accessibility of the human infrastructure (beneficiaries).

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PUBLICATIONS

PUBLICATION 1

Krishi Kontho: An Agricultural Information Service in Bangladesh

Lars Rune Christensen, **Hasib Ahsan**, and Eshrat Akand. 2018. *Krishi Kontho: an agricultural information service in Bangladesh*. In Proceedings of the 10th Nordic Conference on Human-Computer Interaction (NordiCHI '18). Association for Computing Machinery, New York, NY, USA, 203–214. https://doi.org/10.1145/3240167.3240225

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ABSTRACT
In this paper, we present *Krishi Kontho* (literally, "agricultural voices"), which is an agricultural information service that utilises pre-recorded voice messages, and SMS, that are pushed to smallholder farmers mobile phones at intervals carefully choreographed with the life cycles of their crops. We present the design of the service, and we present the result of an eleven-month field trial in rural Bangladesh. Findings indicate that this type of service, that synchronises messages with cultivation practice, may improve crop yields while reducing the use of agricultural inputs such as fertiliser and pesticides. We find that the farmers in the field trial deemed the service to be of value to them in regard to improving their agricultural practices. We conclude by discussing our findings and their implications for the design of agricultural information services, including the challenge of designing for specific temporalities, or rhythms of practice, in rural Bangladesh and elsewhere.

AUTHOR KEYWORDS
HCI4D; ICT4D; Agricultural Information Service; Temporality; Crop Cycles; Voice; Mobile; Bangladesh.

ACM CLASSIFICATION KEYWORDS
H.5.2. Information interfaces and presentation (e.g., HCI).

INTRODUCTION

In many developing regions, agriculture is crucial to the economy and the food security of the people [1, 2, 32]. In Bangladesh, which is our focus, agriculture forms the base of the economy, and it is the primary source of the country's food security, it employs 48% of the workforce, and accounts for 19% of the gross domestic product [16]. The government of Bangladesh has invested heavily in its agricultural extension program, in which trained field officers support rural communities with training on farming techniques and technologies. Although there are almost 14,000 government field extension officers in Bangladesh, tasked with informing farmers on agricultural practices, it is not adequate as each agent has to assist more than 2,000 farming families [16].

Information and communication technologies have the potential to increase the reach of agricultural extension. Our work explores the use of voice messages, and SMS, to provide agricultural knowledge in step with the life cycles of the farmers' crops. Voice is an assessable medium for smallholder farmers who often have limited formal education. Voice content can be accessed using low-cost mobile phones, which are common in rural comminutes around the world [18]. Moreover, agricultural knowledge is highly sensitive to the life cycles of the crops. That is, the farmers' reception of information may preferably be in step with the temporality of their cultivation practices, including the life cycles of the crops they are farming at any given time [1, 2, 18].

Previous HCI research has focused on understanding the temporality of practice [12, 8, 10, 23, 25, 37], and designing for temporal coordination [3, 27]. In addition, previous research on agricultural information services includes work on voice forums [32], rural information portals [14], and rural radio [7, 24]. However, one challenge with voice forums, rural information portals and to some extent rural radio is the temporal delivery of information to the farmers. As indicated, the nature of the agricultural production entails that farmers need information on a variety of topics, at a variety of stages, including seeding, preparing and sowing, growing, harvesting, packing and storing, and selling [13, 26]. Farmers have different types of information needs during each stage [18]. Arguably, online voice forums, rural information portals, and rural radio may lack a tight coupling between the temporally given information needs of the individual farmers and the content of the information provided to them. The information to the farmers, then, must be delivered in a rhythm that corresponds to the temporality of the farmers' cultivation practices.

To explore this idea, we designed, implemented, deployed and evaluated an agricultural information service called *Krishi Kontho* (literally, "agricultural voices") in rural Bangladesh. The service utilises pre-recorded voice messages, and SMS, that are pushed to the farmers' mobile phones at intervals carefully choreographed with the life cycles of their crops. This paper, then, delivers an example of how one may address the core HCI challenge of designing for the temporality of practice. The paper demonstrates that simple (voice and SMS) technology (albeit in a complex setting) may benefit smallholder farmers in the Global South as advice is synchronised with the rhythms of their agricultural practices.

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The paper is structured as follows: First, we will consider related work. Secondly, we will present the design of the Krishi Kontho agricultural information service. Third, we will present findings from an eleven-month field trial of the service. Fourth, we will discuss the implication of the findings. Lastly, a conclusion is provided.

RELATED WORK

In this section, we will relate to previous research on temporality in HCI as well as the body of literature on agricultural information services and voice-based ICT interventions. We will attempt to bring these streams of research together in this section. We will start with the HCI literature on temporality and subsequently turn to the research on ICT interventions in the Global South.

Time and designing for the temporality of practice is a topic that is pervasive in HCI. Building on organisational scholarship about the formation and regulation of temporal order in organisations [22, 33, 34], HCI researchers have introduced the concept of *rhythms* to describe various temporal orders integral to practice. Much of this research has highlighted the plurality of rhythms in workplace settings and the considerable effort it may take to bring this multiplicity into practical alignment [5, 20, 28, 37, 39]. For example, Reddy and Dourish [37], detail both large-scale and finer grained temporal rhythms of practice. Relatedly, Møller and Bjørn [27], highlight the notion of being *in due time,* which refers to an activity being completed in a timely manner allowing for subsequent activities to be shaped in an orderly fashion. Furthermore, Bardram [3] focuses on *temporal coordination* understood as the temporal aspect of cooperative work to inform the design of a tool for synchronising distributed work. Bardram links successful coordination to artifacts stating that "… a temporal artifact such as the clock or the calendar can be turned into a temporal coordination artifact, mediating the temporal coordination, when shared within a collaborating community of practice [3, p.164]. Notably, for an artifact, computational or otherwise, to work as a coordination tool in practice calls for a (shared) sense of temporality, or rhythm, among the practitioners involved. We may interject that in our case the sense of temporal order, the rhythm inscribed in the Krishi Kontho service, stems from the crop cycles of the agricultural practices (we will elaborate on this point below).

Turning to the literature on ICT interventions in the Global South we find that several agricultural information services have targeted developing regions, including voice forums [32], rural information portals [14], and rural radio [7]. Since textual literacy is a significant issue in developing countries, especially in rural areas, several information systems for rural communities are speech-based. Studies pertaining to voice forums, based on interactive voice response, show that users can use voice-based systems, irrespective of their literacy levels [18, 35, 40]. Related to our work is, for example, a system called Avaaj Otalo, which is an interactive voice application for smallholder farmers in Gujarat, India. Avaaj Otalo allowed farmers to connect to a question and answer forum to record questions, provide answers, or browse an existing list of questions and answers [32]. This and other forum-type applications focused on user-generated content, to be produced, curated, and searched by the end-users themselves [e.g. 40].

Agricultural information services based on text and video, rather than voice, have also been deployed on the Internet for the benefit of farmers in developing regions [1]. One example is The Farmers Portal provided by the Department of Agriculture, Government of India [14]. The vision of the portal, which is at the time of writing available to the public in a Beta version, is to provide Indian farmers with "all relevant information on specific subjects around his village/block/district or state. This information will be delivered in the form of text, SMS, email and audio/video in the language he or she understands.", as described in the portals 'about' section [14]. The scope of this particular agricultural portal, then, is broad. It will potentially cover crop management, extension activities such as farm schools, post-harvest advice, risk management, disease management, animal husbandry, and more. Often portals of this kind may be accessed by the farmers through information kiosks [21]. Information kiosks in this context refer to ICT enabled services: shared computers in rural kiosks. Kiosks are often to be used by members of income groups who cannot afford to own a computer, but who needs access to agricultural information services and other Internet resources [18, 21].

In addition, radio is a well-established way to provide information in rural areas, including information on agriculture. That is, radio is used extensively in developing countries to promote changes in farming practices to improve agricultural production [29]. While other technologies like television are found in the homes of affluent farmers, transistor radios running on batteries are affordable for the poorer segments of the population. Furthermore, radio does not require textual literacy, and an increasing shift to local radio program production and broadcasting is removing language and dialect barriers. As a result, radio has become a medium of communication and dissemination of information, as well as for training and education, for broad segments of rural communities pertaining to agricultural subjects [30].

However, voice forums and rural information portals may leave it up to the farmers to navigate the forums or portals and find the information they need for themselves by themselves. Arguably, if for example a voice forum or an information portal is very complex and full of different types of information it may be a challenge for the farmers to navigate such services and find precisely what they need when they need it [2, 18]. Moreover, a further challenge with voice forums, rural information portals and to some extent rural radio is the temporal delivery of information to the farmers. The nature of the farming suggests that smallholders need information on a variety of subjects, in a variety of

phases, including seeding, preparing and sowing, growing, harvesting, packing and storing, and selling [13, 26]. Farmers have different types of information requirements during each step, ranging from weather forecasts, pest attacks, fertiliser, improved cultivation practices, pest and disease management and finally prices. Arguably, voice forums, rural information portals, and rural radio may lack sufficient coordination between the crops cycles of the individual farmers on the one hand and on the other hand the content of the information available to him or her.

In sum, rather than having farmers with low-literacy levels seek out information for themselves, an information service could ideally provide the information to them in a manner synchronised with the rhythms of their agricultural practice. To address this challenge, we as mentioned designed, implemented, deployed and evaluated an agricultural information service called *Krishi Kontho* (literally, "agricultural voices") in rural Bangladesh. Will turn to this service now.

KRISHI KONTHO DESIGN

The agricultural information service Krishi Kontho was made in a collaboration between the international NGO Christian Aid, the technical partner mPower, the local NGO Gana Unnayan Kendra (GUK), as well as local farmers in the area of the field trial. While it was the role of Christian Aid to provide funding for the project from its international network, it was the role of mPower, GUK, and selected farmers in the GUK area of operation to develop the service. This was done in a highly collaborative manner where mPower facilitated the design process, and GUK staff and local farmers joined as co-designers. Briefly put, the design process took approximately six months and included field trips and design workshops in addition to more technical activities and tests.

As indicated, it is a voice-based agricultural information service, although it also utilises SMS messages, and is accessible to the farmers via (low-end) mobile phones. A key aspect of the service is that it delivered the messages in a temporal order to fit each stage of the crop cycle. That is, the participating farmers received thirty automated voice messages on their mobile phones, during the production cycle of maize and chilli, which was their main crops. Each message was a 30-59 second audio recommendation on various practices about each stage of crop cultivation, such as soil preparation, seeding, fertilisation, irrigation, pest and disease control, harvesting, drying, storage and more. The voice format was chosen to mitigate the low literacy rates in rural Bangladesh. In Bangladesh, 36% of adults are illiterate, among residents in the rural areas the number is 52% [4]. In addition to voice some technical information, such as pesticide and fertilisation dosages, was also sent using SMS. The idea is that if a farmer, for example, cannot remember the precise fertiliser dosage from having heard a voice call – he or she can always show the SMS with this information to someone literate such as children in the household of school age.

Mobile phone-based interventions can potentially provide poor farmers with information and knowledge that in turn may help them improve their farming practices and their livelihoods [2, 18]. The high potential for sharing agricultural information via mobile phones is related to the high penetration rate of mobile phones in developing countries (this can be seen in contrast to the low penetration rate of, e.g. personal computers in these regions) [1]. In Bangladesh, while the mobile phone penetration rate is 77,9%, the mobile broadband penetration is just 17,8 %. Mobile phones are still primarily used for voice calls. Households with fixed (wired) internet access at home are 13,8 %, and fixed high-speed broadband penetration in the home is 2 % of households. There is still, then, limited availability of Internet-enabled devices and bandwidth in Bangladesh, especially in rural areas [19]. Therefore, mobile phone-based solutions made sense.

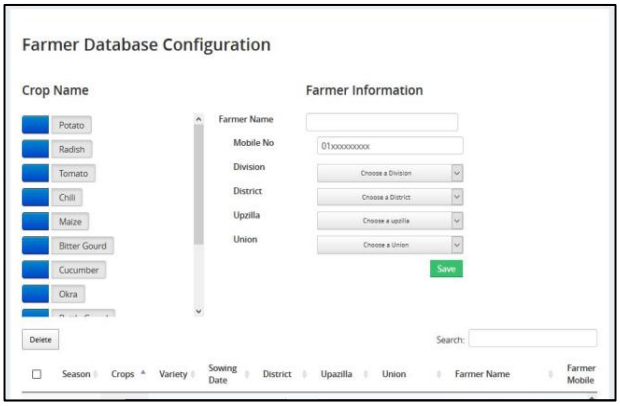

Figure 1. The farmers where registered in a database as part of the initiation of the field trial. Important data included name, phones number, crops, sowing dates, and location.

Crudely put, the service worked in the following manner. First, the field manager collected basic information on the individual farmers, such as their names, phone numbers, crop types, and plantation dates. Second, the field manager entered this information into the Krishi Kontho system (see figure 1). Third, the agro-manager configured and added the messages to be sent to the farmers phones. Fourth, the service automatically called the farmers and delivered the recorded voice messages to the farmers at set times and intervals. As mentioned, the voice message was accompanied by SMS that replicated the technical specifics of the voice messages for later use.

Content

A key activity in the design phase of Krishi Kontho was to author the initial voice-messages that were to be pushed to the mobile phones of the farmers. This was done in collaborative workshops with representatives of all project partners and with the participation the intended beneficiaries, i.e., the farmers themselves. The task was to design a set of voice-recommendations pertaining to each of the crops,

namely maize and chilli, that was to guide the farmers throughout the crop cycles. After their authoring, the messages were recorded by a professional voice actor in a studio and were later uploaded to the service where they were disseminated according to schedule.

Particular emphasis was taken to tailoring messages so they were pertinent to specific stages of popular crops, namely, chilli and maize. To validate their content mPower – the technical partner - organized validation workshop with agricultural experts.

Content, then, were related to the different stages of the crop management of chilli and maize including seed selection, seedbed preparation, heat stress, cold stress advice, and more. Some examples of the voice message content are given below:

১. মধ্য আশ্বিন থেকে মধ্য কার্তিক (অক্টোবর - নভেম্বর) মাস পর্যন্ত ভুট্টার বীজ বপনের উত্তম সময়।

You may plant Maize now as October to November is the best time to plant Maize.

২. ভুট্টার জমিতে জোঁ থাকা অবস্থায়, (৩/৪) বার চাষ দেওয়ার পর মই দিয়ে মাটি ঝুর ঝুরে করতে হবে এবং আগাছা ও আর্বজনা পরিষ্কার করে নিতে হবে।

If you plant Chili directly in the field, without seeding bags, then two and half kilos of seeds will be appropriate for 33 decimals[1] of land.

৪. মরিচের জাব পোকা দমনের জন্য হলুদ রং এর ফাঁদ ব্যবহার করা, গুড়া সাবান (৫গ্রাম/ লি) পানিতে মিশিয়ে ভালভাবে স্প্রে করা, অথবা ইমিডাকো রপ্রিড গ্রুপের ঔষধ নির্দিষ্ট মাত্রায় ব্যবহার করা।

You can spray detergent to control the pest 'Green Peach Aphid' in your chilli plants. Use 5 grams per litre of water and spray evenly and lightly.

The messages above, then, are examples of the voice messages that the farmers received during the field trial of the service.

Having accounted for the design, we will now turn to focus on the field trial of the service.

THE FIELD TRIAL

To gain experience with the service, and to provide input for further development, the service was put through an eleven-months field trial. The total number of farmers *actively* taking part in the trial was one hundred, hereof eighty women and twenty men. The field trial started May 2016 and ended March 2017.

During the field trial, each of the one hundred farmers received thirty voice messages and accompanying SMS messages on the management of maize and chilli. The messages were scheduled to be sent in the afternoon and evening as the farmers usually stay at home at this time and thus are available to hear the messages.

The operational cost of sending one voice message to a farmer was 1.00 BDT (0.01 USD), and 0.25 BDT (0.003 USD) per SMS message. Both this operational cost and the initial development cost was taken on by the project partner Christian Aid. No cost was passed on to the farmers

The deployment area

The Krishi Kontho service was put to its field trial in the area of Upazila Fulchari. To give an impression of the area and the people in it, we may start by saying that ninety percent of the geographical area of Fulchari Upazila, is comprised of what is known as Chars. These islands are comprised of sediments naturally occurring from the gradual accretion of silt and sand in the main rivers that runs through the area. The villagers and farmers taking part in the field trial live on such Char islands. A Char island may have a lifespan of for example ten years or so. It emerges out of the river, so to speak, only to be submerged by the river again some years later. In the interval, these numerous Char islands are used for residence and farmland by thousands of farming communities. This ecological and geographical situation leads to unstable settlement patterns for the farmers, with frequent loss of farmland. In fact, the people of the Chars in the Fulchari Upazila area are effectively landless due to either never having owned land or having lost their Char land to flooding. In the years 2016 - 2017, the area was repeatedly flooded and the Chars shifted as a result of heavy rain in India and China brimming the Brahmaputra River with water on a massive scale and carrying it downstream through Bangladesh.

In the area, smallholder farmers are prone to take advice from people who are not experts. As mentioned, although there are almost 14,000 government field extension officers in Bangladesh, tasked with informing farmers on agricultural practices, it is not adequate as each agent has to assist more than 2,000 farming families [16]. Consequently, farmers often have to rely on advice from sellers of inputs such as fertiliser and pesticides, whom may be prone to oversell and give poor advice. In addition, female farmers are often led out of public field extension programs due to gender barriers, as female farmers may not be permitted to interact freely with male governmental field extension officers for reasons of tradition and culture. Note that eighty percent of the users of Krishi Kontho were women. Furthermore, the agricultural

[1] A decimal is a unit of area in Bangladesh approximately equal to 1/100 acre or 40.46 m².

advice farmers can get through traditional media is very generic, and not customised to fit their specific needs let alone match the crop cycles that the farmers are engaged with. Therefore, there is in this area arguably a need for a service along the lines of Krishi Kontho.

In preparation for the trial, the project partners lead a campaign to make farmers in the area aware of the field trial and the opportunity offered, namely, to use the service free of charge. This effort was rewarded with support on the part of the farmers in the area, and it was relatively straight-forward to recruit the participants needed for the field trial. As the farmers joined the field trial, they had their name registered along with their phone number, crop types, and seeding dates to enable the delivery of the right set of messages to them at the right time. This data was, in turn, entered into the Krishi Kontho database (see figure 1).

Before we move on to describe the findings of the trial, we will pause to consider the methods by which data on the trial was generated.

Methods for generating data on the field trial

Figure 2. Focus group in progress on the farmers' experience of using the service.

As part of the Krishi Kontho field trial, we gathered data through a mixed method approach spanning quantitative and qualitative analysis.

Before the start of the field trial, we created a baseline of the previous year's crop yields, production costs, and pest and insect infestation. The purpose of the baseline was to enable a comparison between the situation before the field trial and the situation at the end of the trial. The baseline acted as the foundation of a quantitative impact assessment. The data for the baseline was generated through several data generation instruments, including a survey and public record data. The local NGO administered the survey to the farmers in the area taking part in the trial. The field data collection team included five GUK field facilitators that know the area and were familiar to the farmers. At the end of the field trial, data on the same parameters of crop yields, production costs, and pest and insect infestation were generated, using similar data generation instruments as before.

In addition to the intervention group of one hundred farmers, we also randomly selected another one hundred chilli and maize farmers from the same area. These 'control group' farmers were not sent any voice messages or SMS messages, rather they followed their usual practices of information seeking such as for example consulting local input retailers for advice. The rationale behind this approach was to enable a comparison between farmers that had actively used the service and a similar group that had not done so. The two groups of farmers in the trial, then, were created by an approach of simple randomisation. That is, two hundred farmers were recruited randomly from a larger pool of volunteers, out of the two hundred farmers, one hundred were randomly designated 'intervention group', and the remainder were designated 'control group'. In this manner we attempted, by simple randomisation, to guard against selection bias as far as practically possible, while introducing a comparative element to the quantitative part of the field trial.

In terms of qualitative inquiry, we conducted three focus groups with the beneficiaries of the service shortly after the end of the field trial (see figure 2). The participations in the focus groups where randomly selected among the farmers of the intervention group. Of the one hundred farmers actively taking part in the trial we managed to include twenty-nine in the three focus groups. The focus groups had the participation of eight to ten farmers on each occasion, and they lasted for about ninety minutes each. In this manner, we spoke to more than a quarter of the individual farmers actively involved in the trial. Focus groups may be said to provide a way of including a relatively large group of informants, allow for conversation among peers, and facilitate a rage of communication processes [41]. In our focus groups, we experienced a range of communicative processes including, storytelling, joking, debating, boasting, teasing, and the negotiation of consensus.

The focus groups were conducted in the farmers villages to make them as comfortable as possible with the situation, and they were conducted in the local language of Bangla. We facilitated a discussion among the farmers on a range of topics including their "user experience", the "impact of the service on farming practices", the "impact on their livelihoods", and we further encouraged a discussion of future scenarios, including "how the service might be improved", and "what one might be willing to pay for such as service if anything". We presented the topics to the focus groups in everyday language and encouraged the farmers to give examples that might illustrate their points. In addition, we made room for discussion of topics brought forward by the farmers themselves such as "the inadequacy of the government agricultural extension service", and "the hardship of life in a flood-prone area". All focus groups were

audio recorded, transcribed, and in turn translated into English. After the third focus group we experienced data saturation, i.e. we were roughly getting the same answers, and therefore we did not organise a fourth focus group.

In addition, we also conducted four semi-structured one-to-one interviews in order to get the perspective of some of the NGO staff and managers involved. We interviewed two field managers and two agro managers. These interviews mainly provided us with a contextual understanding of the situation in the area and the role of the NGO. The interviews with the field managers and agro managers were conducted in English. Lastly, we also conducted two one-to-one interviews with female farmers to further probe the value of the service to the farmers.

Our analysis of the qualitative data, i.e. from the focus groups and the one-to-one interviews, took a broadly practice-oriented perspective [9, 11, 38, 42] with inspiration from ethnomethodology [15, 36]. Practice studies, in our perspective, explicate how participants organise their practice and emphasise how technologies and artifacts may become an integral part of a practice. The authors read through and discussed the data in various analytical session in person and on Skype. The data was organised into themes as topics emerged from the analytical sessions. A concerted effort was made to have the themes, and in turn, the findings emerge from the data itself.

The findings of the field trial

In this section, we present the main findings of the field trial. We will start with the quantitative inquiry (see table 1) before moving on to the qualitative one.

Farmers	Crop	Yield compared to the previous year	Production cost compared to the previous year
Intervention group	Chili	Up 14%	Down 4 %
	Maize	Up 10%	Down 8 %
Control group	Chili	Up 9,5 %	No change
	Maize	Up 4 %	No change

Table 1. Summary of quantitative inquiry

On average, we found a twelve percent increase in crop yields. The production of maize and chilli had increased compared to the previous year. The average chilli production of the intervention group was 864 kg pr. acre, compared to 755 kg pr. acre the previous year. Among farmers in the area *not* actively taking part in the Krishi Kontho field trial, the annual chilli yield was 827 kg pr. acre. Year on year increase in production, then, was fourteen percent for chilli (109 kg pr. acre) for the beneficiaries of the Krishi Kontho project. In comparison, the year on year increase in production was nine and a half percent for chilli (72 kg pr. acre) among farmers in the 'control group'. Judging from the fact that both the beneficiaries of the project as well as non-beneficiaries had increased chilli crop yields, some of the overall year-on-year increase in production can be explained by more favourable climate conditions the year of the field trial, compared to the previous year. Having said that, the beneficiaries did have the largest yield increase for chilli compared to the non-beneficiaries. This picture repeats itself in relation to the other crop of the field trial, namely, maize. The average maize production of the farmers using Krishi Kontho was 3,798 kg per acre compared to 3,444 kg per acre the previous year. That is a ten percent increase or 354 kg per acre from the previous year. Among farmers in the 'control group' maize production was increased by four percent. Of the farmers in the intervention group, eighty-five percent were able to increase their production of maize and chilli.

This increase in production yields compared to previous years, and compared to the farmers not using the service, is all the more significant if one also takes into consideration the reduction in production cost that was associated with it. The overall decrease in production cost was on average eleven percent for both crops, respectively four percent for chill and eighteen percent for maize. That is, the previous year the production cost of an acre of chilli had been 45,753 BDT (USD 566), in the year of the field trial the production cost of an acre of chilli was 45,000 DBT (USD 558) for the participating farmers, a reduction in production cost pr. acre of 753 BDT (9,3 USD). For an acre of maize, the production cost had previously been 40,905 BDT (507 USD). During the field trial, however, the production cost fell to 38,475 BDT (476 USD), that is a reduction per acre of 2430 BDT (30 USD). Cost reduction is as important to the farmers' livelihood as is the increase in crop yields.

The reduction in production cost was mainly a consequence of a more modest use of fertiliser and pesticides, which in turn benefits the natural environment, the work environment, and the quality of the crops produced. Associated with the farmers' use of Krishi Kontho, then, was smaller doses of fertiliser and pesticides, the dosage was kept lower due to well-timed use. That is, the timing and rhythm of fertilisation and application of pesticides, dictated by the tempo and content of the voice messages, had an impact on production cost. In addition, irrigation cost was reduced, also due to well-timed and moderate use. Also, pest and insect infestation was lessened compared to the plight of the farmers in the non-intervention group.

In sum, we may say that the use of the service correlates with increased crop yields and a decrease in the use of fertilisers and pesticides. The quantitative data analysis, then, points to the potential of this kind of service to improve the livelihoods of smallholder farmers. Note that the limitation of the quantitative findings presented above is that the data was generated through one eleven-month field trial, in a limited

area with two crops, rather than through multiple trials or more extended trials.

Value and experience offered to the farmers

Our qualitative inquiry, our focus groups and interviews, reveals that many users attributed value to their interactions with Krishi Kontho. The users saw the service as a source of information, an alternative to the advice of input sellers and the overextended public agricultural extension agents. This sentiment was often strongest among female farmers:

> *We thank you for the messages. They helped us a lot. Thank you.*
>
> (Female farmer, Fulchari Upazila, Gaibandha)

Women farmers used Krishi Kontho to build their farming skills, build social capital, and share information. Independent of male extension agents and male input sellers. After getting the voice messages, they would share the information with other farmers in their village who did not have access to the service. This would help their neighbours, and it would build the social capital of the female farmers sharing the information with others including men in the village. This would elevate their status in the village to the point where those *not* taking part in the field trial would become "jealous" of those holding the information. Having access to Krishi Kontho, then, was seen as valuable:

> *We got the messages and were fortunate, and some of the others became a little jealous. But of course, we shared the messages with them - all they had to do was ask.*
>
> (Female farmer, Fulchari Upazila, Gaibandha)

Farmers without access to the service, then, wanted that access as well. In addition to the social value of using and sharing information from Krishi Kontho, the farmers appreciated the more tangible rewards. One farmer reported that in the season where he used the service his maize yields moved from 800 kg to 1,400 kg. And for chili, his yields were up from 320 kg to 480 kg. This particular farmer especially appreciated the detailed seeding advice of the service:

> *I know what kind of chili seeds to plant, how close and how many. I know that now from the messages […] This harvest was 480 kilos, much better than the previous harvest.*
>
> (Male, farmer, Fulchari Upazila, Gaibandha)

To get advice and recommendations, the farmers had previously called the public extension officer on the phone, but this had been very time-consuming. For example, in the case of plant diseases and pest, they previously had to take the affected plant to the extension officer in town. However, this was rarely done. The public extension officer was often too busy to come to their village. The service of Krishi Kontho somewhat alleviated this kind of predicament in the sense that the service also provided voice-messages with recommendations on plant diseases and pests in relation to the crops included in the field trial, namely, maize and chilli. However, what the service did not do was to provide for two-way interaction between farmer and agricultural expert (we will discuss this limitation in further detail below). Furthermore, the service only advised on maize and chili, other crops farmed by the villagers in the area such as wheat, jute and chickpeas were not advised on. This made the farmers ask for recommendations in concerning these crops. On the one hand, this speaks to the limitation of the field trial service; on the other hand, it speaks to the future potential of this kind of service in the sense that it is a clear indication that the concept of Krishi Kontho was appreciated by the farmers - as they wanted "more of the same" in relation to other crops. As one farmer put it:

> *You send us messages on maize and chili. We are very thankful for that. But we have other crops as well. I farm with my wife. So, it would be great if you could provide us messages on wheat and chickpeas also. And we also used to grow jute before the flooding. Can you also give us messages on jute?*
>
> (Male farmer, Fulchari Upazila, Gaibandha)

The farmers in the area lost much or their land due to land and river erosion in recent years. They live, as mentioned, on the slit islands (Chars) and none of them has television or electricity. There are some houses with solar panels, but those are few, they are the homes of the *comparatively* affluent families. This is partly where the phones are charged. Farmers in the area almost all have mobile phones of the feature phone variety with a price tag of about 10 USD. Smartphones beginning at 75 USD, however, are beyond their reach. This is partly why a service such as Krishi Kontho based on voice-messages sendable to any kind of phone resonates with this community of farmers. Sometimes the farmers hear agricultural radio programs on their phones, many of the phones have an FM receiver. One farmer said:

> *Sometimes we listen to Krishi Dibanishi [an agricultural program – in English "Day and Night Agriculture"]. And we understand what is said. It is interesting. But it is not always what we need to hear. We*

would rather have messages on what we need to hear.

(Female farmer, Fulchari Upazila, Gaibandha)

This response opens up the topic of the temporal delivery of information. Many users appreciated the rhythm of message delivery via Krishi Kontho, where information, as mentioned, was delivered in step with the crop cycles of maize and chilli, synchronised with the sowing dates of the farmers for each of these crops. One of the most applauded features of Krishi Kontho was the synchronisation of the message delivery with the temporal order of farming. Our findings support that this part of the service worked out well in practice; the farmers taking part in the field trial valued the temporal delivery of the messages that helped structure their cultivation practices:

The messages came when needed and gave us an idea of how to take care of our fields. Sometimes we already knew some of what the messages said, for example how to spray for insects, but we did not know exactly when it was the best time to do it. (Female farmer, Fulchari Upazila Gaibandha)

Services like Krishi Kontho may provide a tight coupling, then, between the temporally given information needs of the individual farmers and the content of the information provided to them - without requiring the farmers to search for information. The farmers may know some of the advice already, for example how to spread fertiliser, but may still benefit from receiving the messages as they also pertain to *when* it is best done. Furthermore, the very appearance of the messages on the phones can serve as reminders.

The advice and the timing of the delivery of the advice is relevant in slightly different ways to different farmers. That is, Krishi Kontho provided its services to farmers in different households with slightly diverse levels of farming experience. While for example in one household farming would employ all of working age and be the main activity, in another household the woman might farm only for subsistence (rather than selling) while her husband work in town driving a motor-rickshaw. That is, some farmers have more experience with, and knowledge of, farming than others. Crudely put, three kinds of farmers may have benefitted from the service. First, those that needed to know both how and when to do something. Second, those that already knew how but needed to know when (and vice versa). Third, those that just needed to be reminded to do something. In this manner, the farmers may be said to pair their knowledge and experience with the advice offered by the service each in their way. This raises the question of how to further personalise the service to fit the knowledge profile of the individual farmers better.

Furthermore, the farmers sought more information not only on additional crops, but also on adverse weather such as flooding, and market prices. When asked how the service could be improved, the farmers called for warnings of the water masses coming down the Brahmaputra River during monsoon, often flooding their fields and invading their homes. To them flood warning is a priority:

We have left our villages so often to take refuge in government shelters, while our houses and fields are under water. It does not make sense to plant, fertilise and spray for insects only to have the crops flooded before harvest.

(Female farmer, Fulchari Upazila Gaibandha)

Effective flood warning was not an integral part of Krishi Kontho during the field trial, and there is a clear potential to improve the service in this respect. Also considering the very vulnerable situation of the farmers on the Char islands.

Furthermore, there was an information need that was not disaster or cultivation related, and that was the wish for market information. The present situation of the farmers is that they sell at the local market in the nearest small town, and there is no practical alternative to this market and the group of wholesale buyers there. This means that the farmers are in a weak situation, without adequate alternative markets, there is no real competition in relation to the price-setting of their produce. Some collusion on prices, on the part of the wholesale buyers, have been a problem according to the farmers. With this in mind, it is understandable that local farmers would like to be informed on the crop prices at several nearby markets and towns on a timely and regular basis to be able to compare prices. However, one of the challenges of this is that wholesale buyers in neighbouring markets are not known or familiar. As one farmer put it:

How do we know that a buyer [in another town] will actually pay the prices he claims he will pay? Once we have travelled there with our harvest, he might change his mind and offer another price. How do we know?

(Female farmer, Fulchari Upazila, Gaibandha)

This reservation towards trusting (partial) strangers' springs from previous experience. Many farmers just go to their local market where they might not be offered the best prices because they have a relationship with the buyers there and trust that buyers will pay them the said price and on time. This trust issue, however, did not temper most farmers' wish for market information (but it does complicate the practical

delivery of trustworthy market information as we will discuss below).

Furthermore, there is the issue of the financial sustainability of Krishi Kontho. During the field trial of Krishi Kontho, the farmers used the service free of charge. As mentioned, the operating cost of the service was BDT 1 (0.012 USD) per voice message sent to the farmers, in addition to that were the operating costs of the ICT infrastructure, not to mention the cost of designing and deploying the system. Asked if they would be willing to pay for this service in the future, most farmers gave somewhat evasive answers. There was no real appetite among the farmers to pay for what had previously been free:

> *We need to understand first how you are going to charge us for the messages before we can [fully] answer you. What amount for what information? I need to know – and if I find a message to be useful, I might pay for it, but I cannot guarantee that the others will.*
>
> (Female farmer, Fulchari Upazila, Gaibandha)

This attitude of caution and restraint when it comes to giving out cash is quite understandable considering the farmers' precarious and unpredictable situation on the Char islands. Farmers find it hard to accurately plan for the future when so much is contingent on the climate and the level of flooding. Saving some cash is one of the few safeguards the farmers have against natural disaster.

DISCUSSION

In this section, we discuss the implications of our findings for the future design of agricultural information services in developing regions.

The value of voice-based services and synchronised message delivery

One of the most lauded features of Krishi Kontho was the synchronisation of the message delivery with the temporality of farming. Each message, as mentioned, was delivered on the mobile phones in step with the crop cycles. It was the intention that farmers should have the information they needed at the moment they needed it. Our findings support that this part of the service worked out well in practice; the farmers who took part in the field trial valued the temporal delivery of the messages, which helped structure their cultivation practices. This finding is in line with the HCI literature on the temporality of practice, reviewed above, which underscore the significance of designing for the rhythms of practice [3, 27, 37]. In our case, the rhythms were those of maize and chili cultivation, rather than those of for example hospital work as considered by Bardram [3], Møller and Bjørn [27]as well as Reddy and Dourish [37]. As indicated, services like Krishi Kontho may provide a tight coupling between the temporally given information needs of the individual farmers and the content of the information provided to them - without requiring the farmers to search for information. As mentioned, voice forums as well as rural information portals it to the farmers to navigate the forums or portals and find the information they need by themselves. As indicated, if for example a voice forum or an information portal is very complex and full of diverse types of information it may be a challenge for the farmers to navigate such a service. Having said that, one may note that the expert-oriented and highly-structured approach of Krishi Kontho do not afford two-way interaction between farmers and agricultural experts, or between peers for that matter - as a voice-forum or rural portal might have done [14, 32]. Furthermore, the Krishi Kontho approach may struggle to add information in the same high tempo as those information services that take advantage of user-generated content. For Krishi Kontho voice messages, for example, had to be pre-recorded by a voice actor adding to the production and running cost of the service.

There seems to be a distinction, then, between the affordances of for example voice forums and agricultural information portals with (1) peer-generated, peer-curated, searchable content, with supports for peer interaction [32], and (2) the affordance of a service such as Krishi Kontho that relied on messages authored and selected by experts to be delivered at set intervals and in a tempo to corresponds to the users' non-digital practices. Generally speaking, one approach is not better than the other. However, one might say that each approach has different affordances and hence delivers value to the users in different ways. Voice forums have had significant usage in developing regions [see e.g. 32, 40], and we may cautiously say that the approach of Krishi Kontho seems to add value to agricultural practice as well in the form of better crop yields, less expenditure, and new knowledge of farming. But the approaches differ. Arguably, the two approached may be seen as complementary, rather than mutually exclusive. That is, smallholder farmers in developing regions may ideally be serviced by both the likes of Krishi Kontho as well as, for example, voice-forums relying on mass user-generated content.

The need for additional information on adverse weather and markets

One of the striking findings of our study was the need for more information on adverse weather. Prior work on information services in developing regions has also emphasised the climate dimension [2, 18, 31]. Climate change affects the lives of farmers in very concrete and often negative ways, with flooding in for example Bangladesh [17] or drought in for example Ethiopia [6]. In general, we advocate that agricultural information services in exposed developing regions include early warnings of adverse weather. Regular news broadcasts, on FM radio for example, may not deliver this information in a timely manner and may deliver it without a focus on potential issues for crop cultivation. Hence, the need for systematic farming related

information on weather, especially on upcoming adverse weather conditions.

Market prices is another example of information sought after by the farmers in our case. Providing market information for several local markets in developing regions may sound straightforward on the face of it. However, when one introduces conditions of ambivalence, contingencies, and lack of trust, then reliable market information delivery becomes more of an issue. For example, how is a service provider to guarantee that the prices quoted via an information service actually will be honoured on the ground, so to speak, on the market when it is time for the transaction? Keep in mind the trust issues mentioned above. One can imagine that it only takes a few bad or inaccurate price quotes that do not live up to what was promised, to erode confidence in an agricultural information service. As far as we can see, useful market information requires the commitment of not only the farmers but also of the wholesale buyers in the area. This theme remains to be explored further.

The financial sustainability of agricultural information services in developing regions

As agricultural information services such as Krishi Kontho aim to move from field trial to established service, questions of the financial sustainability inevitably arise. As mentioned, during the field trial the service was provided to the farmers free of charge, and the participating 100 farmers freely shared the information with non-participating farmers, spreading the recommendations to other villagers. At first sight, it might seem like a simple solution to let each farmer pay his or her share of the operating cost of the service: Krishi Kontho might, for example, works as a subscription service, or charges might be levied on the delivery of each voice message, there are a few complications to consider. First of all, some farmers, as described above, indicated that they would be hesitant to use the service if it was not free. Second, through informal discussion, it emerged that if the service was not free, farmers might adopt the approach of one person formally paying for the service and then informally sharing the information with the rest of the community. One way to counter this might be to do subscriptions per village, rather than per person. Another solution to the issue of financial sustainability is to look elsewhere for the operation cost. For example, sellers of agricultural equipment, or providers of inputs such as fertilisers or seeds, might be convinced to bear the cost. A sort of sponsored advertisement. This and other business models remains to be explored. The issue of financial sustainability remains an issue for many types of service aiming to move from field trial to more established service in developing regions [2].

CONCLUSION

In this paper we have present Krishi Kontho, which is an agricultural information service that sends voice messages, and SMS, to farmers, in order to provide them with agricultural knowledge, which is in step with the life cycles of their crops. In addition to presenting the design of the agricultural information service we also reported from an eleven-month field trial and found that the service may improve crop yields while reducing production cost. Furthermore, the farmers valued the service and were able to pair their knowledge of farming with the advice offered by the service. The service addressed the challenge of limited literacy by providing advice in the form of voice messages, rather than for example only text.

One challenge associated with Krishi Kontho and services like it, especially in developing regions, is the question of financially sustainable. This is an open issue. Also open for further research is the integration of weather and market information, and the question of how to further personalise the service to better fit the knowledge profile of the individual farmers.

In sum, the paper has addressed the core HCI problem of designing for the temporality of practice. It has done so by providing an example, Krishi Kontho, made to deliver agricultural advice to low-literacy rural communities in the Global South in accord with the rhythms of their crop cultivation practices.

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PUBLICATION 2

Are You Magicians? The Collaborative Work of an Agricultural Information Service

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Are You Magicians?

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ABSTRACT

Based on fieldwork, we investigate the integration of an agricultural information service into a rural community in Bangladesh. We find that it takes work beyond the initial design and cursory introduction of the service to make the service work in a low-income rural community: it takes the strength of the farmers self-help groups to circulate the messages by word-of-mouth, it takes posters placed at key junctions according to a socio-geographic understanding of the village manifest in a map, and it (ideally) involves the support of the elite of the community via the broadcast of messages at places of high symbolic value. It takes all this in addition to a well-made information service delivering relevant and timely messages on for example agricultural matters. Hence, reducing the issue to one of technical delivery mechanism does not tell the full story.

CCS CONCEPTS

Human-centred computing; Empirical studies in HCI; Computer supported cooperative work

KEYWORDS

ICT4D; HCI4D; climate and agricultural information service; mobile agricultural advice; appropriation of technology; field study; cooperative work.

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1 INTRODUCTION

Information and communication services have the *potential* to increase the reach of agricultural extension by providing agricultural advice to smallholder farmers in the Global South [13, 17]. For example, Patel et al. [18] describe the use of a voice-based service called Avaaj Otalo which allowed farmers to connect to a question and answer forum, to record questions, provide answers, or browse an existing list of questions and answers. Christensen et al. [7] analyse how a mobile information service that synchronises messages with the crops stages of the farmers come to improve crop yields. Furthermore, Nyareza & Dick [15] describe radio as a way to broadcast information in some (more affluent) rural areas, including information on agriculture.

It has been established that working an ICT initiative into the fabric of a rural community in the Global South requires collaborative work and effort [9, 16, 26]. Relatedly, the interesting point is what kind of work it takes, whose work, what the modalities of this work are, and what social and technical infrastructure is it based on. Indeed, there is a lack of research detailing the cooperative work of making technological initiatives work in disadvantaged communities in the Global South. Arguably, this is a piece of the puzzle that is crucial to understanding why some initiatives thrive where others fail. One notable effort to fill this gap, albeit outside ICT for agriculture, includes O'Neill et al.'s [16] ethnographic investigation of the work of making a new digital loan payment service work for auto-rickshaw drivers in Bangalore. Relatedly, Wyche & Steinfeld [26] argue that designing ICT services for rural communities demands great attention to the broader ecosystem in which the service is to be used.

Building on the existing literature, we investigate the integration of an agricultural information service into a rural community in Bangladesh. The service is called the Climate and Agriculture Information Service (CAIS). We explore the work of integrating the service into a wider socio-technical ecosystem. In this manner, we aim to contribute to the body of research detailing the cooperative work of making technological initiatives work in disadvantaged communities in the Global South.

Our empirical data originate from an exploratory field study in a rural community in Bangladesh. We find that it took

concerted efforts beyond the initial design and cursory introduction of the service to make the service work in the community: it takes the energy of the farmers self-help groups to circulate the messages by word-of-mouth, it takes posters placed at key junctions according to a socio-geographic understanding of the village manifest in a map, and it (ideally) involves the support of the elite of the community via the broadcast of messages at places of high symbolic value. It takes all this in addition to a well-made information service delivering relevant and timely messages on agricultural matters. This is what we mean when we say that technology cannot stand alone.

The paper will proceed as follows. First, we will consider related research. Secondly, we will turn to the field setting and the methods of the study. Third, we present an analysis of the integration of the agricultural information service into the community. Fourth, we will discuss the findings. Lastly, we will provide a conclusion.

2 RELATED RESEARCH

Agricultural information services in the global south typically aim to overcome the shortfalls of information within smallholder rural communities by supplementing local knowledge with (expert) agricultural advice, local weather forecasts, or local market prices for agricultural products, or some combination of the three [9, 13]. For example, the Knowledge Help Extension Technology Initiative (KHETI) in Madhya Pradesh, India, was used to raise awareness of agricultural extension services among farmers by providing them with mobile phones with short dialogues and videos [10]. Another example is Gandhi et al. [19], who developed Digital Green in India to provide targeted agricultural advice to farmers via video. Using a comparative experimental design, the authors found that Digital Green users had higher adoption rates for certain agricultural practices as compared to conventional extension approaches used by another group of farmers. Christensen et al. [7] examine the use of an agricultural information service in rural Bangladesh that push voice messages, on weather and crop-related issues, to the farmer's phones in a manner closely synchronised with the growth stages of their crops. The mixed method study shows increased crops yields as well as user satisfaction while also discussing the limitations of the service not least in terms of financial sustainability [7]. In addition, Patel et al. [18] developed a voice message forum to foster the creation of online communities of farmers sharing advice and local knowledge. Some messages were on weather-related issues, others on pest control, irrigation, fertiliser use, and the crops cycles in general. The authors found that the farmers were mainly interested in (expert) technical agricultural advice, thereby suggesting the need for such advice. Other initiatives have focused on improving the bargaining power of smallholder farmers vis-à-vis traders by servicing them with market information for example by sending text messages with price information on several nearby markets [13] – thereby ideally providing farmers with an informed choice on where to sell their produce. A key assumption of these services is that addressing a key market failure – that of imperfect information – will help poor rural populations sell their produce at higher prices [1, p.43]. While some studies have noted that access to markets information services actually have improved the livelihood of farmers, other studies have found that the lack of trust in unfamiliar traders, road distances, and long-standing ties with dominant traders, often weight heavy on the farmers decision making when it comes to deciding where to sell their produce [9]. Relatedly, Burrell and Oreglia fundamentally criticise the notion that 'market price information' may benefit at all income levels, and describe it as a myth that it will 'automatically result in market efficiency'. In their account, market prices may be subordinate to other factors in trade-related decision making such as the before-mentioned nature of social ties.

ICT initiatives may vary not only regarding the types of agricultural services and the information they provide but also in terms of the human and institutional support that they are associated with. The least supported services offer access to voice-based or text-based databases of information regarding agricultural practice, weather predictions, or market prices – but no additional support. More integrated services may offer in-person technical and agricultural training, support by phone, or support through e-learning programs [1]. Some services are part of a larger socio-technical environment comprised of e.g. physical facilities, human expert advisers, and access to agricultural inputs. For example, the eChoupals initiative, operating in Madhya Pradesh in India, provides market prices and weather information integrated with crop transportation facilities, weighing and storage, and payment system (Kumar 2004). Another service is Grameen Foundations *Community Knowledge Worker* initiative in Uganda, which equips extension agents with smartphones to act as community agents of agricultural information [14].

Furthermore, some ICT initiatives explicitly set out to mitigate climate change related issues [13]. For example, Donovan [9] reports on a project focused on forecasting the microclimatic conditions of the Kastamonu province of Turkey to local orchards giving them sufficient time to prepare for e.g. cold snaps. Another example focused on building climate change resilience is early flood warning in Nepal. Due to climate change flooding is exacerbating in parts of rural Nepal. Giri & Malakar [12] reports on a project enabling upstream villages to warn downstream villages of river flooding at an early stage. Helping reduce damage to property, crops, and livestock. Bangladesh's Plant Clinics are another example of ICT interventions responding to climate change issues such as increased salinity in the soil in coastal areas due to sea-level rise, more frequent flooding, delay in monsoon, and crop failures due to erratic weather patterns [2]. The Plant Clinics support farmers whom can call them and ask for advice and visits. The lesson from this project is that climate change adoption needs to be integrated into broader agricultural information services and must be locally relevant and specific [2].

The above studies, then, suggests that farmers in the Global South can benefit from agricultural information services receiving agricultural advice, market information, and actionable information on local climate. However, these studies rarely focus on describing *in detail* the cooperative work of making these services work in the first place. As mentioned, one notable effort to address this theme, although outside agriculture, is O'Neill et al.'s [16] ethnographic investigation how a new digital loan payment service is worked into a community of auto-rickshaw drivers in Bangalore. Making an ICT initiative usable for its intended users may take considerable work and may only be achieved as the service becomes embedded into a wider, trusted, socio-technical ecosystem. As Donovan holds "technology cannot be airdropped into a situation and guarantee positive results" [9, p.57]. Relatedly, Wyche & Steinfeld [26] makes the argument that designing successful ICT services for rural communities demands close attention to the ecosystem in which the service and its technical devices operates. Their conclusions are based on a study of the use of mobile phone by farmers to gain market information in rural Kenya. In addition, Chaudhuri et al. [3] study the practices surrounding the implementation of a weather information system for farmers in West Bengal and find that the capabilities of the ICT system are intimately tied to how it is made part of local practices.

As indicated, we build on these above studies to examine the cooperative work that enables smallholder farmers to benefit from an agricultural information service in Bangladesh and attempt to show how the agricultural information service becomes embedded into the wider socio-technical ecosystem in order to work.

3 METHODS AND SETTING

In this section, we shall describe the methods and the setting of the study.

3.1 Methods

We conducted the field study of the practices associated with the introduction and use of the Climate and Agriculture Information Service (CAIS) over a period of six months in late 2017 and early 2018. We conducted extensive participatory observation, carried out six in-situ semi-structured interviews, and conducted three focus groups with the farmers. The participatory observation was conducted mainly by the second author, while the interviews, the focus groups, and a lesser part of the ethnography, was conducted jointly by the authors.

We conducted participant observation on the use of the service in the villages. This included accompanying the NGO staff working in the villages during their employment of the information service, and it included being with the farmers as they used the service, shared and talked about the information, and farmed their land. Informal conversations with the farmers and the NGO staff where a large part of conducting the participant observation, and in addition to begin informative, these conversations served to create rapport with the informants. At the time, the second author was part of the organisation mPower which was the technical partner in the project and as such with the project for the duration.

The three focus groups with the farmers included questions on education; family; community; village life; financial circumstances; income; climate; farming; and their experiences with the agricultural information service. The focus groups were conducted in Bangla, the language of Bangladesh.

Of the six semi-structured interviews, five where with NGO staff, and one was with a local government official. The interviews with the NGO staff included questions on background; work experience; the NGO; relationships with farmers; village life; climate; and their experiences with the agricultural information service. The interview with the government official was on the activities of government sponsored agricultural extension in the area and the plight of the local smallholder farmers.

The data from the participant observation, focus groups and interviews was recorded through extensive field notes, audio recordings and photographs. The focus groups and individual interviews were transscribed and translated into English. Our analysis took a broadly practice-oriented perspective [6, 8, 22, 25] with inspiration from ethnomethodology [11, 20]. Practice studies, in our perspective, explicate how participants organise their practice and emphasise the ways in which technologies and artifacts are an integral and indispensable part of the accomplishment of that practice. The authors read through and discussed the data in various analytical session in person and on Skype. The data was organised into themes as topics emerged from the analytical sessions. A concerted effort was made to have the themes, and in turn, the findings emerge from the data itself.

3.2 Setting

The geographical setting of our study, where the farmers live, is part of the Chalan Beel wetland in the Sirajgonj District of Bangladesh. This is a large inland depression, marshy in character, with multiple rivers and waterways running through it. An important geological factor affecting farming and living in the area is the large proportion of silt carried by its rivers. It is the silt which has created the land and made it habitable by building up through the years and centuries. It is slit which is fertilising the land but is also the silt which is at the core of the precarious situation of the people in the area. Silt is depositing continuously in the river beds and is thus making the rivers change course regularly. Although this is a reoccurring phenomenon, it can be somewhat unpredictable, creating problems for people living and farming on the silt islands. The farmers seasonally, and sometimes permanently, has to abandon an area that is going underwater to move to new slits islands, which are developing and emerging out of the water from silt deposit on the river bed. This makes for precarious livelihoods when one is dependent on working the land for income and sustenance as the farmers are. Surveys typically classify Bangladeshi smallholder farmers as poor or extremely poor [21].

Smallholders typically earn minor amounts on a seasonal basis depending on crop yields and prices. In addition to relying on their farms for financial income, the farmers in our study depend on their agricultural output for sustenance. Low crop yields, or outright crop failures, therefore represent a serious challenge to the farmers. During flooding or other agricultural crisis, the male household member often seeks alternative employment such as running a local tea stall or operating a rickshaw on the mainland. However, this alternative self-employment is typically inadequate in terms of supporting a household of often ten members or more. Some of the households that were part of our study were struggling.

The village, the main setting of our study, is situated on a Char islands which is less than ten years old. It is flooded seasonally at the height of the monsoon. This does not mean that the community is no more than ten years old. Indeed it is, it just means that the present village location is no older than that. Given their precarious situation, it is perhaps no surprise that many farmers in the area are extremely poor. In addition to the flooding, the Char situation creates land disputes and title to land can be hard to secure legally for the farmers. Although the farmers in practice may farm a plot for years, they may not be able to gain title to that particular plot legally, and hence are not able to use it as collateral for investment loans. Even if farmers were to gain the land title, commercial lenders are not disposed to accept chars land as security for long terms loans, as the land itself can hardly be described as secure.[1] This situation leads to a lack of large-scale investment in agricultural production on these islands. Hence the production remains underfunded.

4 WORKING AN ICT INITIATIVE INTO A RURAL COMMUNITY

It has been established that working an ICT initiative into the fabric of a rural community in the Global South requires collaborative work and effort [9, 16, 26]. As mentioned above, the interesting point is what kind of work it takes, whose work, what the modalities of this work are, and what social and technical infrastructure is it based on. We may dub such efforts *integration work*. By this, we mean the collaborative work required to extend the digital infrastructure into the community and make it part of the community. These are the themes that we address below. However, before doing so, it is timely to introduce the design of the agricultural service alluded to above.

4.1 The design of the agricultural information service

As indicated above, the Climate and Agriculture Information Service (CAIS) is a mobile service that delivers agricultural information to the handsets of smallholder farmers in Bangladesh. It was developed in a collaboration between mPower, the technical partner, the farmers and the local NGO Manab Mukti Sangstha (MMS) as well as the NGO Friends In Village Development Bangladesh (FIVDB). All funded by the German NGO Welthungerhilfe. During the development, mPower, the technical partner, visited the field site twice and facilitated a co-design process with representatives of the armingcommunity together with the local NGO team. In this process it was agreed that the service should support smallholder farmers by (1) assembling weather forecasts from the public domain for the specific village locations, (2) associate agricultural advice with the weather forecasts, and (3) send text messages to the farmers with the weather forecasts and the associated agricultural advice. The rationale for this new service was that smallholder farmers in remote rural areas do not have access to such information. The governmental agricultural extension service does not have the resources to visit the farmers on the Char islands frequently enough. Not only is the public agricultural extension service understaffed and underfinanced, it is also considered somewhat dangerous for the extension officer to visit the Char islands. In addition, there is no electricity on the Char islands other than one or two solar panels per villages. These are mainly used for lighting and charging mobile phones. Nobody owns a TV set. Hence, the farmers in the area do not have access to local weather forecasts, nor do they have access to expert agricultural advice.

The service was designed to send SMS messages to 250 farmers once a week during normal conditions and up to three times a week during disasters such as flooding. To make the service operational basic data on the names of the farmers, their mobile phone numbers, crop types, crop stages, and more had to be collected by MMS and FIVDB, and entered into the system. In addition, an initial series of alert types had to be created by agricultural experts working for the project. That is, for each crop types, crop stage, and weather condition an appropriate message for the farmers had to be created. It was mPower that generated the local weather forecasts based on public domain data, and the associated agricultural advice was made in a collaboration between mPower, Welthungerhilfe and agricultural experts at MMS. The content validation was done by Agriculture Officers at the Department of Agricultural Extension (DAE). This is an example of the web-based panel of the service:

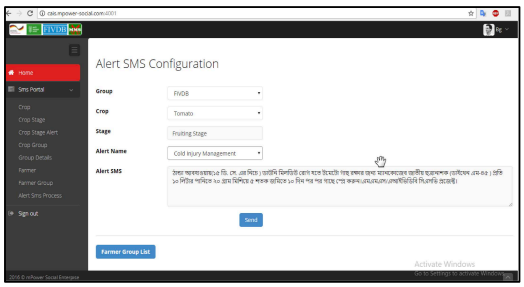

Figure 1. SMS panel

[1] There are of course other (historical) reasons for the precarious situation of these farmers such as for example overpopulation and the colonial heritage.

The figure above is illustrative of the system (see figure 1.). It shows how NGO staff may configure text messages to groups of farmers based on upcoming weather conditions and associated that information with agricultural advice. We can see that the group of farmers involved is designated FIVDB, and we can see that the crop concerned is tomato at the fruition stage, and the subject of the message is Cold Injury Management. That is, a cold snap is approaching, and the farmers are warned to take precautions to shield their Tomato's from the cold:

A cold wave with heavy fog may occur in your area in the next 2-3 days. During that time, to protect your tomato plants from fungal attack spray fungicide (Dithene M-45) onto the plants. Use 20 mg in 10 liters of water for every 5 decimals2 of land. (SMS sent 2nd Jan 2018)

Another example of the content of the service is a message which is also concerned with the prevailing cold weather and fog in the area. The concern here again springs from the fact that fog may leave dew on the leaves that in cold weather may lead to fungus. A method of removing the dew drops is advised:

The mild cold wave with heavy fog will continue this week too. Due to cold weather do not irrigate in the sweet gourd field at the flowering stage but do mulching. Remove dew (fog) from the upper leaf of the Boro rice plants by using a string moving across the field. (SMS sent 14th Jan 2018)

Moving long cotton strings or nylon cords across the upper leaves of the plants may shake off the dew and reduce the risk of fungus infecting the plants. Rain, in general, is a concern:

There is a chance of heavy rain (44-88 mm/day) in your area within the next two days. Create drainage in the seedbeds of chilli, tomato, bottle gourd and sweet gourd so water can drain quickly. (SMS sent 19 Oct 2017)

Draining is advised to prevent stale water and in turn rot in the seedbeds. Some crops tolerate stale water far better than others do, rice being the obvious example. Another example of agricultural management advise is concerned with pollination, it is related more to the stage of the crop than to any upcoming weather condition. In fact, the weather is not mentioned in this message:

Do hand pollination (manually transfer pollen from the stamen of one plant to the pistil of another) in the bottle gourd plants in order to maximise fruit. (SMS sent 5th Jan 2017).

The above messages are examples of the kind of SMS messages that were sent to the farmer's phones through the service. We shall go into the reception and use of this kind of messages below. For now, let us elaborate on the message system. Consider an example of message configuration concerned with eggplant.

The table below (see table 1) is one of the original ones used among many others as a basis for the service (albeit the recommendation SMS part has been translated from Bengali to English as a service to the reader). Mapping the connections between crops type, crop stage, DAS stage[3], weather condition, threshold values, and SMS message texts. First, a list of priority crops was selected by the farmers in collaboration with the NGO field staff. Subsequently, a list of adverse weather conditions was drawn up defined by threshold values. The idea being that if real-life conditions at a given time meet the values of a defined "adverse weather condition" then the associated set of SMS messages would be sent to the farmers. The messages sent to 500 farmers designate as "lead farmers", i.e. those individuals leading a particular village self-help group (we will elaborate on the importance of these gropus below). The lead farmers would receive only those SMS messages that pertained to his or her group, that is, their crop types and the stages of these crops. This logic required MMS staff to record data on the lead farmers (i.e. name, location, phone number, group) and record and update data on the groups continuously (i.e. crops types, sowing dates, and crop development). If was important to have accurate data on these items for the service to be able to function as planned. This data work was assigned to MMS staff.

Crop	Crop stage	DAS Crop Stages	Adverse weather condition	Threshold values	SMS text
Egg-plant	Seed sowing	DAS 1-6	Heavy rainfall	44-88 mm/day	
			High temperature	More than 30 C for 3 consecutive days	
			Drought	Mild to medium drought for 1 month	
			Cold injury	Less than 15 C for 3 consecutive days	
			Cold injury	Less than 15 C for 3 consecutive days	

Table 1.: This table is an example of the systematic configuration of messages for the service, here, the

[2] A decimal is a unit of area in Bangladesh approximately equal to 1/100 acre or 40.46 m^2.

[3] DAS is an international standard that in a very detailed manner refers to different growth stages of crops.

example is concerned with eggplant during the stage of seed sowing.

Having presented the service, and the basic features of it, we are now in a position to consider how it was worked (further) into the fabric of village life.

4.2 Word-of-mouth

At first, the main village studied resembled any other village in the Charlands of rural Bangladesh that the authors had visited during their stay in the Sirajgonj district. Yet, from talking to the villager's something about its organisation stood out. Assisted by the local NGO, the villagers had organised themselves into self-help groups each comprised of about ten farmers with one of the farmers acting as 'lead farmer' for the group. The lead farmer was someone with a certain standing in the local community and was, without exception, the owner of a mobile phone. Far from all the farmers in a self-help group owned such a device.

A shared consensus among the farmers, that village life benefitted from these groups, emerged from conversation. The self-help groups had mapped the village, created a savings scheme, and acted as conduits for the information delivered by the agricultural information system. The lead farmer of the group would receive the messages from the service and in turn relay the advice to the rest of the group (most of which had no phone). This oral retelling of the advice created a word-of-mouth network, where the lead farmer would tell one or two other farmers from her group, and these farmers would, in turn, tell other group members, and perhaps also the neighbours, and so on. In this manner, the advice would spread by word-of-mouth. Word-of-mouth would extend the digital infrastructure of the agricultural information service. This was necessary to reach more farmers.

During this process of retelling, of relaying the advice from the phones of the few to the ears of the many, the information would be contextualised through conversation, it would be interpreted, and instructive conversation sparked by the information would emerge.

"I could not at first understand the message about the fertiliser, but she explained it to me, and showed me how to mix the fertiliser and the water right."

By word-of-mouth the information from the service would be retold, lead to instruction and learning, and in this manner be far more valuable than mere 'objective' relaying of the messages could ever be. The point is that the engaged retelling of the information by the members of the self-help groups improved the service, it added value to the service. This is because the retelling created opportunities for conversation, instruction, and collaborative learning. This would happen, for example, in relation to understanding the use of fertiliser as the quote above indicates, and it would happen in relation to learning new farming techniques such as the removal of dew from plants to avoid fungus. One message from the service reads like this on a mobile phone:

The mild cold wave with heavy fog will continue this week too. Due to cold weather do not irrigate in the sweet gourd field at the flowering stage but do mulching. Remove dew (fog) from the upper leaf of the Boro rice plants by using a string moving across the field. (SMS sent 14th Jan 2018)

Figuring out how exactly to move a cotton string across a rice field to drop dew from rice plants is not obvious if you have not tried it before a farmer told us. The retelling of a message, such as the one above, by one farmer to another may create a collaborative learning situation where the two farmers in collaboration figure out how this is done, or if need be, ask for further assistance from for example the lead farmers, who have often been educated in farming techniques by the local NGO.

Another matter for deliberation among the farmers is the accuracy of the weather forecasts which were often part of the messages as seen above. On one occasion the weather forecast was off (as such forecasts occasionally are), that is, the message had predicted heavy morning fog, and the farmers had taken precautions by covering up some of their plants to lessen the risk of fungus, but in the morning no fog. This situation prompted some good-humoured mockery of the NGO staff by the farmers. The NGO staff who had introduced the service was seen as vouching for it, as responsible for it. When weather predictions were right, it would lead to praise of the NGO staff by for example farmers asking – half in jest and half in earnest - "are you some sort of magicians?". And when the predictions were off it would as mentioned lead to good-humoured taunts. This goes to show the degree to which the local NGO staff were strongly identified with the service that they introduced to the farmers (but only in part designed).

The weather predictions were more often right than wrong, and the farmers ended up mostly adhering to them, as ignoring them could have serious or even devastating consequences for their crops. Taking precautions against adverse weather such as fog (covering plants), or heavy rain (digging rain gutters), was at worst a waste of time if the weather forecast was wrong. It was not a disaster as ignoring the weather forecast might be as fungus-induced by fog or rain might take the plants. In this manner, there was a certain economy of practice is adhering to the weather forecasts, rather than ignoring them. The prediction of rain may also save on irrigation, but if the rain does not come, the plants are at risk of drying out. So, there is something at stake, and therefore the messages were often the object of reflection, conversation, and deliberation, rather than something which was followed 'mechanically'.

4.3 Posters

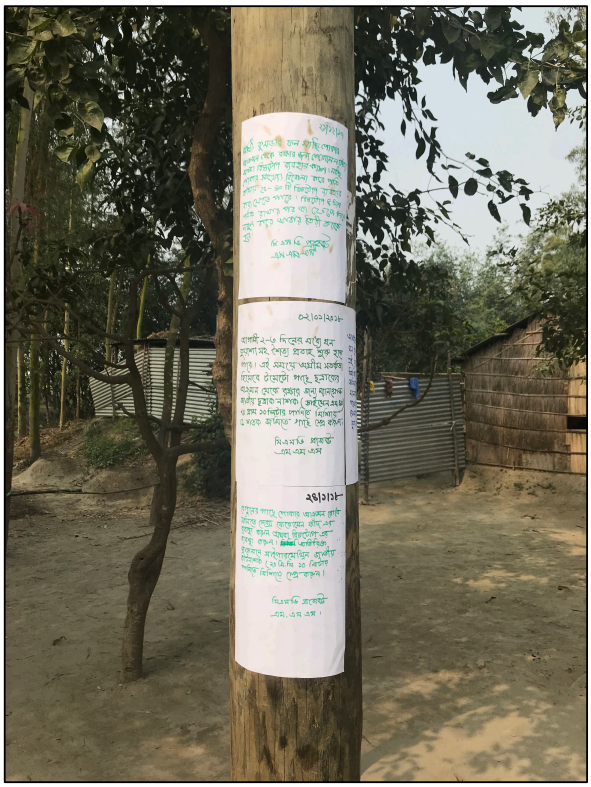

Figure 2: Handwritten posters with messages from the agricultural information service were placed at central locations in the village.

Another way of reaching those without phones where through posters placed at central spots in the village (see figure 2). Posters were most often handcrafted by the lead farmer, or NGO staff, and displayed the (phone) messages that were deemed to be of special importance to the farmers.

Messages where at times, though not always, placed at spots where they were especially relevant. For example, messages about the risk of flooding were placed at flood-prone areas, posters on the risk of fog were placed where fog might gather, and messages about certain crops were placed at their fields. It emerged from conversations that the farmers had very good knowledge of the layout of the village. The farmers pointed to the collaborative creation of maps as contributing to this understanding. Let us elaborate.

The farmers had in collaboration with the local NGO created a map of the village which depicted the village, its households, and it (ecological) vulnerabilities (see figure 3). Lowland and saline-prone areas were singled out on the map as potential trouble spots. That is, areas that called for vigilance and a concerted collective effort. In addition, all the households were shown and given a number for easy reference on the map. Furthermore, important structures such as the village Mosque and the local boat mooring site is also shown. The map shows all 366 households of the village, it shows what kind of crops are planted where, and it shows what areas are flood-prone, what areas are drought-prone, and where fog may gather. Furthermore, it contains information on the quality and nature of the soil that are important parameters for agriculture. Also, colour codes are used to designate households with for example pregnant women or children under the age of five. Both being indicators of a vulnerable household – someone to "look extra out for". Every six months or so the maps where to be updated – to reflect the development in each household and each field if any.[4]

This mapping of the village, this sense of place, was used by both those (lead) farmers that placed the posters and by those farmers that subsequently read them. The digital information service was extended by the posters, then, and in this work of integrating the advice into the fabric of the villages the maps played an important role as enabler. For example, from looking at the map, it was readily apparent to the farmers that messages concerning maize cultivation, maize pests, and maize diseases belong next to the maize fields. While, messages concerning fog were relevant to those farming the fields where the morning fog gather, and so on. In this manner (some of) the advice and forecasts stemming from the service were 'plotted onto the village map' and in the process gathered meaning and significance. For whom, what, or where a message might be relevant was partly settled with the help of the village map. Not necessarily by overtly pointing to the map but more often by reference to the knowledge that the making of the map had created.

That the map of the village, and the knowledge made in the process of producing it, became a frame for appreciating the messages testifies to the importance of framing. That is, we may argue that the (fruitful) reception of the messages was in part due to the villagers own high level of self-understanding and appreciation of their situation which was (partly) generated in spatial terms via the map and mapping process. We should not overemphasise the importance of the map as an artefact but rather recognise the process of making the map as a contribution to the villages self-understanding and by extension also to their sense of community and solidarity.

The map, then, in its many incarnations and versions, is not a traditional map for travel, locomotion or navigation. Rather, the map is a depiction of the socio-spatial configuration of the village, including the vulnerabilities of the farmers, including their flood-prone fields, their drought-prone fields, their saline soil, and places where fog may gather and in turn fungus may appear. Moreover, one can see the placement of the posters as a direct extension of this mapping, this spatial view of the village. The poster was placed, assigned places, in accord with the

[4] The farmers showed the authors several versions of this map.

villagers' socio-spatial knowledge of themselves and their lifeworld. Placing a poster well, where the message might be needed, is a way to continue to manifest socio-spatial knowledge.

The map reaches out beyond the agricultural and includes as mentioned all households, with an emphasis on vulnerable families with children, has landmarks such as the mosque and more. The local mosque, in the midst of the village, was also central to the circulating of the messages as we shall see next.

Figure 3: Map of the village made by local farmers in collaboration with MMS the locally active NGO. The map roughly represents an area of 2,25 km^2.

4.4 Public announcements

The village mosque lies at the centre of village life, metaphorically as well as physically. It is the spiritual, moral and religious epicentre of the village. Therefore, it was a blow to the project that the local Imam, after consideration, disallowed NGO staff's use of the mosque's PA system as a means to broadcast messages. The local Imam did not approve of the announcement of messages such as weather forecasts and associated agricultural advice, stemming from the service, in his mosque. The reason given by the Imam was theological: "only Allah knows". The field officer assigned from the local NGO to the village comes every five days or so and was hoping to announce some messages and forecasts to the villagers using the mosque. Select messages on for example extreme weather predictions such as drought or flooding that may be considered important and even vital for the welfare of the village. And the NGO officer was hoping in the process to promote the service and the work of the NGO. A few messages were mic'ed in the Mosque – to use the expression of the NGO officer – before this practice was discontinued.

Using the Mosque as a platform would have not only potential practical benefits - i.e. a large audience for the messages - but also symbolic significance. That is, by broadcasting from the Mosque, by using the mosque as a broadcasting platform, the legitimacy and status of the service would be heightened considerably according to NGO staff. As mentioned, this was not to be as the practice was soon discontinued by the intervention of the Imam. The Imam concluded that Islam does not permit such messages in a Mosque. By this act the reverse of what the NGO hoped for happened, that is, the legitimacy of the agricultural information service decreased in the eyes of the villagers. In conversation with the local field officers if became apparent that the support of the local elite, including the Imam, was important to the implementation of any kind of development initiative, including the agricultural information service in questions here.

Although the Imam, then, denied the NGO the legitimacy associated with speaking the messages in the Mosque, the promotion of the service outside of the Mosque was tolerated by the Imam. He just preferred to reserve the Mosque for the excursive of religious practice and was not willing to let other kinds of messages, messages associated with science, another form of authority, into that space.

The farmers, for their part, valued the weather forecasts. The records of the NGO show that approximately four out of five messages were accurate in terms of predicting the local weather. One has to keep in mind that before the introduction of the service the farmers had not experienced a digital service of this kind before. Previously their access to general regional weather forecasts was very limited as the village had no televisions nor radios. Mobile (feature) phones were the only communication technology available - and the village was without access to the Internet. Thus, information from beyond the island came with people coming and going to and from the village by boats and small ferries and by phone calls. Before the introduction of the service, accounts of the upcoming weather were anecdotal at best and based on regional forecasts that the travellers or commuting workers had seen or heard in the city perhaps the day before. In contrast, the weather forecasts of the service were local, rather than regional, and associated with agricultural advice such as "cover your tomato seedbed with plastic sheets due to upcoming heavy rain", or "dust your eggplants with ashes as fog is excepted tomorrow morning". One farmer told us that he lost almost an entire field of eggplants the year before the introduction of the service due to fungus infection, this year he spread ashes on the leaves to prevent morning fog from settling on the leaves, this, in turn, prevented the spreading of fungus and improved his yields. The farmers tell us that he hardly lost an eggplant to fungus this year. We heard many accounts like this. Obviously, the value of the service, especially in relation to crop yields, cannot be evaluated based on anecdotal evidence alone[5], and therefore we will make no sweeping claims regarding yields. Rather, we will suffice to say that it emerged through conversation that the farmers experienced the service as valuable and worthwhile.

[5] Rather, an impact evaluation would require a systematic evaluation of the service with for example a baseline and end-study. This is beyond the scope of this paper.

Moreover, using the service can be characterised as a learning experience, rather than a mere 'consumption' of messages. For example, the technique of spreading ashes to prevent fungus was new to the farmers. It was something that they learned through the service, and through conversations with peers using the service. The farmers also learned to moderate their use of fertiliser and pesticides and thus save money, safe keep the environment, and improve crop yields. Just as they learned a number of other agricultural techniques associated with the crop cycle, weather, disease and pest prevention. In this manner, the experience of using the service, the outcome, was to a large extend educational. For example, once the farmers had learned that fog threatens fungus and that spreading ashes is the appropriate countermeasure against this threat, then this lesson had been learned, once and for all. That is, after having used the service for a while some of the advice associated with the weather forecasts became somewhat superfluous to some farmers. The weather forecasts in time became enough for some of the farmers that had learned the weather-related advice by hearth. They had, from engaging with the service, already learned the techniques and did not need to have them repeated. This testifies to the educational value of the service.

5 DISCUSSION

Taking our cue from the title of the paper, we may note that although all good technology may appear as magic to its users,[6] none was involved in our case. Rather, it took hard work and a concerted collaborative effort to make the service work. The work to make ICT initiatives work, embed themselves, and become an integrated part of practice may easily be overlooked. In our case, it took the diligent and careful work of the farmers and the NGO staff, as well as the resources and infrastructure of the community, to make the agricultural information service work out. To put it in general terms, the co-constitution of practice and technology may require intentional effort and cooperative work [see also e.g. 4, 5, 23, 24].

Our findings resonate with the work of O'Neill et al. [16], Wyche & Steinfeld [26], and Chaudhuri et al [3]. As noted above, these studies either emphasise or prescribe the collaborative efforts of working an ICT initiative into a community in the Global South. The studies differ in scope and subject matter e.g. urban vs rural and finance vs agriculture. Common, however, is the acknowledgement that ICT initiatives do not sort themselves out by default, it takes work to make them work. This point echoes the slogan purported by Donovan, namely, that "new technology cannot be airdropped into a setting" [9]. An ICT service in action may metaphorically speaking be described as a living and breathing entity, that needs nurturing, care, and legitimacy to work in a community. In the eyes of the users' legitimacy may be achieved through the demonstration of practical value as well as through more symbolic means. Two very different kinds of legitimacy. The paper shows how hard it may be to achieve both kinds - the latter via the blessing of all stakeholders in a village community – and the former through cooperative work in the village.

We may say that climate change resilience in the context of agriculture may be addressed by providing information to the farmers on the weather, on a local scale, and importantly, what to do about it in actionable terms. It is perhaps one of the strengths of the service, its core value, that it operates at the intersection of climate and agriculture by coupling weather forecasts and agricultural advice. The (derived) benefits of learning agricultural techniques, the prospect of higher crop yields and better food security, and in turn improved livelihood, all this, may very well lie at the nexus of climate and agriculture, between the weather and how to act in accord with it agriculturally speaking. This is true not only for the farmers in our case but for farmers in the Global South in general (and elsewhere on the planet for that matter).

In its own limited way ICT initiatives, of the kind we have described in our case, may contribute to building resilience to climate change, not by warding off the rising sea water, or stopping the torrential rains, but rather by promoting micro adjustments to for example agricultural practice in step with the changing climate on a localised level. In the best cases, what ICT of the kind described here may do is that it may work locally to diminish the harms of climate change while improving livelihoods. To achieve that, and this the point, one must acknowledge the local collaborative efforts and the local socio-technical networks, in their many forms, that makes such ICT initiatives work in a community.

6 CONCLUSION

In this paper, we have examined the collaborative efforts associated with working digital advice into a rural community. That is, we have examined the introduction and use of a mobile service that delivers agricultural information to the handsets of smallholder farmers in Bangladesh. The service was designed to support smallholder farmers by assembling weather forecasts from the public domain for specific locations on a localised scale, associate agricultural advice with the weather forecasts, and send text messages to the farmers with the combined weather forecasts and matching agricultural advice. The digital advice of the service was obtained and appropriated through local community networks, and in several modalities, including, word-of-mouth, poster, and public announcements. It took the strength of the farmer's self-help groups to circulate the messages by word-of-mouth, it took posters placed at key locations according to a map of the village, and it took an (aborted) effort to publicly announce the messages at a place of high symbolic value. It took all this in addition to a technically well-made mobile information system to deliver the agricultural advice to smallholder farmers.

[6] The futurist Arthur C. Clarke famously proposed that "Any sufficiently advanced technology is indistinguishable from magic". By this he meant that technology may appear 'magical' at first sight to the uninitiated.

Working an ICT initiative into the fabric of a rural community in the Global South, then, requires collaborative work and effort. Relatedly, future research within ICT4D may further highlight what kind of work it takes, whose work, what the modalities of this work are, and what socio-technical infrastructure is it based on. Further research may further highlight this theme to tease out how such *integration work* may differ from case to case, from ICT intervention to ICT intervention. This may help build a body of knowledge related to this theme, and it may emphasise that during project work ICT practitioners may take such integration work into account.

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PUBLICATION 3

Agribuddy: Infrastructuring for Smallholder Farming in Cambodia

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ABSTRACT

Based on a field study, this paper presents an analysis of the ICT-driven agricultural initiative in Cambodia and shows how it may be understood as infrastructuring for value chain, for microcredit, and for capacity building. The paper considers the relational, connected, emerging, and intentional character of the initiative. In doing so, it outlines an approach to the investigation and conception of infrastructuring for smallholder farming in the Global South.

CCS CONCEPTS

• **Human-centered computing**; • **Collaborative and social computing**; • **Empirical studies in collaborative and social computing**;

KEYWORDS

Collaborative infrastructure, infrastructuring, agriculture, ICT and development, Cambodia

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1 INTRODUCTION

In this paper, we consider infrastructuring for rural development in the Global South, including how initiatives may strive to work on market terms and potentially address some of the plight experienced by smallholder farmers. We are inspired on the one hand by the wave of infrastructure studies that are motivated the move 'from artifacts to infrastructures' with a view to expand the conceptual and empirical basis of the research field [e.g. 3, 16, 19, 35] and on the other hand we are informed by research on rural and agricultural development in the Global South, especially in regard to the importance of value chain integration [e.g. 24], access to microcredit [e.g. 8], and capacity and skill-building [e.g. 6]. We bring these perspectives together to examine Agribuddy, which can be described as an ICT-driven initiative in-the-making that aims to promote smallholder farming in Cambodia and elsewhere. We do so to contribute, especially in regard to infrastructure studies and the conception of smallholder agricultural development in the Global South.

The paper is based on fieldwork and participant observations with the Agribuddy organisation in rural Cambodia. Most Cambodian smallholder farmers are at present part of a poorly integrated agricultural ecosystem. Their income is low, and most farmers cannot afford inputs such as seeds and fertilizer; banks don't like to give them loans as their income is unpredictable and often undocumented; manufacturers have a hard time explaining to farmers the correct way to use agricultural inputs such as fertiliser and herbicides; crop buyers cannot stock enough ingredients buying from the farmers so many machines and mills remain underused; and buyers are constantly short on cash. Agribuddy, the initiative in question, aims to address this situation by creating stakeholder integration and thus form an infrastructure for Cambodia agriculture taking the plight of smallholder farmers as their starting point.

This is a compelling case, as development initiatives to support the rural poor in the Global South are not typically conducted on market terms. Rather, development initiatives may be funded by (international) donors. Agribuddy attempts to reverse this trend by operating on market terms, rather than relying on donations. This is significant because historically speaking the development community has been somewhat struggling to create initiatives that are financially viable and live beyond their initial donor funding. Development initiatives may initially be successful but in turn have issues with their long term viability due to the lack of a "revenue stream" [13.]. There are exceptions to this, such as M-Pesa in Kenya [18.], and a few other initiatives [13.], but this is arguably the general trend. Donor agencies are presently trying to do something about this (unhappy) situation. That is, more and more international donor agencies are asking for project proposals that include plans for the continuation of the project beyond donor funding and are in effect asking for a "business model" with a substantial "revenue stream". In many cases working with a commercial partner is also seen as desirable [38.]. A such, the Agribuddy case is interesting to the development community, and the parts of research involved in development initiatives (commonly referred to as ICTD and ICT4D), because it pertains to a market-based efforts to create infrastructure that may be viable and improving the livelihoods of smallholder farmers in the Global South.

The Agribuddy initiative, our focus, can be understood in terms of its efforts to create inclusive integration through the creation of rural infrastructure. In our analysis, we focus on this work of infrastructuring and break it down, for closer scrutiny, into three parts: *infrastructuring for a value chain, infrastructuring for microcredit, and infrastructuring for capacity building*. Our findings show

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that these efforts may (potentially) bring the actors of Cambodian smallholder agriculture together to mutual benefit. Furthermore, we also consider the relational, connected, emerging, and intentional character of the initiative

The remainder of the paper is structured as follows. First, we consider the literature on infrastructural inquiry and in turn, identify infrastructuring efforts that may contribute to smallholder farming in the Global South. Second, we will introduce the setting and methods of the study, including data sources and analytical approach. Third, we will present our empirical findings and investigate efforts of infrastructuring that are central to the Agribuddy initiative and its aim of development for smallholder farmers in the Global South. We also consider the relational, connected, emerging, and intentional character of the initiative. Finally, a conclusion is provided.

2 RELATED WORK

In this section, we will attempt to bring infrastructure studies together with the stream of literature on interventions for smallholder farming in the Global South. We will start with the former.

As mentioned above, we are informed by the wave of infrastructural inquiry that calls to move HCI and CSCW 'from artifacts to infrastructures' and in the process expand the empirical and conceptual basis of the field [19.]. The argument is that localist empirical studies of the 'here and now' of computational artifacts may be supplemented with a view of (information) infrastructures that have presence beyond the local in terms of both space and time [19.]. In their (constructive) critique of infrastructure studies Lee & Schmidt [17.] note that the concept of infrastructure may be seen as complementary to what they refer to as the "indigenous" research program of CSCW that explores the socio-technical from the point of view of the local work practices [see also 32]. Granted, the study of locally situated work practices can span sets of interrelated work practices that overlap and intersect in a systematic manner [5.]. Having said that, a focus on infrastructure and the acts of producing and reproducing them offer an alternative perspective to 'localist' workplace studies in CSCW [16., 17., 19.].

Based on an extensive review of the literature, Karasti & Blomberg [16.] synthesise five dimensions of infrastructures:[1] (1) relational, (2) invisible, (3) connected to, (4) emerging and accreting to, and (5) intervention and intentionality. Let us consider the five dimensions in turn.

Infrastructures are fundamentally *relational* as they are embedded into work arrangements [11., 16., 35.] that they are at once scaffolding for as well as made of. That is, the relations between the heterogeneous actors are partly a product of the infrastructures that they enact as we shall see in the case of Agribuddy. A central assumption that has guided infrastructure studies across diverse domains is that they may be *invisible* when they function well and as such slip into the background of everyday interactions [16., 33., 36.]. They may become taken for granted once their use has become a mainstay of a community of practice [34.]. Bowker and Star Bowker and Star [3.] and Star [3.] focused on breakdowns as key sites of empirical inquiry, rightly stating that infrastructures may become remarkably visible during breakdowns [see also 20]. We may add that it is not only in situations of breakdown that we may explore key infrastructures but also as they are generated. As we shall see, in Cambodian farming, especially for smallholder farmers, it is not so much a case of infrastructural breakdown, as a case of generating infrastructure against a backdrop of *infrastructural absence* Infrastructure is not only relation it is also *connected* or connecting in the sense that it requires other elements to complete it, and in the sense that it connects these elements in both time and space [16., 34.]. For example, the Agribuddy infrastructure connects the spatial movements of goods and people to the tune of the temporal rhythm of the crop cycle as we shall see. Here the notion of *scale* is also important, as the infrastructure scales (or can scale) from connecting, for example, a few hundred farmers to connecting hundred thousands of farmers to a commercial process with global reach. Ribes and Lee talks of scaling up the number of collaborators or broaden a geographical reach [28.]. The object of study, then, may be a moving target as it expands and contracts in open-ended ways [16., p.238]. The relational character, the connecting and scaling, makes for an *emerging* phenomenon. That is, infrastructures are not only in-the-making but may come together in ways that are uneven, with backtracking, rather than forward moving continuously. Infrastructures, such as in the Agribuddy case, demand policing, upkeep and monitoring to keep momentum, to keep scaling [14.]. Infrastructure may grow or accrete, then, and this may require upkeep [16.]. Lastly, according to Karasti & Bloomberg's [16.] heuristics, the *intentionally* of infrastructures may represent many stakeholders, and in that sense, nobody is in charge of an infrastructure, rather a multiplicity of concerns and interests are at stake in a dynamic process. For example, the genesis, direction and scaling of an infrastructure may be traced back to livelihood and commercial concerns, but along the way multiple other factors such as public policy and regulation may tailor, shape, tune or even appropriate the initiative [16., 27.]. In addition, we may note that the verb *infrastructuring* (rather than, e.g. the noun infrastructure) is increasingly used to underline the in-the-making character of infrastructures [16., 27.].

Turning to the literature on smallholder agricultural development in the Global South, we may begin by noting that infrastructuring for a value chain is crucial to moving smallholder farming to commercial scale. To the move beyond subsistence farming, farmers have to bring their products to market and sell it at worthwhile prices. The organisation of the agricultural value chain varies among countries, between local and global food systems, and along a multitude of other dimensions including a particular region's economy, population demographics, geography, and culturally-specific diet requirements. The movement of produce from farms to consumers' homes usually involves the coordination of many agents. Each stakeholder, e.g. farmers, farmer cooperatives, consumers, extension agents, brokers, retailers, millers, input sellers, output marketers, has different rights, obligations, interests and information need with respect to their place in the chain as a whole [12., 24.]. Given that market failures are common (e.g. cartels, price-fixing) it is a key concern for farmers to find fair and reliable buyers of their output, and it may be associated with a significant transaction cost to do so. Wyche et al [41.] focus on the factors

[1] Star and Ruhleder [33.] initially characterised (information) infrastructures along a set of dimensions to include (1) embeddedness, (2) transparency, (3) reach and scope, (4) learned as part of membership, (5) links with conventions of practice, (6) embodiment of standards, (7) build on an installed base, (8) and visible during breakdown. A ninth was added by Bowker and Star [3.] i.e. fixed incrementally Karasti [16.].

that may impede the adoption of for example market information services in rural areas in the global south and find a mismatch between the design of MIS and smallholder farmers' perceptions of their mobile phones' communication capabilities. Having said that, ICT interventions may have an impact and energise the move from subsistence farming to commercial farming For example, banana farmers in remote rural areas of Uganda were found more likely to sell in a market than at the farm gate once they had access to mobile phones [21.]. Access to the internet increased the number of Peruvian smallholder farmers who sell on the national market - increasing internet usage by one percentage point lead to two and a half per cent increase in market participation [30.]. Moving to market may also mean participating in a supply chain: moving from selling directly to consumers to selling into a longer supply chain. For example, In Madhya Pradesh, India, the e-Choupal initiative enabled smallholder farmers to sell their output directly to a large corporation rather than relying on local wholesalers [10.]. Those that did so reportedly saw a 33 per cent increase in their profits. Part of forming the value train is to ensure that producers have access to credit. We shall turn to this next.

Infrastructuring for microcredit is critical to smallholder farmers in the Global South as it may enable them to engage in commercial enterprise. Microcredit is the extension of small loans to impoverished borrowers who typically lack collateral, predictable income, and verifiable credit history [22., 23.]. Gaining access to credit may mean moving from subsistence farming to commercial farming. ICT based microcredit schemes may enable smallholder farmers to invest in their agricultural business e.g. buy inputs such as seeds, fertiliser and pesticides as well as tools and light machinery. Ideally, microcredit may support smallholder farmers moving out of poverty. However, critics point out that micro-credit can create indebtedness. Notably, some microcredit institutions have charged in excess of 20 per cent on small business loans [42.]. This situation has generated debate among scholars and development practitioners, with some claiming that microcredit institutions apply the practices of 'loan sharks' for their personal enrichment [8.]. Having said that, indications are that ethical microlending and investor profit can go hand-in-hand and may support, for example, smallholder farmers. Of note here is also the accent of social and financial support groups, wholly outside banking, that may enable access to credit [4.].

Infrastructuring for capacity building is vital to smallholder farmers because having access to people, resources, information, advice, and training is critical to obtaining the skills necessary to be a successful and productive farmer. Initiatives in this category range from large-scale Farmer Field Schools with dedicated training sessions to ICT enabled agricultural information services that provide agricultural advice on best practices on a regular basis. Farmer Field Schools often use a face-to-face group-based learning process to address a lack of knowledge among smallholder farmers relating to agroecology, particularly the relationship between insect pests and beneficial insects, and the use fertiliser and pesticides [13.]. Agricultural Information Services, in contrast to Farmer Field Schools, mostly rely on the delivery of information digitally, rather than through face-to-face interaction. It is mostly the widespread penetration of mobile telephony to most all corners of Asia and Africa, including Cambodia, which make this kind of service viable [7.]. One example of such services is Krishi Kontho that utilises pre-recorded voice messages, and SMS, that push advice to smallholder farmers mobile phones at intervals carefully choreographed with the life cycles of their crops — reducing the use of agricultural inputs such as fertiliser and pesticides [6.]. Another example is Avaaj Otalo that allowed farmers to connect to a question and answer forum to record questions, provide answers, or browse an existing list of questions and answers [26.]. Skill and capacity building, then, is central to the development of small-scale agriculture in the Global South. Infrastructures that support skill-building, then, may be central to support farmers move out of poverty. Sultana et al highlight the opportunities and issues that arise in designing technologies to support low-income rural communities [37.].

In addition, then, to the relational, invisible, connected, emerging, and intentional character infrastructure, we may point to three dimensions of infrastructuring that are important to rural development for smallholder farmers in the context of a market economy. These include infrastructuring for a value chain (micro), for microcredit, and for capacity building.

3 SETTING AND METHODS

The Agribuddy enterprise, our case in point, can be described as a start-up that strives to work the entire agricultural value chain mainly in Cambodia, with minor activity in India and Myanmar. The Agribuddy Company was formed in 2015 with USD 730,000 of venture capital funding from iSG Investment Work and from angel investors. In turn, Agribuddy attracted additional investors and received investments of USD 2 800 000 notably from Mistletoe Inc (Japan), Smart Axiata (Cambodia's biggest telecom operating), and Forte Investment Holdings (an insurance investment company).

Behind the idea of forming an enterprise focused on Cambodia's agriculture is the present CEO, Mr Kengo Kitaura, then a financial expert from Japan. During visits to Cambodia, Mr Kitaura discovered that the main crop, i.e. rice, had a productivity of 2.5 tons to 3 tons per hectare. This is a remarkably low yield compared to international standard and Cambodia's neighbouring countries. For example, Vietnam's rice productivity stands at 6 tons per hectare. Mr. Kitaura identified several shortcoming of Cambodian agriculture that might possible explain the shortfall, including a lack of integration and coordination of key stakeholders such as farmers, banks, input-producers, millers and wholesalers, a lack of financing options for smallholder farmers, and a deficit in terms of skill and farming expertise on the part of smallholder farmer that make up the mainstay of Cambodian agriculture. Mr Kengo Kitaura envisioned that the yield of rice and other crops may be doubled in Cambodia, and the income of the farmers increased if only the above-mentioned shortcomings were adequately addressed.

The empirical data related to our study of Agribuddy was generated over a period of six months in late 2018 and early 2019. We conducted extensive participatory observation, carried out twelve semi-structured interviews, and conducted three focus groups with the farmers. The participatory observations were conducted mainly by the third author, while the interviews, the focus groups, and a lesser part of the ethnography, was conducted jointly by the first and second authors.

We conducted participant observation with the Agribuddy organisation in Cambodia. This included accompanying the staff working

in the villages during their work with the Agribuddy service, and it included being with the farmers as they used the service, shared and talked about the information, and farmed their land. Informal conversations with the farmers and the Agribuddy staff where a large part of conducting the participant observation, and in addition to being informative, these conversations served to create rapport with the informants. At the time, the third author was part of the organisation Agribuddy and as such with the organisation for the duration.

The three focus groups with the farmers included questions on education; family; community; village life; financial circumstances; income; climate; farming; motivations and reservations towards joining the service; and their experiences with the Agribuddy service. The focus groups were conducted in Cambodian, the language of Cambodia.

Of the twelve semi-structured interviews, three were with Agribuddy staff, three were with lead farmers acting as 'buddies' (advisers) to the farmers using the service, four were with local farmers that had experience with the network, and two were with crop processor and suppliers. The interviews with the Agribuddy staff included questions on background; work experience; the organisation; relationships with farmers; village life; climate; and their experiences with the Agribuddy service. The interviews with the buddies where on their experiences of guiding the local farmers using the Agribuddy service, the interviews with the farmers were on their experiences of using the service and their motivations and reservations in regard to joining (see figure 1), and the interviews with the crop processor and the fertiliser supplier were on the experience of collaborating and doing business within the Agribuddy framework.

The data from the participant observation, focus groups, and interviews were recorded through extensive field notes, audio recordings and photographs. The focus groups and individual interviews were transcribed and translated into English. The authors read through and discussed the data in various analytical session in person and on Skype.

Our analysis was driven by the three dimensions described-above that are inspired by the infrastructure studies [e.g. 1-3, 16, 17, 19, 27, 35] and directly informed by the literature on interventions for smallholder farming in the Global South [e.g. 6-8, 10, 21, 23, 24, 26, 42].

Constructing our three dimensions and in turn the analysis, then, was done in an iterative process moving between the empirical material and the research literature. Actively seeking a framing that would hopefully constitute an interesting object of study and would in turn yield worthwhile insights. Noting that all study designs have embedded assumptions, Winthereik et al. [39.] encourage researchers to experiment with different framings of the object of study, or more precisely, experiment with different ways of constituting the object of study. One may say that our three dimensions represent one such experiment. Note that there is no immediate overlap between the dimensions of Karasti & Blomberg [16.] on the one hand and on the other hand the three dimensions of infrastructuring for a value chain, for microcredit, and for capacity building, we are about to unfold next. That is, our three dimensions as they unfold in the analysis are at once a description of the work done in the world of Agribuddy by heterogeneous actors (e.g. the Agribuddy company, buddies, farmers, input sellers, wholesale buyers, bankers, and technologies) and an outcome of the work done by the researchers (i.e. us) aiming to understand that work informed by the research literature.[2]

4 INFRASTRUCTURING WITH AGRIBUDDY

"Strictly speaking, many smallholder farmers in developing countries are not [commercial] farmers. They are unemployed people who have land. On the many vacant lots they own, they are just growing their own food there. They try to convert the portions of the crops that they do not consume into money to buy things that can only be acquired with money. They are not farmers by choice. They would quit farming if they could. But if farming became a profitable profession, they would continue." Kengo Kitaura (Founder of Agribuddy)

In this section, we will consider how the efforts of Agribuddy amounts to *infrastructuring for a value chain, infrastructuring for microcredit*, and *infrastructuring for capacity building*. Note that we deliberately use the verb *infrastructuring* (rather than, e.g. the noun infrastructure) to underline the ongoing and in-the-making character of the initiative.

4.1 Infrastructuring for a Value Chain

"I am a farmer, but how can I make a living?" forty-two-year-old Bora Keo's simple question speaks to the situation that he and other smallholder farmers in Cambodia find themselves in. Surveys typically classify Cambodian smallholder farmers as poor [40.], making less than 700 USD a year per hectare farmland with farms typically smaller than 2 hectares. Earnings fluctuate from year-to-year, from season-to-season, depending on weather, climate, pests and plant disease, and market prices. Low crop yields, or outright crop failures, represent a severe challenge to the farmers and their household. Farmland in Cambodia is vulnerable to climate change, with unseasonable drought and unpredictable rainfall. Transplanting - a cost-effective, traditional farming method of moving rice between fields — relies on rain falling predictably during two peaks of the year, which used to occur with regularity. However, unseasonable droughts and unpredictable rainfall are increasingly disrupting cultivation and forcing Cambodian farmers to search for jobs outside of agriculture. During an agricultural crisis, the male household member often seeks alternative employment such as running a local tea stall or working in the brickmaking industry. However, this alternative self-employment is most often inadequate in terms of supporting a household that may include ten members or more.

The World Bank recommends countrywide investment in Cambodia to develop the agribusiness and agro-processing industry and to integrate the stakeholders in Cambodian agriculture more effectively to promote smallholder farming [40.]. Accordingly, Agribuddy seeks to integrate key stakeholders such as farmers, banks, input manufacturers, crop processors, and wholesale buyers. One goal is to turn smallholder quasi-sustenance farming into viable commercial agriculture. Not by creating large commercial farms, as one might think, but by aggregating the output of many small farms and market their products on the (global and local) markets through an integrated value chain.

[2]These three dimensions of infrastructuring are close, we think, to what Jensen and Winthereik [15.] call a *practical ontology*.

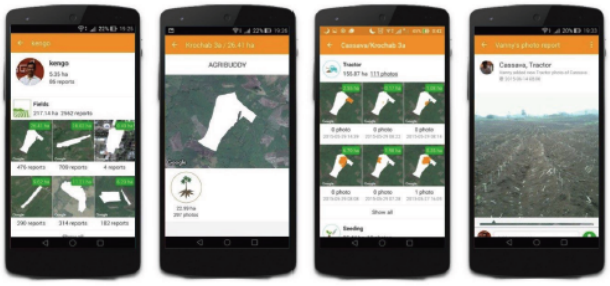

Figure 1: The Agribuddy app supports the activities of the ecosystem. Here the measurement of land holdings for credit assessment purposes using GPS and mapping functionality.

The aim of Agribuddy is quite tangible when put in terms of crop yields and investment:

"We are aiming to increase the yields by making the farmers invest a little more. For example, farmers normally invest 400 USD per acre of rice and the return in a good year may be expected to be 480 USD. However, when they join Agribuddy, we usually tell them to invest up to 500 USD per acre in better quality inputs such as fertilizer and the excepted return may be around 720 USD per acre. That means 220 USD profit per acre, rather than 80 USD in the old scenario." (Agribuddy manager)

This is a significant livelihood improvement for a modest extra investment, and the quote directly above is perhaps best understood as a "mission statement", rather than a statement of results. Meeting the goals above requires not only more of an investment but in fact the creation of agricultural infrastructure.

So far, Agribuddy has, since its inception in 2017, operated across Cambodia recruiting 4931 farmers to the network (as per September 2019) and have made arrangements with a commercial bank to back the (micro) loans that Agribuddy offers to the farmers to invest in their farms. Further, Agribuddy has secured the collaboration of input suppliers as well as crop processors and international wholesale buyers. Thus, attempting to form a value chain for small-scale commercial farming.

To understand Agribuddy, one has to understand the role of the "buddy". Agribuddy's field-level intermediary the "buddy" act as a hub linking farmers, banks, agro-input manufactures, crop processors, millers and wholesale buyers. Agribuddy is structured around clusters of farmers headed and supervised by a buddy. It is the buddy that facilitates the farmer's initial introduction to the network, helps with credit applications, and oversees the sale and transport of the harvest. A buddy will typically have the responsibility for 25 of his peers usually from the same village as him- or herself. Good standing in his or her village, literacy, and ownership of a smartphone counts towards becoming a buddy. The smartphone ownership is essential because Agribuddy has an app which acts as a gateway, and the buddy must use this in performing his or her duties (see figure 2). Agribuddy will compensate the farmer acting as buddy with 33 USD per farmer per crop cycle, amounting to 825 USD every 4 to 6 months. This comes as an addition to the buddies regular income as a farmer. The app supports registration, knowledge sharing, and importantly the acquirement of credit.

Many of the farmers that we talked to had experienced significant improvement in their livelihoods after joining Agribuddy albeit the experiences were somewhat unevenly distributed in accord with the skills, fortunes and quality of the land of the farmers. Seen from the farmer's point of view, Agribuddy may potentially offer access to a regulated and predictable market, credit to buy fertiliser and other agricultural inputs with, and advice on how to improve farming practices. Especially the access to credit is critical as we shall see next.

4.2 Infrastructuring for Microcredit

One of the overarching challenges for smallholder farmers in Cambodia, and elsewhere in the Global South, is getting access to credit. Smallholder farmers have low and unpredictable incomes compared to salaried workers. This raises their credit risk in the eyes of lenders and almost always results in denial of credit from the traditional financial sector. This is one of the challenges addressed by Agribuddy (and the microfinance movement in general).

As indicated, Agribuddy facilitates lending in collaboration with commercial financial institutions. We observed Agribuddy working with AMK Cambodia – a leading microfinance organization in the Siem Reap Province. This helped us understand Agribuddy's modus operandi: The buddy in the village, in coordination with the Agribuddy supervisor, does a farmer baseline and profile. This baseline and farmer profile works towards obtaining a loan with the microfinance institution. The baseline data consists of household information. The buddy identifies the members of the household, assets such as TV, smartphone, tractor, power tiller, and whether or not the farmer has outstanding loans. In addition, importantly, the farmer is also assessed according to farms size and crop types. The buddy records the size and location of the farmers land by simply walking the perimeter of the fields, phone in hand, using the GPS to create a map of the farm (see figure 1). Knowing the size of the farm, the crop types, and the market prices, the algorithms of the application can calculate or approximate the farmer's yield and income for the coming season. This approximation becomes part of the basis for providing the farmers with a loan, it acts as a proxy for traditional loan security.

On average, the loan of a marginal farmer is USD 167.5 dollars at 1.5% interest per month. On top of the interest rate, Agribuddy adds a once-off 1.5% service charge to the loan. In comparison, the

interest rate of more informal lenders in Cambodia is 3% to 5% per month.

The relatively low interest rate is partly the outcome of an arrangement that lowers the risk of the lender: The farmers that obtain a loan do not get cash-in-hand (at first), rather they get credit to buy agricultural inputs with, and this directly from Agribuddy. The farmers only see ready cash once their harvest has been sold and the loan has been repaid in full. This is to avoid the misappropriation of loans:

"The trouble with microcredit here [in Cambodia] is that farmers and other people take out loans for one purpose but end up using the money for other things. A man may get a loan to buy fertilizer or even a tractor and end up buying a television and a trip to Thailand. And to repay the loans he then has to take out new loans. People have a lot of debt here and some new loans to repay old loans. But not so with Agribuddy." (Farmer, buddy, member of Agribuddy.)

At Agribuddy, repayment is ensured by channelling revenue from crop sales directly to the lender only providing the farmer with the profits after deducting the loan repayment. The individual farmer does not handle the money apart from the final surplus or profit from this chain of transactions. Agribuddy can do this because it controls the processes of loan giving, input sales, harvest sales, and loan repayment. The flow of capital and goods, then, is largely internal to Agribuddy. According to Agribuddy, this is as indicated to ensure access to credit, limit the misappropriation of loans, ensure high-quality agricultural inputs (e.g. fertilizer and pesticides), ensure fair sales prices, and secure the repayment of loans. Agribuddy is configured as a close collaboration, then, between financial institutions, agro-input manufacturers, crop-buyers, and importantly farmers.

Generally speaking, the farmers appreciate this approach as it enables them to get a hold of agricultural inputs, notably, fertiliser on credit. This is important since cash is scarce and credit may be unobtainable for many as farmers may already have multiple loans making it impossible to borrow elsewhere. The approach of Agribuddy, then, bypassed the issue of "bad credit" and limits the importance of the individual farmer's credit history by holding on to the sales revenue from the crop sale and only passing the profit back to the farmers. The risk of loan misappropriation is eliminated, then, in the sense that farmers cannot withhold loan payment. Loan repayments are recorded and cross-referenced by both Agribuddy, the buddy, and the farmers making the repayments transparent. However, crop failures can ruin the harvest, and at times do so, making (full) repayment impossible for the farmer. In such situations, the farmer's debt may be partly or entirely forgiven depending on the nature of the situation.

The fertiliser that the farmers may obtain on credit is imported from Japan and is marketed as a high-quality product and contrasted to Vietnamese brands more commonly found in Cambodia. The fertiliser is almost twice the price per unit compared to other offerings on the market. This makes some farmers sceptical: "How do I know if this new fertiliser is as good as they [Agribuddy] says it is? Why is it so expensive?" one farmer asked us. Also, some farmers do not appreciate the Agribuddy credit process and would rather just go to the market: "When we go to the market to buy fertiliser, there, we don't have to answer questions, sign documents or have our land measured, we just buy it. With Agribuddy there are so many questions" a farmer told us. In the end, some, but far from all, farmers do accept the process and the terms of credit and become part of the Agribuddy initiative.

Key to the workings of Agribuddy, then, is the availability of (relatively) cheap credit that enables the farmers to buy inputs (e.g. seeds, fertiliser, herbicides and pesticides) and start farming more intensively and on a larger scale than they have previously done.

4.3 Infrastructuring for Capacity Building

Generally speaking, moving from sustenance farming to small scale commercial farming may require building capacity in the farming communities. Adopting a more commercial or professional approach. It is the ambition of Agribuddy to facilitate skill-building and in time have the app be a hub for a community of practice facilitating a learning experience for smallholder farmers in Cambodia and elsewhere. Accordingly, the Agribuddy app provides infrastructure. For example, access to a forum where farmers and buddies can ask questions and post answers. Questions may pertain to pests, plant disease, and the use of inputs such as fertilizer and pesticides. The idea is that any farmer may take a picture of, for example, an infected plant for identification of the disease and solicit advice on how to approach the ill. Relevant information such as time, global position and contact information will automatically be tagged onto the image. Subsequently, advice on the matter may be posted by another member of the Agribuddy community. That's the idea. However, at present, this is a feature that Agribuddy is somewhat struggling with. Not technically but in terms of incentivising the community, skills and ensuring trustworthiness. In terms of motivation, it is unclear why someone knowledgeable would spend his or her time answering what may be potentially thousands of request for advice on, e.g. pests and disease every week. Furthermore, it is unclear if there are in fact the skills in the network of peers to answer all the questions in a satisfactory manner, and this affects the trustworthiness of the answers posted on the forum.

"My buddy (lead farmer) took a picture of my cassava plants that had what looked like a fungus infection and put it on the forum for advice. The next day someone gave a short answer and said that it was not a fungus but pest that caused the trouble. And that I should spray for insects. But how do I know if this is true? I don't know the person that gave that answer." (Farmer, member of Agribuddy.)

Providing the technology for posting questions and answers may not be sufficient, in and of itself, a working community of practice may require more than that. And there is still a steep learning curve, we think, that the farmers, as well as Agribuddy, have to climb to realise their ideas of digitally enabled knowledge transfer. This part of the infrastructuring, then, is very much still in the making.

Parallel to the workings of the digital platform, knowledge travels from buddy to farmers as they meet and talk face-to-face. As one farmer reports: "I used the new fertiliser and was disappointed with the development of my rice plants, asking my buddy about it he told me that I was using the fertiliser wrong and that I should pay more attention to the weather and the risk of rain-washing fertiliser away, I took his advice and it helped some". In this manner, face-to-face interaction between individuals that know each other well may be a viable alternative to the (quasi) anonymity of the app space. To be fair, it is the role of the buddy to advise the farmers in his or

her group, and as such Agribuddy is building an infrastructure for knowledge exchange both digitally and otherwise.

In sum, infrastructuring for smallholder farming in Cambodia, in the case of Agribuddy, (partly) translates to providing access to credit, supporting a community of practice, and bringing products to market. These infrastructuring efforts may potentially move scores of farmers out of subsistence, or near subsistence farming, to commercial farming with all the benefits that entail not least in terms of improved livelihoods for the farmers their families. However, the success of these infrastructuring efforts also depends (partly) on the good reputation of Agribuddy.

5 POLICING AT AGRIBUDDY

The management of Agribuddy is painfully aware that Agribuddy connects people, organizations and companies, and that although the Agribuddy organisation is the face of this, it has limited control over all the partners:

"Reputation is important – it is an economy of reputation where the farmers have to trust the local buddy, the buddy has to trust the Agribuddy company, and the Agribuddy company has to trust its commercial partners. Also, the commercial partners have to trust the Agribuddy company. It is like a circle." (Agribuddy manager, Siem Riep)

Agribuddy, then, is based on an economy of reputation to function, as much the flows of goods and finance. Relatedly, if a partner falters, this may reflect poorly on the whole. For example, if a seed supplier provides bad seeds, then the farmers will blame Agribuddy – although Agribuddy might rightly point to the supplier. Or if the fertilizer supplier delivers late, i.e. the trucks with the fertilizer are not with the farmers in due time, then the farmers will blame Agribuddy, rather than the trucking company. In this manner, Agribuddy is held responsible by the for example farmers for the conduct of other actors within the network.

The good reputation of Agribuddy, then, is instrumental in linking the partners in the network: financial institutions, input sellers, farmers, crop processers, and wholesale buyers. It is a challenge to manage all these stakeholders, and it is especially so because the Agribuddy company has no direct control over these partners *per se*. Influence, yes, but no direct control. What they can do, though, is suspend cooperation with partners that do not live up to their standard. Policing the infrastructure, weeding out bad seeds so to speak, is part of participating in this economy of reputation, central to the enterprise:

"Although we vet our partners, some may not live up to our trust and expectations, and we have to act on that swiftly. For example, we had a case of one buddy that had the idea of charging ten USD as a registration fee of each farmer joining us. This is not Agribuddy policy. As soon as we found out, he was dismissed. We have had another problem with millers that had a dubious practice of weighing the rice that he received from the farmers to mill. It always seems to weigh less than the farmers expected. We got rid of him as well." (Manager, Siem Riep)

Agribuddy selects partners that already enjoy a good reputation. For example, farmers that are already enjoying a good standing in their respective communities, i.e. farmers of good repute in their village, may more readily become buddies. This also applies to millers and other stakeholders.

From conversation, it emerged that the draw of Agribuddy on the farmers is the access to credit, more so than, for example, the new and more expensive fertilizer that Agribuddy offer. As mentioned above, Agribuddy encouraged the farmers (via their buddies) to invest more than usual in their farming to be able to market their harvest for greater profit, but this was not without its complications:

"Farmers normally invest 400 USD per acre of rice and the return in a good year may be expected to be 480 USD. However, when they join Agribuddy, we usually tell them to invest up to 500 USD per acre in better quality inputs such as fertilizer and the excepted return may be 720 USD per acre. That means 220 USD profit per acre, rather than 80 USD in the old scenario. With minimal extra investment. But they do not appreciate the idea and ask us why we are trying to make them spend 100 USD more per acre. Are you trying to cheat me?"(Manager, Siem Riep)

Agribuddy organizes regular workshops where the farmers can meet their prospective buddies, talk to representatives of the financial institution, and meet the input suppliers about the merits of the new fertilizer, and in general, interact with the Agribuddy staff. At the workshops model farmers testify to their success and the advantages of Agribuddy: access to modestly priced credit, the new Japanese made fertilizer and good sales prices at harvest. Although these workshops go some way to alleviate the farmers' anxieties towards joining the enterprise, many farmers are still very cautious and ask a lot of questions:

"We are questioned by the farmers all the time: Are you really going to help us? Do you honestly think that they [the financial institution working with Agribuddy] will give you the money? How do I know if you will pass the money on to me? How can I be sure that you can deliver the fertilizer on time? Why is your fertilizer more expensive than the regular one? Are you sure you will pay me for my harvest on time? These are just some of the questions that the farmers ask us." (Manager, Siem Riep area)

Farmers in the area have good (historical) reasons to be suspicious, we are told, as they have been duped in the past by unreputable 'businessmen' drawing them into Ponzi schemes. To counter this situation, the Agribuddy company relies on time and the results of the model farmers to speak for themselves as well as the reputation of their more established partners. Our interviews reveal that some farmers are sceptical of Agribuddy, hesitant to join the network, and accordingly adopt a cautious approach:

"I am going to wait and see how it works out for my neighbours [who joined Agribuddy] before I will think seriously about joining" (Male farmer, Siem Riep)

The CEO of Agribuddy, Mr Kengo Kitaura is sanguine about their prospects "we are just a start-up and headwind is to be expected, we will gain the farmers trust in time. In fact, we are slowly doing just that". In addition, not only the farmers are cautious. Representatives of one of the financial institutions partnering with Agribuddy initially refused to extend credit to two named villages in the Siem Riep area. The institutions had in the past experienced many non-repaying customers living in these very villages and as a consequence chosen to deem the communities "bad credit". Lifting this blanket denial of credit on anybody living in these villages, making access to credit again an individual matter, was

hard-fought but ultimately successful. In turn, Agribuddy could recruit buddies and farmers in these villages and provide them with all the opportunities of the network, including access to credit.

In sum, infrastructuring for smallholder farming in Cambodia, in the case of Agribuddy, relies on an economy of reputation that is as important as the flow of capital and goods within the ecosystem.

6 DISCUSSION

While infrastructuring for a value chain, for microcredit, and for capacity building as well as policing the infrastructure, is, running ahead of ourselves, at once relational, connected to, emerging, and intentional, it is not, as far as we can see, *invisible* as such. Not much of an infrastructural inversion, we think, is needed to bring Agribuddy into view [for contrasting examples see e.g. 20, 25]. The overt visibility of the Agribuddy infrastructuring efforts is arguably tied to the intentional and commercial character of the initiative as it is in-the-making. The Agribuddy stakeholders, especially the founders, have to work hard for the establishment of the initiative: police the partners, court banks, convince farmers, recruit buddies, talk to millers, and establish links with input companies and whole sellers. This makes the initiative highly visible.

Arguably, the efforts of Agribuddy are sunk into the fabric of rural Cambodia that acts as an "install base", to use Star and Ruhleder's [34.] expression [see also e.g. 11]. For example, the Agribuddy initiative builds on the existing farmers, banks, agro-input manufactories, crop processor, millers and wholesale buyers. Agribuddy connects these actors in new ways, notably by the infrastructuring efforts we have described above, including for example the introduction of the buddy, the new microcredit scheme, and the efforts to build skills and farming know-how.

That Agribuddy is *connected to* other elements that are required to complete it is evident by its relation character (see also Karasti and Blomberg [16.]). Scaling and multiplying these connections are at the heart of the initiative. For example, it is a stated aim driving the initiative to add more farmers, more buddies, lend more money, harvest more crops, and broker more produce. This scaling, or its ambition, is also spatio-temporal in nature [see also e.g. 9, 29], with efforts to move the centre of gravity from the Siem Riep province to include other parts of Cambodia, and in time to Indonesia, India, and Africa. The reach and scope of Agribuddy's connectedness can be thought of as a would-be-profitable increase and distribution in time and space driven (in part) by the above-mentioned infrastructuring efforts of value chain, microcredit, and capacity building.

The effort to scale the number of connections makes for an *emerging* phenomenon that is perpetually in-the-making [15., 16.]. The scaling is not a uniform march towards greater and greater market share and expansion. The stability of Agribuddy is relative to, e.g. its commercial success and needs to be produced in an ongoing manner not only through the infrastructuring efforts of value chain, microcredit and capacity building but also through the policing of the initiative. There is reputation to consider as described at length above. The emergence of Agribuddy may be characterised by uncertainty, ups and downs, and occasional disconnects. As stated above, the future success and growth of Agribuddy is far from certain.

The notion of intentionally, as presented by Karasti & Blomberg [16.], may lead to a discussion of the extent to which the initiative may be said to be built deliberately and with control. Arguably, Agribuddy is quite deliberate in the sense that it is a motivated initiative with identifiable key actors set on a course to scale and grow. There are people that stand to gain should the enterprise succeed - this is no secret. A Karl Marx inspired analysis would probably take its flow of capital and its mode of production as the starting point of an analysis. In that sense the Agribuddy enterprise harbours clear intentions, not of exploitation, we think, but of commercialisation of smallholder agriculture in a socially responsible way in the context of a market economy. Turing to control, we may argue that there is more intent that there is control looking at the initiative. Control is hard fought, as indicated above, and relative to the policing of the partners such as farmers, buddies, banks, input suppliers, millers, and wholesale buyers. Control is not absolute, far from it, as the there is an innate tension between the process of scaling the number of connections on the one hand and on the other hand the emergent properties of the Agribuddy initiative, which is partly a result of the scaling efforts [see also 31].

Agency, a broader term than intentionality or intervention, and arguably a less human-centric term, also warrants consideration. That is, agency can be thought of as intentionality and control, but also simply as 'that which is producing a particular effect'. And in the latter sense, numerous non-humans have agency in the Agribuddy infrastructure, including the weather, the investments, the seeds, the fertiliser, the herbicides, the pesticides and the machinery of agriculture to mention a few. Accordingly, we have seen the weather at stake in the analysis of Agribuddy in the form of changing patterns due to climate change, and we have seen the properties of the Japanese fertiliser sold by Agribuddy at stake in terms of its price and worth. In this manner, the agency of non-humans also plays their part in the making of Agribuddy [see also 20].

In sum, we may say that initiatives such as Agribuddy may be considered along several infrastructural dimensions, including being relational, invisible, connected to, emerging, and intentional [16.]. And to that, we can add the broad notion of 'agency'. Furthermore, the Agribuddy initiative may be considered an infrastructuring effort along the three dimensions of infrastructuring for a value chain, for microcredit, and for capacity building introduced above. Bringing this multidimensionality together may forward the investigation and conception of smallholder agricultural development in the Global South. The point is that it may be of analytical value to complement the (abstract or generic) dimensions of for example Karasti and Blomberg [16.] with a set of dimensions of an infrastructuring effort (e.g. for a value chain, for microcredit, and for capacity building) that is close to the empirical phenomena, close to the doings of the actors (in this case the Agribuddy company, buddies, farmers, agro-input providers, wholesale buyers, bankers, mobile technology, and etc.).[3] By having brought this multidimensionality together, then, we hope to have shed some light on the investigation and conception of smallholder agricultural development in the Global South.

[3]Note that the dimensions of infrastructuring for a value chain, for microcredit, and for capacity building are *not* somehow "theory-free". As mentioned above, they stem from an interplay between the empirical data and the research literature on not least agriculture in the Global South.

7 CONCLUSION

In this paper, we have investigated Agribuddy, which is an ICT-driven initiative that aims to enable smallholder farming in Cambodia and elsewhere. The investigation has taken the form of an infrastructural inquiry with a focus on how the agricultural initiative may be viewed as infrastructuring for a value chain, for microcredit, and for capacity building. Furthermore, we also considered the relational, connected, emerging, and intentional character of the initiative. That is, the emerging infrastructure is *relational* in the sense that it builds on the existing "install base" of farmers, banks, agro-input manufactories, crop processor, millers and wholesale buyers. It is *connected to* other elements that (partly) complete it and scaling these connections in terms of, for example, attracting more buddies and farmers is an essential ambition of the project. Agribuddy is *emerging* as it is very much in-the-making, prone to backtracking and setbacks. It is *intentional* in the sense that it is motivated with key actors set to scale the infrastructure for profit. Lastly, it is *visible*, rather than invisible, in rural Cambodia as the entrepreneurial efforts of attracting allies and partners depends on being visible and attractive to them.

In sum, the paper has addressed the challenge of understanding development for smallholder farming in the Global South. It has done so by providing an example, Agribuddy, seen through a multifaceted lens of infrastructural inquiry. Arguably, it has in the process added to CSCW by extending the conceptual and empirical basis of the field. While the conceptual basis has been expanded by bringing established views of infrastructure together with new ones emerging from the study, the empirical basis of infrastructural inquiry has been expanded with a view of agricultural development in Cambodia.

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The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic

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The Reordering of Everyday Life through Digital technologies During the Covid-19 Pandemic

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Abstract

This paper offers an exploration of everyday life during the Covid-19 pandemic in Bangladesh with a focus on how it has been reordered through commonplace digital technologies and services. We present findings from a qualitative field study. Themes emerging from the findings suggest that digital technologies have been important to the reordering of everyday life during the pandemic: videoconferencing have been instrumental in allowing urban residents to work from home, digital money has enabled workers in rural areas to continue financial transactions, and social media has been a source of news and rumours during the pandemic. However, the benefits of the digital reordering of everyday life are unevenly distributed. The themes emerging are used to frame a discussion of the notion of reordering compared to the concept of resilience within ICTD.

CCS CONCEPTS

Human-centred computing • Empirical studies in HCI • Computer supported cooperative work

Additional Keywords and Phrases:

ICTD, ICT4D, crisis, pandemic, covid-19, field study, digital reordering,

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1 Introduction

Digital technologies and services have the potential to mitigate and provide support in times of crisis such as pandemics [15]. The recent literature within ICTD and related research fields attest to the many purpose-build solutions that have been brought forward. For example, Biswas et al [4] presents an interactive visualization system to represent and compare the rate of spread of COVID-19 across different countries over time. Gupta el al [13] consider a contact-tracing app called Aarogya Setu, developed by the Government of India. The App uses Bluetooth and GPS technologies to alert a user when they are nearby a COVID-19 infected person. Furthermore, Jagadish et al [19], propose a framework called FIDES for reasoning about data-driven decisions making during crisis such as the Covid-19 pandemic.

These important studies point to the fact that digital systems can be designed to support people in times of crisis such as pandemics. In addition to purposeful designs people may take advantage of existing technologies and use them to defer the shock of crisis to their everyday lives. Indeed, there is a lack of research detailing the role of generic or common place information technology in the reordering of everyday life during crisis such as a pandemic and especially in the Global South. It is close to self-evident that everyday digital technologies have been important to the reordering of life during the Covid-19 pandemic [25]. Relatedly, the interesting point is what kind of reordering has taken place, whose reordering, what the modalities of this reordering has been, and what social and technical infrastructure it was based on. Arguably, this is a piece of knowledge that is crucial to (partly) understanding why some people thrive during a pandemic while others suffer. One notable effort to fill this gap, albeit outside of the Global South, includes Winthereick et al's investigation of life during the Covid-19 pandemic that describe how people relied increasingly on digital technologies in their everyday routines but at the same time were critical and vary of technological overload and control [25].

Building on the existing literature, we investigate the role of commonplace digital technologies in the reordering of everyday life during the early stages of the Covid-19 pandemic in Bangladesh. We explore the reordering efforts in a variety of locations and social strata, urban and rural, middleclass, and working class, with a view to how the crisis of the pandemic has led to a reordering of everyday life and the role of information technology herein. In this manner, we aim to contribute to the body of research detailing the reordering of everyday life (partly) through digital technologies during a crisis in the Global South. In the process we aim to complement the important ICTD literature on technology and resilience [1, 2, 5-8, 16, 20].

Our empirical data originate from an exploratory field study in Bangladesh. We find that digital technologies have been important to the reordering of everyday life during the pandemic: videoconferencing have been instrumental in allowing urban residents to work from home, digital money has enabled workers in rural areas to continue financial transactions, and social media has been a source of news and rumours

during the pandemic. However, the benefits of the digital reordering of everyday life appears unevenly distributed. Stories of hardship emanate mostly from those that rely on daily wages, rather than the salaried. This is what we mean when we point to digital inequalities.

The paper will proceed as follows. First, we will consider related research. Secondly, we will turn to the field setting and the methods of the study. Third, we present an analysis of the reordering of everyday life (partly) through digital technologies during the pandemic. Lastly, we will provide a conclusion and perspectives.

2 Related research

Digital reordering – to arrange everyday life again and differently in times of crisis through commonplace information technology - runs parallel to notions of resilience employed in ICTD. That is, the reordering perspective and the resilience perspective, we think, share an interest in how communities and households may fare in times of crisis. However, they also differ.

The notion of resilience has a long history in multiple disciplines [2] and is enjoying rising popularity in academia and policymaking [5, 20]. Resilience has in engineering and ecology been associated with a technical- or ecological systems ability to return to a stable state following a shock. Its ability to do so and bounce-back marks its resilience [2]. In ICTD, researchers have mostly conceptualised resilience as pertaining to the larger socio-economic landscape [15]. Moreover, the idea of 'digital resilience' or 'e-resilience' has been advanced referring to the contribution of ICTs to community resilience [16]. Resilience associated with digital interventions, then, has been studied and conceptualised [e.g. 3, 9, 16, 21]. For example, Heeks & Ospina [16] employed a resilience framework in an urban community in Costa Rica; benchmarking both community resilience and "e-resilience" and developing from these a set of action priorities. One conceptual critique of the idea of resilience as 'bouncing-back' is that it's at odds with the notion of lasting change, contributing to some conceptual ambiguity [5, 20].

To reorder is to rearrange differently, rather than to bounce-back to an equilibrium. The reordering perspective that we are forwarding here has its roots in a particular understanding of the dynamics of 'the everyday' with roots in the phenomenological tradition. More precisely, its philosophical underpinnings can be traced to the phenomenology of Husserl as seen in his notion of life-world [18], later developed in the philosophy of Heidegger [17] and in the sociology of, for example, Schutz [24]. To Husserl, the concept of life-world emphasis a universe of what is self-evident, it emphasises the state of affairs in which the world is experienced and lived [18]. Husserl's work influenced Heidegger's notion of being-in-the-world [17] as well as Schutz phenomenological approach to sociology exemplified in the notion of the natural attitude [24]. An attitude of taking the everyday for granted until there is reason not to do so anymore [24, p.73]. The interest in the order of the everyday, and how that moral order is produced and reproduced, can also be seen in the ethnomethodology tradition ignited by Garfinkel [12]. Dorfman's recent work on the reordering of contemporary everyday life is especially relevant for this paper. He is concerned with how reordering – the ability to arrange everyday life again and differently to defer trauma and shock – is central to understanding the dynamics of change during crisis. That is, trauma and shock may be integrated into the everyday through reordering where shocks are deferred and "the new is integrated into the old" through repetition [10, p.14]. Central here is Dorfman's claim that it is impossible to understand the ordinary apart from the mechanisms of how the extraordinary may be absorbed and become ordinary through reordering practices [10]. Digital technologies may support the absorption of shock and help turn the extraordinary into a new version of everyday life. However, this process may be unevenly distributed across people and places.

In sum, whereas the concept of resilience in ICTD is often employed to analyse the systemic robustness of a society, community or household, the notion of digital reordering used in this paper shifts our attention towards the dynamics of change and how it may be achieved through commonplace digital technology and services.

3 METHODS

To understand the reordering of everyday life (partly) through commonplace digital technologies during the early stages of the Covid-19 pandemic in Bangladesh, we conducted a short-term field study from March 26th, 2020, to May 27th, 2020. During this period Bangladesh was in a state of lockdown in response to the pandemic (see below). The empirical material was generated through semi-structured interviews, supplemented by photos and videos. Due to the lockdown restrictions, and the risk of cotangent, observations were conducted on a very limited scale and captured only in the form of the above-mentioned photos and videos. The visual material helped to convey a sense of the informants physical living condition under the lockdown, which was helpful for the analysis.

Table 1: Overview of the twenty-two interviewees taking part, with age, gender, geographic location, occupation, and the number of household members.

Participant	Age	Gender	Occupation	District and Area
1	27	Male	Small Businessman	District: Satkhira, Southern Bangladesh
2	55	Male	Small Businessman	District: Rangpur, Northern Bangladesh
3	48	Female	Livestock farmer	District: Rangpur, Northern Bangladesh

Participant	Age	Gender	Occupation	District and Area
4	61	Male	Farmer	District: Lalmonirhat, Northern Bangladesh
5	65	Male	Farmer	District: Patuakhali, Southern Bangladesh
6	48	Male	Teacher	District: Rangpur, Northern Bangladesh
7	26	Male	Small Businessman	District: Borguna, Southern Bangladesh
8	45	Female	Assistant Teacher (School)	District: Lalmonirhat, Northern Bangladesh
9	30	Female	Home maker & livestock farmer	District: Satkhira, Southern Bangladesh
10	31	Male	Garment worker	District: Rangpur, Northern Bangladesh
11	26	Male	Auto Rikshaw Driver	District: Patuakhali, Southern Bangladesh
12	36	Male	School Teacher	District: Barguna, Southern Bangladesh
13	30	Male	Farmer	District: Dinajpur, Northern Bangladesh
14	40	Male	Farmer	District: Barguna, Southern Bangladesh
15	33	Male	Farmer	District: Dinajpur, Northern Bangladesh
16	45	Male	Farmer	District: Satkhira, Southern Bangladesh
17	22	Male	Rickshaw Puller	District: Lalmonirhat, Northern Bangladesh
18	28	Male	Small Businessman	District: Dinajpur, Northern Bangladesh
19	32	Female	School Teacher	District: Patuakhali, Southern Bangladesh
20	48	Male	Garment worker	District: Borguna, Southern Bangladesh
21	45	Male	University Professor	District: Dhaka (Capital)
22	43	Female	University Professor	District: Dhaka (Capital)

The mainstay of the empirical data consists of twenty-two semi-structured interviews with people from different walks-of-life across Bangladesh (see table 1.). The participants were selected from different regions of Bangladesh. Briefly told, ten of the participants were in the northern part of the country, ten in the southern part, and two were in the capital of Dhaka. An effort was made to recruit people from different walks of life, and we managed to include farmers, people in business, schoolteachers, garment workers, rickshaw drivers, and university professors. In this manner, we selected the participants to reflect a broad spectrum of Bangladeshi in terms of their location and occupation. The participants were interviewed mostly outside near their homes, often in their garden, front yard, or at their doorstep. The familiar surrounds were not only the practical option during the lockdown, but it also had the added benefit of allowing people to relax and talk about the setting of their lockdown confinement while they were in it. Each interview lasted about an hour and began with the participants being informed about its purpose. The study was described to the participants as an effort to understand 'how everyday life had been affected by the pandemic and the lockdown, and the role of technology'. Following the description of the purpose of the study, consent from the participant was given and the interview could proceed. During the interviews the participants were asked about their household, their occupation, changes to their everyday life and routines, their experience of the lockdown restrictions, positive and negative experiences, how they handled the changes to their situation, their use of digital technology, their neighbours' situation, as well as expectations and whished for the future.

The majority of the interviews (twenty) were carried out by research assistants recruited and trained by the authors to follow the about mentioned interview protocol. The authors were due to the restrictions on international and local travel only able to do a minor part of the data collection. The research assistants were selected to conduct interviews with participants that lived close by to minimise travel. During the interviews, precautions were taken against cotangent by the interviewer and the interviewees that wore face masks, used sanitiser, and importantly observed their distance to one another. A subsection of the interviews (two) were carried out by the authors online. We opted for the majority of the interviews to be carried out by the research assistants in person because especially in rural Bangladesh there is a lack of

stable broadband data connectivity that would make quality online video interviews possible. Doing the interviews as a telephone conversation was ruled out at an early stage due to concern about rapport and a lack of data richness. Interviews via phone only were deemed too impersonal to create the rich data we required. An added benefit of visiting the home of the participants was the opportunity to add photos and video to the data set. Twenty-two videos, one for each participant, and eighty-eight photos were added. Each video is lasting about two minutes. The photos and videos contributed to an understanding of the physical setting of the participants under lockdown. For example, one video takes us through the empty streets and alleys of a town and to the doorstep of a rickshaw driver showing us his (empty) neighbourhood and his home from the outside. Another video clip shows a family in rural Bangladesh at their farm wearing face mask standing at a generous distance to one of our research assistants likewise donned in protective gear. In this manner, the videos and pictures are evocative and a testament to the situation of the participants and to the interview situation.

While the in-person interviews were conducted in the local language of Bangla, the two online interviews were done in English. All interviews were audio-recorded and transcribed for analysis. Furthermore, the interviews in Bangla were translated into English. The analysis was based on an iterative process of gathering, listening, categorising, comparing, and contrasting common themes and major issues found in the interview data. The coding of the interview transcripts involved the creation of labels and tags which, based on how frequently the issues were mentioned and the level of importance they were given, led to the discovery and development of the analysis. Broadly speaking, we came to focus our attention on how everyday life had changed for the participants during the pandemic. In doing so, we followed the notion that there is plasticity to the everyday, an ability for change in response to shock by deferral and repetition [10]. The study is part of a larger effort to understand how the Covid-19 lockdown(s) has forced people to reorder their everyday routines through ad-hoc and impromptu digitization. That is, the study connects to a larger effort to examine how people may have been forced to fix their 'broken' daily lives through a new kind of participation becoming digitally engaged in new ways [22].

Lastly, the quasi-narrative presentation form that we have chosen to employ below is partly associated with the ethnomethodological tradition [12] and more broadly speaking ethnography [14]. Although our series of interviews, photos, and videos do not make up an ethnography in the usual sense as it lacks in observations, we have found it useful to present our findings using narrative inflections, rather than more forcefully structuring and categorising the findings. Arguably the upside of this is the flow and hopefully evocative nature of the presentation, while the downside may be a lack of overview and the inability of the reader to comprehend the text 'at a glance'.

4 The reordering of everyday life through digital technologies

In this section, we will consider the impact of the Covid-19 pandemic on everyday life in Bangladesh by attention to a range of voices from across Bangladesh. We will foreground the role of information technologies in people's efforts to reorder their lives. As mentioned, our qualitative data show that videoconferencing has been instrumental in allowing urban residents to work from home, digital money has enabled workers in rural areas to continue financial transactions, and social media has been a source of news and rumours during the pandemic. As we will attempt to show, the burden of the pandemic and the (somewhat) mitigating effects of information technology in unevenly distributed. As a primer to this, we will provide some background on the situation at the time of data collection.

4.1 Background: timeline and government response

Along with most of the world, Bangladesh had at the time of data collection undertaken a range of measures to protect its population from Covid-19. The measures included the general special leave initially declared by the government from March 26th to April 25th, 2020. Workplaces and educational institutions had been closed, and people had been asked to work from home or simply laid off. The latter most vivid example being the garment workers send from the factories to their home villages, to be told to turn around and return to their workstations only a few weeks later. Exacerbating the situation and the spread of the virus. The general holiday, as it was known, had been extended until May 30th, 2020, with instructions to be followed, including no movement outside from 8 pm to 6 am, from May 10th shopping malls has been allowed to open on a limited scale observing physical distancing and stepping up sanitation and hygiene. Many local markets remained closed. No intercity transport and commuting was allowed. People were encouraged to stay in their homes. The schools and universities were asked to restrict physical access, and the universities were asked to start teaching classes online. Mass gatherings at religious institution across the country was beening curbed. People were asked to pray at their home. The restrictions on movement did not apply to emergency transport, healthcare services, food production and distribution as wells as pharmaceuticals [23].

4.2 Working from home and the use of videoconferencing

On the streets of the capital of Dhaka traffic usually moves at a slow pace grinding to a complete stop every couple of minutes, making, for example, a three-kilometre commute a one-hour journey. The Dhaka commute is so notoriously slow that people will relocate their homes as they change jobs, we are told, even if it is just to get a few kilometres closer to their place of work. In Dhaka, traffic means time wasted or at least that is how it used to be. Recently traffic has picked up pace as the lockdown measures have taken effect and people are staying indoors, and some are working from home.

> *"It has been such a relief that I can stay at home – I really needed that. I feel bad about what is happening out there, but I am rather enjoying the lockdown. Now I can spend time with my daughter and my husband, and I have more time to focus on my work. You know, I used to spend hours commuting each and every day". University Professor, Dhaka.*

Some urban professionals are experiencing what we might call the upside of the pandemic (and they are feeling somewhat guilty about it too). The added time spend in the home has made balancing home life and work-life easier. It has tilted the balance in favour of the home, in favour of family and childcare, and brought new attention to loved ones. In addition, the rhythm of the day and the division of labour in the home has changed for some.

> *"We used to have a part-time cook and cleaner helping us out, but we had to let her go because of the pandemic. I do most of the housework now, but it does not feel like a burden, mostly because I am free to do it whenever I feel like. I can work until midnight on my passion, my research, and leave the vacuuming and floor moping to the next day. I am in charge of my own time now. I can do justice to myself and my family. You know, I used to sleep only five hours a night. This has changed, and I get my sleep now. I can work, play with my daughter, and spend time with my husband. We are happy here in the apartment and do not need the outside world right now." University Professor, Dhaka.*

For the urban professional, the added time spend with the nucleus family has not been at the expense of productivity we are told. This is partly due to time being freed up (i.e., no commute, less tyranny of the clock), and partly due to digital technology being used more readily than before. Digital technology has afforded new ways of working and coping with the situation.

> *"Teaching online is a new experience for me. I am not a tech-savvy person [laughing], but this Covid-situation has forced me to take classes online. Communicating with my students online and giving them feedback. So, the new situation has made me face my fears of technology and has given me a new freedom to work in a new way." University Professor, Dhaka.*

In general, video conferencing may be part of a new online experience of everyday life during lockdown. Moreover, the urban professionals we talked to were painfully aware that their situation of sheltering relatively comfortably in place is not shared with large parts of the population of Bangladesh that live a more precarious existence. Bangladesh is a country of one-hundred and sixty-eight million people where most live in small towns and villages relying on small scale commercial agriculture and sustenance farming as well as small businesses.

4.3 Struggling to work and the use of digital money

In the towns and villages outside Dhaka and outside the circle of comfortable living conditions and a regular paycheck, the interviews paint a different and less attractive picture of life under lockdown. One of stress associated with cramped living conditions, idleness, loss of income, and uncertain prospect for the future. One contrast to the urban professional experience of the lockdown is the testimony of those living day-to-day to feed their families, including shopkeepers, sustenance farmers, and rickshaw pullers to give a few examples.

> *"I was out with the rickshaw this morning and went to the market to pick up passengers. I saw very few people there because people had been chased away by the police. They hit them with batons or make them sit up and hold their ears [to embarrasses them]. No one gets to the market, and there are few people on the streets for fear of this. I drove out at eight o'clock today, and at twelve, I had yet to make any money. Then I went back home and could not make anything even after going out again in the afternoon. I make money if the wheels turn, but the wheels do not turn […] Now, I am lucky to make 100 Taka [1,2 USD] a day. It used to be around 400 Taka. I cannot support my family, my mother, wife and daughter on 100 Taka a day." Rickshaw Puller, Lalmonirhat District.*

Denial of work and income may be an unintended consequence of a lockdown that was motivated by a desire to curb the contagion. The consequences of the lockdown, then, are especially felt by those that primarily rely on daily wages to support themselves and their families.

> *"If I sit at home and watch TV, it costs electricity. And my wife says there is no food at home, my daughter wants this and that, but I can't give it to her. She wants to eat fish, but I can't afford fish. Then she cries. I used to borrow money from the house next door and take my daughter to the shop and get biscuits. But now my neighbours don't want to lend me money because I can't repay them on time." Rickshaw Puller, Lalmonirhat District.*

Although taking out loans may soon become a burden, some resort to borrowing money from friends, family and neighbours. In the process, they may take advantage of digital services such as the popular *bKash* mobile money system operated by Bangladesh Bank. During the pandemic, mobile financial services may be used readily. BKash users can, for example, deposit money into their mobile accounts, receive money from other bKash users, and pay bills from a range of service providers. This has proven useful during the pandemic.

> *"I got 300 Taka from my father-in-law through bKash. My father-in-law lives more than ten kilometres from here. It would be difficult to go there and ask for the money because of the lockdown. That's why we used bKash. We are able to bring money digitally […], and we pay our electricity bill with bKash now. This is new to me. My neighbours don't want to lend me money" Rickshaw Puller, Lalmonirhat District.*

In general, adopting digital money and payment services may be part of a new ‘grammar of participation’ in everyday life during the pandemic as people are forced to fix their ‘broken’ routines through ad-hoc and impromptu digitization, thus becoming differently engaged with each other. Also, digital money may allow some business to stay open.

> *“Previously, I had no idea of what a 'lockdown' is. Now, using Facebook, I know that lockdown means that you are only to go outside in special circumstances and in emergencies. There are rules like not walking around the market, staying at least three feet away from each other, maintaining social distance, wearing a face mask, staying home from 6 pm to 6 am. These are the laws of lockdown, I think.” Shopkeeper, Rangpur District.*

However, the imposed lockdown rule are not observed at all times. In fact, the rules may be systematically flaunted, creating a rhythm of enforcement and relaxation, where the representatives of the state and the people of a village ‘play games’ with each other.

> *“On Facebook, we can see people that have not followed the lockdown rules being stopped by the police, made to regret their mistake, and return to their homes. Therefore, when people see the army or the police, they run. However, I also see things from my home and shop at the side of the road. When the army or police come, everyone runs away and then when the army and police leaves, people hang out in front of the tea stalls again. The shops are selling like thieves, tea, drinks, food, etc. Shopkeepers close their shops at the sight of the police to open them up again as soon as they have gone. In this way, they run their shops like thieves with the army and police chasing them.” Shopkeeper, Rangpur District.*

People, then, may cross back and forth between a moral and legal shadow line in step with the arrival and departure of local law enforcement. An approximation of life as before may go on in the shadows of the lockdown restrictions. Low-keyed and with eyes and ears open trade and the leisure of tea with friends is hidden from the view of law enforcement but in full sight of locals. Arguably, there is a contrast between restrictions enforced by the representatives of the state and the moral order and fellowship of a local community. The latter apparently more relaxed than the former about restrictions during the pandemic. The informants repeatedly use the expression 'like thieves' to describe the shopkeepers' new way of handling opening hours. This may reflect, we think, the new gaze of the police, or more precisely, the way that shopkeepers think that the police look at them when they ply their trade. They are made to work ‘like thieves’ because what was once legal is now not. Some traders have taken the consequences of the strained environment at the market and moved part of their trading online. Negotiating the prices over Messenger and video calls and settling the transaction using bKash. Goods are then transported via autorickshaw. The arrangement minimises face-to-face interaction without completely eliminating it due to physical goods still being delivered. This is how a farmer may buy his seeds.

> *“Previously, if I needed seeds, I would go to Parbatipur market and buy them myself. Now, I am using my phone. If we agree, I send them money via bKash. Then when someone from the village goes there, they pick up the seeds for me. I do this regularly now” Farmer, Dinajpur District.*

4.4 People out of place and the influence of social media

The moral implications of spreading the virus, or risking spreading it, is somewhat ambiguous if we compare the relaxed stance of the locals at the marked described above with the following experience of a rickshaw puller.

> *“I am driving people coming from Dhaka to our town, and I am taking them as we go. I don’t know if they carry the virus. How can I? I will take anyone in the rickshaw that comes along for a ride and is willing to pay. Many locals don’t want to get in my rickshaw because I carry passengers from Dhaka. But what can I do? I have to make a living. I am doing this under duress.” Rickshaw Puller, Lalmonirhat District.*

Without engaging in any kind of condemnation, we can simply note that engaging in life at the market seems to be considered low risk and acceptable in contrast to contact with people from the outside. That is, the locals do not seem too concerned about interaction among themselves, rather they are more concerned about outsiders, especially people arriving from Dhaka that might in their view carry the disease. The rickshaw puller can attest that people are not happy with him carrying outsiders that might harbour the contagion. Admittedly, Dhaka is the capital of not only the country but also of the virus in Bangladesh topping every imaginable statistic in terms of infections and death [23]. Arguably, this representation of the pandemic in the media, including TV and not least Facebook, has led villagers to associate people from Dhaka with impurity and danger. Following the seminal writings of Mary Douglas [11], people arriving from Dhaka may be ‘out of place’, even if they are (former) locals returning home from Dhaka to stay with their relatives. Settling into place may require a period of (self)-isolation.

> *“Those who come from Dhaka have their houses flagged and locked down. That’s good. People in our village, the elderly, the children, if they hang out with people who have come from Dhaka they will get the disease. We know this from Face Book. There is no treatment for this disease, so it is very good that the police and the magistrate lock them in their houses. We are very satisfied with it. It is a positive out of so many negatives during this pandemic.” Teacher, Lalmonirhat District.*

Another example of 'people out of place' may be workers that have been laid off to return unexpectedly to their villages and relatives for shelter. Unable to stay in their factory dorms they may have little choice but to return to their villages. People suspected of having the disease are to self-isolate for two weeks, and the houses they stay in may be marked with a flag to alert neighbours and passer-by of the danger of cotangent. This makes the upholding the restrictions both a legal matter for law enforcement and a moral issue harboured in local sentiment.

> *"A boy from our village that used to live in Dhaka came back here. He had not been tested for corona virus, and it was uncertain if he had the disease. He was born here, but no one allowed him to visit, and everybody kept their distance and did not talk to him. It is as if the Corona virus has reduced our love for one another. Now we are afraid even of our own." Farmer, Dinajpur District.*

In this pandemic, then, strangers may be seen by locals as 'people out of place' and see as danger to be confined, isolated, and avoided. Importantly, these notions of otherness, impurity and danger may be fostered, spread, and communicated via social media such as Facebook.

We will now provide a conclusion and perspectives.

5 Conclusion and perspectives

This paper has explored the role of common place digital technologies during the early stages of the Covid-19 pandemic in Bangladesh with the aim of understanding the social dynamics of such reordering. Findings suggest that people have been able to reorder their lives partly using digital technologies. However, there are striking differences to be seen. For example, the university professor can reorder and create an everyday routine with online teaching and comfortable home life that in some ways, is an improvement to her previous life. In comparison, the rickshaw puller is in trouble and can barely make ends meet, for him the digital technology is used as a conduit for loans, which are at best a stopgap measure that is not sustainable in the long run as the debt burden will easily become too large. Furthermore, digital money may make the market endure by for example making the payment for goods possible at a distance. That is, in some cases cash has been substituted by digital money during the pandemic – transforming for example a traditional rural cash marketplace to digital payments. Furthermore, social media has been a conduit for information and not least rumours about others. 'Otherness' has been fermented via social media.

Two conceptualisations were presented. The concepts are (partly) for our understanding of crisis and the role of digital technologies. The first concept, namely, 'resilience' or 'e-resilience' arguably relies on the metaphor of 'bouncing-back' to understand the ability of for example a community to recover from external shock. The second concept, namely, digital reordering, breaks with the notions of bouncing-back and recovery as it relies on ideas of rearrangement, change, and inequality of outcome. This paper made use of the latter concept for its analysis of the situation in Bangladesh.

The challenge for ICTD emerging from this study is related not only to the fact that the benefits of information technology seem to favour those already favoured but also to the fact that this does not seem to change during a large crisis such as a pandemic. At least judging from our limited study. How can we with available digital technologies reduce the suffering of all people in times of crisis such as a pandemic? A future research agenda on digital reordering in times of crisis may lie ahead for ICTD considering the uncertainties associated with not only pandemics but also with for example climate change.

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Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh

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Of Numbers and Moods: Screening for Mental Health Issues in a Rohingya Refugee Camp in Bangladesh

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ABSTRACT

Screening refugees for mental health issues, medical assistants use a digital tool that produces a numerical score but also, importantly, attunes to the moods of their clients and the atmospheres of their homes. In this article, we propose the concept of *numeration-attunement* as helpful for medical anthropology. Drawing on ethnographic fieldwork conducted among medical assistants working in the Kutapalong refugee camp in Bangladesh, we explore their assessment of the mental health of the refugees: its *numeration-attunement*. To develop the notion of numeration-attunement, we draw on numeration research as well as phenomenology. Comprehending how medical assistants assess the mental health of refugees requires attention both to numeration and datafication by way of a screening tool as well as the revelatory character of attunement to moods.

KEYWORDS

Bangladesh; datafication; mental health; moods; numeration; refugees; Rohingya

It was a rainy morning in the Kutapalong refugee camp in Eastern Bangladesh. There we were, talking to a medical assistant and accompanying her as she went about her daily routines as part of a mental health outreach program. We were three people in a small shelter made with a tarpaulin suspended over bamboo frames. The room had a cloth curtain that separated the dwelling from the path outside. Seerat, the medical assistant, was talking with a Rohingya woman in her early twenties with two small children. Carefully, Seerat explained her purpose and asked for consent to screen the young refugee for mental health issues. The woman did not volunteer at first, nor did she refuse Seerat. Rather, she started to talk about herself and her situation. She spoke of her idleness, cramped living conditions, lack of contact with relatives, her marriage, and her lack of freedom of movement within the camp.

After having tea and engaging in conversation for a while, Seerat and the young woman stopped talking, and the room fell silent. The husband, a lean 40-year-old, entered somewhat shyly. We stood up. He had been sitting outside within hearing distance but out of our view. Somehow, Seerat and the young woman had picked up on his presence. Dressed in a short-sleeved shirt and lungi, he looked at us. The young woman looked at her feet. We did our utmost to express what an honor it was to meet him and repeatedly told him what an important contribution he and his wife were making to our project. We handed him our business cards and had our picture taken with him in a statesmanlike tableau shaking hands for the photographer. After some time, he finally motioned us to sit down. The woman hissed at her children. During the conversation, Seerat insisted that they be screened, it was essential to the project, he was led to understand. The flattery seemed to work, and he smiled. We left after Seerat had screened the couple and the wife had been found to show symptoms of mental health issues. Seerat had asked the women 20 questions read from a tablet computer. Based on her answers, the algorithm had

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Media teaser: Screening Rohingya refugees for mental health issues, health care workers not only use a formally recognized screening app but also rely on spending time with their clients sensing their moods and the atmospheres of their homes in the camp.

recommended that the woman be referred to further diagnostics and treatment at a camp clinic. As we walked outside again on the muddy path between the shelters, Seerat told us: "I can almost predict the outcome of a screening as I sit down with them . . . untidiness, smell, children with running noses, adults hissing at their children, dark marks about the eyes . . . such a home visit will probably end with a referral."

This relatively mundane view of working with an outreach mental health service in a refugee camp indicates some of the ways that digital screening tools may enable health care workers to quantify the mental health of refugees. In our case, the digital screening tools allowed for the quantification of the severity of mental health issues on a scale from one to twenty – where a score of seven or above was the cutoff point for referral to treatment. However, the medical assistants, such as Seerat, did not rely on the tool and its algorithms alone to screen the refugees and make their referrals. Ethnographic data shows that in addition to relying on the screening scores, the medical assistants also relied on their intuition and bodily experience of meeting the refugees in their homes: seeing them, sensing them, picking up on their posture, tone of voice, appearance, and the atmosphere of the home. How was the screening of the refugees for mental health issues by the medical assistants in part achieved through numeration and in part through attunement to moods?

In this article, we examine how the medical assistants screened the refugees for mental health issues in the Kutapalong camp.[1] People with mental health issues have long been known to suffer with negative effects for themselves and their families. Identifying those challenged by poor mental health readily and accurately in humanitarian crises may contribute to the well-being of those in need, such as refugees, by providing referrals to treatment. Yet, in practice, what counts as poor mental health to those doing the referring, such as Seerat, is located between "objective" measures such as the World Health Organization's (WHO) SRQ-20, and more "subjective" attunement to moods and atmospheres mediated through bodily experience. That is, neither numeration nor attunement to moods stands alone in the medical assistants' assessment of the mental health of refugees in Kutapalong camp. Therefore, we refer to the above as "numeration-attunement" to the mental health of the refugees, on the part of the medical assistants, and in doing so introduce the concept to the field of medical anthropology.

While previous anthropological studies of mental health have focused, for example, on maternal mental health in Vietnam seen through the lens of phenomenology and domestic moods (Gammeltoft 2018), the emotional health of migrant families in Texas and how it is connected to their legal status (Logan et al. 2021), task-shifting among volunteers in mental health programs in Kerala (Kottai and Ranganathan 2020), and the importance of kinship for mental health in South Africa (MacGregor 2018), in this article we focus on the duality of mental health assessment in the context of a refugee camp and humanitarian crises for the Rohingya in Bangladesh.

Worldwide, humanitarian crises arising from conflict and disaster are becoming more common. According to data from UNHCR, the UN refugee agency, the number of forcibly displaced people worldwide rose toward 100 million by the end of 2021 (UNHCR 2022b). Thereof, 925,380 are Rohingya, our case in point, residing in camps in Bangladesh (UNHCR 2022a). The latest major influx of Rohingya into Bangladesh followed as they were violently attacked in 2017 by government forces that razed their villages in Rakhine State, Myanmar. This triggered an unprecedented exodus across the border to neighboring Bangladesh (Christensen et al. 2020; Tay et al. 2018). Although estimated rates of mental health issues in the aftermath of humanitarian crises vary depending on circumstances and research methods, a meta-analysis of surveys found rates of 15%–20% for depression and post-traumatic stress disorder in crisis-affected populations (Charlson et al. 2019). Previous studies offer detailed documentation of how the extreme violence of the exodus from Myanmar and living in a crowded camp in Bangladesh have affected the mental health of the Rohingya refugees, showing how trauma, idleness, the breakup of extended families, domestic disputes, and uncertain prospects for the future may depress the mood of the Rohingya refugees and lead some to mental illness (Christensen et al. 2020; Tay et al. 2018). While there has been scholarly attention, then, to mental health in humanitarian crisis, little attention has been paid to how mental health is understood

by those working with the refugees taking responsibility for their welfare, including their referral to treatment.

The empirical data for this article has been generated through ethnographic fieldwork in the Kutapalong refugee camp in Bangladesh. We explore how the screening of the refugees, the assessment of their mental health, was achieved by the medical assistants through numeration practices using a digital tool and through attunement to the moods of the refugees. Previous studies in anthropology and elsewhere have long been occupied with how quantified data in the form of numbers are produced, what they mean and what they "do" (Day et al. 2014; Ruckenstein and Dow Schüll 2017), and anthropological studies of mental health have benefitted from a phenomenological perspective of being-in-the-world (Gammeltoft 2018). Here, we shift to a third, intermediate locus of study, the duality of mental health assessment in a refugee camp – of numbers and moods.

Addressing the duality of mental health assessment

Addressing mental health assessment in anthropological terms requires some theoretical reflection. Through which concepts can we best approach and understand health care workers' assessment of refugees' mental health? In this article, we use the concepts of "numeration" and "moods" to capture the dual quality of mental health assessment by medical assistants in the Kutapalong refugee camp. Our theoretical framing, then, spans numeration research and phenomenology. This theoretical resource alignment takes us into somewhat unchartered territory as we seek to resolve these perspectives on a theoretical level and in our analysis. We heed previous studies that, although using different theoretical resources from us, acknowledge the dual character of certain medical conditions that can simultaneously be objects of numeration as well as being experienced subjectively (e.g. Middleton 2020; Ruckenstein and Dow Schüll 2017).

Our fieldwork in Bangladesh has, as indicated, compelled us to address the assessment of mental health by medical assistants in the camp as combined numeration and bodily experience, giving the process its above mentioned dual quality. We take our first theoretical cue from numeration and datafication research. In this context, we have found inspiration from work on what numbers "do" (Day et al. 2014), and how they are mediated or themselves mediate phenomena (e.g. Desrosières 1998; Espeland and Stevens 2008; Hacking 1990; Porter 1995). Anthropologists have proposed that numbers are social entities (Lippert and Verran 2018; Verran 2012). In a tradition inspired by Michel Foucault, numbers are seen as a way to enable management through rational-scientific means (e.g. Rose 2004). Numeration may make a phenomenon visible and legible and be a source of agency (Scott 1998). There is a performative element to numeration in the sense that the act of quantifying a phenomenon, such as the mental health of individuals, may make that phenomenon visible and actionable (Espeland and Sauder 2007; MacKenzie et al. 2007). Radicalizing the argument, some scholars argue that the performativity of numeration may be a question of ontological shifts, rather than merely epistemological ones, in the sense that a phenomenon, such as mental illness, is not made "visible" as much as it is "made" in the first place by the act of quantification (Lippert and Verran 2018). In addition, studies of the processes whereby qualitative aspects of life are converted into quantified data have destabilized the notion of the "objective" by showing the conditions of datafication (e.g. Adams 2016; Biruk 2012; Bossen et al. 2019; Lupton et al. 2022; Ruckenstein and Dow Schüll 2017). Creating data may be governed by what Daston and Galison (2007) has called the epistemic virtues of "objective" knowledge production such as abstractness, timelessness, and reproducibility. However, in practice datafication and numeration, even if governed by (scientific) standards of production, is always enveloped and constituted by social relations (Biruk 2018).[2]

Comprehending the assessment of mental health in Kutapalong camp, we propose, requires that we think beyond numeration and attend also to phenomenological perspectives, to include the bodily experience of the medical assistants as they provide doorstep services to the refugees and experience their moods, frames of mind, and the atmospheres of their dwellings. For this article, Heidegger's concepts of attunement (*Befindlichkeit)* and mood (*Stimmung)* are pertinent (Heidegger 1962).

Attunement refers to how we humans are always already tuning into our surroundings, open to our lifeworld and its atmospheres that we soak up as a matter of being-in-the-world. Attunement is a matter of existing in a world that we already always share with others. It is as such a matter of being together or *Dasein* (lit. being-there), to use a central term from Heidegger, rather than an act of will or purpose (Dreyfus 1991). The point is that attunement is an inevitable part of being. The world is always already the one I share with others.

Heidegger helpfully associates moods with atmospheres (Elpidorou and Freeman 2015). Moods, like atmospheres, are already here, and we exist in them. They are not inner states of being, rather they are pervasive and open to attunement. Moods, then, have a revelatory dimension in that they disclose our world, our *Mitwelt*, that we share with others, to us (Heidegger 1962, 157; see also Gammeltoft 2018). *Dasein* as being-with lets the *Dasein* of others be encountered (Heidegger 1962, 157). For example, a sad person, say a refugee, may change the mood of being together in the home during a doorstep consultation by a medical professional. Such a health care professional may find herself attuning to moods in her with-world (*Mitwelt)*, and in the context of mental health care in the home, such moods may signify something that matters to her and be revelatory of a patient. However, before we can embrace the revelatory dimensions of moods, it is important to underline some general features of their disclosive character. The ways that moods are disclosed to us are primarily pre-reflective or pre-cognitive in the sense that they are "ways of being-there or *Dasein*." We may find ourselves in moods without articulating them. Moods may go unnoticed or unacknowledged yet reveal our world-with-others in subtle ways (Heidegger 1962, 173). The notion of moods, then, directs us to how we are in the world, sensitive to atmospheres, open to energies and their variations (Gammeltoft 2018). Attunement (*Befindlichkeit*) implies a disclosive being-in-the-world where we may encounter the world in terms of moods (*Stimmung*) that matter to us (Heidegger 1962, 177).[3]

In this article, we consider the moods that pervade the dwellings of the refugees as these moods matter to the medical assistants that go to the refugees and provide health care and assess their mental health. Considering attuning to moods in Heidegger's sense as pervasive to the human existence, we use the concept together with the notion of numeration to designate the assemblage of *quantification* by virtue of the SRQ-20 screening tool and the *attunement* to the refugees by the medical assistants. Comprehending how the medical assistants working in the camp with the refugees come to understand their mental health demands, we contend, dual attention to numeration and attunement to moods within the camp. Our view of numeration-attunement as inseparable in practice, at least in our case, may be useful in the study of mental health and contribute to the important and rich literature on the issue in medical anthropology (e.g. Gammeltoft 2018; Kottai and Ranganathan 2020; Logan et al. 2021; MacGregor 2018), as well as the literature on datafication that also acknowledges the parallax character or duality of some medical practices in terms of the illness-as-objective-measurement vs. illness-as-subjective-experience (e.g. Lupton 2017; Middleton 2020; Ruckenstein and Dow Schüll 2017).

The study: mental health among refugees at Kutapalong

This article springs from a collaborative research project carried out by a Bangladeshi-Danish research team in the Kutapalong refugee camp in Eastern Bangladesh. The larger study used a combination of screening and ethnographic methods to investigate the mental health of refugees in the camp. The project included the screening of 2735 adults for mental health issues and interviews with selected refugees. The screenings were part of an outreach programme staffed by mHealth teams made up of one paramedic (a woman with a degree in health care) and one coordinator (a man and often without formal education in healthcare). Each mHealth team was assigned to a specific area of the camp and walked door-to-door to visit every household and provide primary health care and support. Each mHealth team supported about 300 households, making 10 to 15 visits per day. Follow-up visits for every household were conducted within 14 days of the previous consultation.

During the project, each paramedic visited the households in their area of the camp and, in addition to providing routine primary health care (i.e., for somatic issues), the medical assistants also used a digital screening tool based on the WHO SRQ-20 standard to screen the adult members of the household for symptoms of mental health issues (Beusenberg and Orley 1994). The WHO developed the SRQ-20, a 20-item screening tool (Beusenberg and Orley 1994). It has been widely used throughout the world in low-income countries (Netsereab et al. 2018; van der Westhuizen et al. 2016). The SRQ-20 consists of 20 questions, and a total score is calculated based on the refugees' responses. The maximum score is 20, which indicates a high risk of mental health problems. Cutoff points vary by country, but in most cases, people with scores of 7 or more are considered at risk of mental health issues (Netsereab et al. 2018). Different cutoff points have been used in South Asia, ranging from 6 to 9 (Giang et al. 2006). In our project, we decided on a cutoff point of 7. Those refugees who answered yes to seven or more of the paramedics' questions during the screening sessions were referred to camp clinics for further diagnostics and treatment. Specialists in mental health and well-being handled the referrals at the clinics, where the diagnostics and treatment process for each referred refugee often involved multiple sessions. Further diagnostics (if needed) could include visits to specialists outside the camp.

The SRQ 20-questions: (1) Do you often have headaches? (2) Is your appetite poor? (3) Do you sleep badly? (4) Are you easily frightened? (5) Do your hands shake? (6) Do you feel nervous, tense or worried? (7) Is your digestion poor? (8) Do you have trouble thinking clearly? (9) Do you feel unhappy? (10) Do you cry more than usual? (11) Do you find it difficult to enjoy your daily activities? (12) Do you find it difficult to make decisions? (13) Is your daily work suffering? (14) Are you unable to play a useful part in life? (15) Have you lost interest in things? (16) Do you feel that you are a worthless person? (17) Has the thought of ending your life been on your mind? (18) Do you feel tired all the time? (19) Do you have uncomfortable feelings in your stomach? (20) Are you easily tired? The questions were to be answered with "yes" or "no." If the subject answered "yes" to seven or more of the questions, then that person was referred to a clinic for further evaluation. The tool, then, was used for screening purposes, as envisaged by the WHO, rather than for diagnostics. The questions appeared in the digital screening tool in both English and Bangla (the Rohingya language does not have a written script). Initially (in the preparation phase), the digital tool and the translation were discussed and tested with members of the Rohingya community working with the mHealth teams. In addition, the medical assistants received training in questioning technique and their Rohingya phrasing of the questions. The training took the form of workshops with the presence of the medical assistant, program organizers, members of the Rohingya community, the authors, as well as additional staff.

This article is based on ethnographic fieldwork, then, among the medical assistants who performed the screenings, with a focus on their experiences. We spoke with them, interviewed them, and followed them around as they made house calls. We interviewed 12 medical assistants and observed them and their interactions while they provided services in the homes of the refugees with the help of our Bangladeshi partners. We met with the medical assistants on multiple occasions and accompanied them on their house calls in eight cases. The medical assistants were all Bangladeshi and aged 23–31 at the time and had been working in the camp between 1 year and 7 months and 2 years and 2 months. In addition, through observations and interviews, we followed the work of doctors and counselors in the Kutapalong camp, with a particular focus on their interactions with medical assistants. Furthermore, we carried out a series of open-ended, semi-structured, interviews with Rohingya refugees that in this article mostly figure as background to the experience of the medical assistants that we foreground. Note that the names of the informants have been changed for anonymity.

The numeration and sensing of mental health in Kutapalong

The sprawl of shelters rolls over gentle hills backed by green forest into the horizon. Hosting close to 600,000 people in one-story shelters makes the Kutapalong extension site, as it is formally known, striking by its extent alone. According to the official Bangladeshi policy, the "displaced Myanmar

nationals" living in the camps are not considered refugees per se and are not to settle permanently. The shelters are built to be temporary to reflect the status of their inhabitants. Hence, they are made with tarpaulin suspended over bamboo frames and have compacted stamped earth for floors. A dwelling typically has a heavy cloth curtain rather than a door to separate the main entrance from the rough paths outside that serve as streets. Spread out empty sacks may serve as carpets. Each shelter leans on the next in long winding rows. The rows of shelters cluster and form blocks connected by gravel roads passable by trucks and lorries carrying people and supplies. Everything is organized by the Bangladeshi military and international aid agencies. From conversation, it emerged that the camp had not always been this orderly.

> If I start from the beginning, no proper roads were going into the camp. It was a wildlife reserve for elephants before the refugees came here. The roads were so bad that it was hard for us to walk, and taking a car was out of the question, we had to follow footpaths and everything and everybody was scattered around. One problem was that the refugees used the roads and trails as toilets making the camp extremely dirty, and we had to watch every step . . . We started at 8 in the morning and worked until 4 in the afternoon. We had to leave the camp before dark for safety. During those days, we had little water, food, or rest. They [the refugees] were worse off. Sleeping where they could and eating what they could find. The place was a filthy mess. Many had diarrhea and suffered exhaustion both physically and mentally.
>
> *(Sharmin, medical assistant, camp 11, Kutapalong extension site).*

As we moved through the camp, we could see how things had changed. Roads had been built, shelters and running water and sanitation had been introduced. Sharmin, and the other medical assistants, such as Seerat, walked around the camp providing health care to the Rohingya. This was not readily appreciated or well understood at first.

> In the beginning, every day was a challenge, it was difficult for them [the Rohingya] to accept that women can work like men, and what made it even more difficult was that I was with a male colleague of mine who was the program organizer. To them, it is a sin for a woman to work like this with a man. They would not let us into their homes at first. (Sharmin, medical assistant, camp 11, Kutapalong extension site).

We were moving with Sharmin and her colleague between shelters doing house calls. The ground was muddy from the past days'rain, and it took effort to walk without slipping.

> We used to start our day going to the Majhi,[4] we had to register the refugees by household [. . .] we tried to convince him to allow us to do this registration. The work we do is totally app-based, and before we can provide treatment to people, we have to register the households using our tablet and take their names and pictures for their health records. Doing Khana [household registration], we repeatedly had to explain that we were a medical team and needed access but, in many cases, the Majhi was not listening.
>
> *(Sharmin, medical assistant, camp 11, Kutapalong extension site).*

Only after repeated pleading over several days were Sharmin and her colleague allowed into the shelters. The refugees gave their names readily, but many refused to have their picture taken for the Khana registration. "We were under suspicion of being spies from Myanmar," Sharmin said, "and it took a while to convince them that we are here to help them." The female members of the households held out the longest, and taking their picture was a struggle, Sharmin told us. With every entry into a new block of the camp, the story repeated itself. Only Sharmin was allowed to enter the house while her male colleague was told to stay outside in the street. "I was scared," Sharmin recalled, "I entered every house alone with so many looking at me with suspicion. They could easily have harmed me, and there was no one to protect me." It was difficult to win over the refugees. "Especially the elderly questioned me, saying that we didn't need to collect their personal information and take their pictures," Sharmin said, "I continued to ignore my fear, and this is how we did Khana registration". It was a struggle for Sharmin's team to get accepted. The Khana registration brought up emotions among the refugees who had fled genocide and years of persecution at the hands of the Myanmar state. "It did take time to make a place in their hearts for us," Sharmin said, "but now they are open and let us into their homes." Asked about the refugees in the camp Sharmin made a general observation.

> They are worried about the future of their children. And are anxious to go back to Myanmar . . . They had high hopes of returning to their village . . . this will probably not happen anytime soon. And I think they know that.
> *(Sharmin, medical assistant, camp 11, Kutapalong extension site).*

The SRQ-20 medical survey instrument helped put "mental health" on the agenda but not without effort. Several of the medical assistants told us of their work of making the concept of mental health understandable and relevant to the refugees. There is often no direct correspondence between diagnostic categories of mental distress defined in the Global North, and the Rohingya lexicon. This complicated the communication between the medical assistants and the Rohingya refugees. There is, for example, no direct correspondence between Rohingya terms and what a health professional would call "depression" or "PTSD." Instead, Rohingya commonly describe symptoms of "depression" in terms such as *monmora* (feeling sad), *gaa furer* (burning sensation in the body), *gaa bish lager* (pain in the body).[5] Moreover, such symptoms were often somewhat trivialized by the Rohingya.

> They [the refugees] didn't regard mental health as anything – they thought you had to be "mad" before it was a problem. I told them that feeling sad all the time and not having any energy for your family is bad . . . and that screening is a way to find out if you need help
> *(Rabeya, medical assistant, camp 11, Kutapalong extension site).*

Consequently, it took some explaining on the part of the medical assistants to clarify to the Rohingya what they were screening for and the rationale of the service, its purpose and relevance. Further along, as we walked door-to-door, Sharmin told us how she had developed a sensitivity to her reception by the refugees. She had come to see how they greeted her as significant and laden with meaning.

> When I knock, and people [the refugees] keep me waiting at the entrance for a long time then . . . their greetings can tell me a lot. The pitch of their voices, the sounds of children playing or not. It tells me about the home . . . people who smile and invite me straight-in are usually doing okay.

We spoke with many of the medical assistants that used the full range of their senses to attune to the mental state of the refugees in the context of the screening process. Sharmin and Seerat, then, told us "as a matter of fact" that they could "read the room" and that in their experience the atmosphere of the home was significant and had predictive or foretelling qualities. Arguably, Sharmin and Seerat were reporting on the revelatory dimensions of moods and atmospheres. Sharmin's reception at the door-step and Seerat's sitting down with her beneficiaries was revelatory to them regarding the state of the household's members: their well-being and state of mind.

In addition, at times, it took experience and acquired techniques to engage the refugees and make them respond to the questionnaire. Seerat, for instance, shared her personal approach with us. She had developed a preamble to asking the SRQ-20 questions.

> "I would tell them [the refugees] that I had been sleeping badly and ask them if they also had trouble sleeping. Or I would say that I had headaches and was tired. And sometimes they [the refugees] would say that that they had also felt that way . . . One woman that would hardly speak to me opened up after I told her about how hard it had been for me to move from my home to Cox's Bazar [to work in the camp] . . . " (Seerat, medical assistant, camp 11, Kutapalong extension site).[6]

This investment of her own person in the relationship with the refugees shows (again) how the SRQ-20 questionnaires did not stand alone. Some of the medical assistants had been going to the same households for months, in some cases years, and in the process, become attuned to the people and the atmosphere of the homes they visited. Charu, a medical assistant, told us about her experience with a 42-year-old woman whom she visited regularly.

> "She used to be easy to talk to, welcomed us, and smiled when we came by. But after a while, there was a change in her. She became quiet . . . hardly ever smiling . . . (Charu, medical assistant, camp 11, Kutapalong extension site).

Charu, Sharmin, Seerat and the other medical assistants reacted to a worsening in the mood of their refugee clients and counted their clients' symptoms using the SRQ-20 with a view to a referral.

Furthermore, the medical assistants repeatedly coupled their sensitivity to the plight of their beneficiaries to their use of the questionnaire.

> One family had some bad luck. The building materials for their part of the camp ran out before their house could be properly built. They lived in a tiny house made from leftover materials [. . .]. When I visited them, I tried to make sure that they were all screened. I wanted to be sure that they were all right . . .
>
> *(Asama, medical assistant, camp 11, Kutapalong extension site).*

The epistemics of being in the world was complemented by the epistemics of a medical survey instrument. There were life situations that the medical assistants came to recognize. This became apparent to us after visiting a family who, with no income in the camp, could not afford the dowry or other expenses for their daughter's wedding. Two young women ready for marriage still lived at home. As pointed out by the medical assistant, their situation was far from unique:

> I see it all over the camp, I see others having the same trouble with their daughter's dowry. You know these girls should have been married long ago [referring to the young women]
>
> *(Rabeya, medical assistant, camp 11, Kutapalong extension site).*

The recognition that the situation of the parents and their daughters fit a malignant pattern typical of camp life prompted the use of the SRQ-20. Recognition of such patterns requires familiarity with camp life but not necessarily a deep intimate relationship with the particular family. The medical assistants, then, may identify life situations across cases, across households, expressed as narratives by the refugees, and act upon that in terms of using the SRQ-20 with a view to possible referral.[7]

Arguably, the numeration of the mental health of the refugees may provide a sense of certainty and legitimacy important for medical assistants, as it is instrumental for referral. Numeration, we think, can in some cases be said to extend the attunement to moods by imputing it with authority and connecting it to a wider medical infrastructure. The medical assistants are counting their clients' symptoms when they screen them with SRQ-20. These symptoms come from a finite set of twenty symptoms given in advance by the WHO. Arguably, the SRQ-20 on the tablet computers of the medical assistants represents the dominant model of "Western medicine," and it gets its authority from there. The medical assistants are, as it were, leaning on the authority of the SRQ-20 and by extension, "Western medicine" when they refer via the questionnaire. Attunement to moods may not be "enough" on its own to warrant referral in the context of the health care infrastructure of the camp, and therefore the agency of numeration is a force that works well as an ally.

> One thing about the app [the SRQ-20 application] is that it can make sure that someone like her [a client] will get help. When I use the questionnaire, I will create a referral for her if she answers the questions right . . . she would never come to a [camp] clinic on her own . . . If we had not been there and screened her, she would not be treated.
>
> *(Asama, medical assistant, camp 11, Kutapalong extension site).*

Throughout fieldwork, a common narrative was that while coming to the homes of the refugees was important to understand them, it was the SRQ-20 that could "ensure" referral. The identification of refugees with, for example, sleeplessness, headaches, lack of appetite, feelings of hopelessness, low self-worth and casting those people as having symptoms of "mental health issues" is central to the rationale of the screening process. The medical assistants recognized that their work may help a few in their daily lives but not change their situation fundamentally.

> The refugees are still in the camp no matter how many times we screen them and no matter how many times they go and see a counselor . . . They are in the camp to stay for a long time . . . all we can do is ease their pain a little . . .
>
> *(Asama, medical assistant, Ukiah, at the project closing event).*

However, this realization did not make the medical assistants we talked to bleak or disillusioned. Instead, as funding expired, the medical assistants were somewhat frustrated about the closing down of the project.

> I feel that I am letting my beneficiaries down . . . Who is going to talk to them and care about their situation now? I had to promise them [the refugees] that I would be back, but I really don't know . . .
>
> *(Seerat, medical assistant, Ukiah, at the project closing event).*

The project closed with the medical assistants arguing for a continuation of the project both for their own sake of employment, we think, but also for the sake of their beneficiaries.

Concluding remarks

In line with the arguments made above and the ethnographic data presented, future research may arguably further advance our understanding numeration-attunement in medical practice. That is, the lens of "numeration-attunement" may be helpful in future studies of health care, perhaps also in studies of datafication in global health. As such, it may supplement sources of inspiration made explicit in this article, including numeration and datafication studies in healthcare and elsewhere (e.g. Adams 2016; Biruk 2018; Bossen et al. 2019; Day et al. 2014; Lippert and Verran 2018; Lupton et al. 2022), studies of illness-as-objective-measurement vs. illness-as-subjective-experience (e.g. Middleton 2020; Ruckenstein and Dow Schüll 2017), and phenomenological perspectives on lived experience (e.g. Estroff 2001; Gammeltoft 2018; Nielsen 2017; Root et al. 2017; Wainwright 2017). The latter may make further inroads in studies of numeration and data production in health care.

To clarify, whereas previous research within anthropology and elsewhere has often focused on numeration and the idea of "objective" data, destabilizing the notion by showing the conditions of data production (e.g. Adams 2016; Biruk 2012; Bossen et al. 2019; Lupton et al. 2022; Ruckenstein and Dow Schüll 2017), this article has focused on how mental health professionals mobilize their own (inter) subjectivity, even prioritizing it so as to use the "objective" scale at times as a supplement, to legitimize, their own attunement to moods and the situation of their beneficiaries. We have shown how what is often difficult to discern, namely, moods, may be mobilized and enacted in health care services when coupled with numeration and data production in the context of a digital health care service. Arguably, this emphasis on moods and senses – not only of beneficiaries but also of medical professionals – deserves attention in the context of numeration as it in practice may couple and rub against what Daston and Galison (2007) has called the epistemic virtues of "objective" knowledge production such as abstractness, timelessness, and reproducibility (see also e.g. Biruk 2012, 2018).

The use of the SRQ-20, the survey instrument, was in our case enveloped in the atmosphere of the dwellings where the screenings took place. To reiterate, the medical assistants conveyed and were adamant that the atmosphere of the home was foretelling or at least relevant to the screenings. In our view, the medical assistants were the survey instrument as much as the SRQ-20 was. Radicalizing the argument, we may say that the SRQ-20 for a large part was subjugated to the senses and attunements of the medical assistants in the sense that often initiations of the screenings were mastered by the senses of the medical assistants. In contrast to this argument is the fact that the connection to the larger medical infrastructure of the camp was dependent on the SRQ-20 and a score above the cutoff point of 7. In this manner, the medical assistant had to couple their sense of their beneficiaries, their attunement to them, to numeral terms through the SRQ-20 if the goal was referral to further diagnostics and treatment within the camp.

Relatedly, the medical assistants were given a pragmatic notion of mental health issues, rather than, say, a formal definition to work with. Arguably, the "definition" (for lack of a better word) was that someone that answered "yes" to 7 or more of the SRQ-20 questions were taken to show *symptoms* of mental health issues. In that way, it was a very pragmatic working definition of mental health issues, or more precisely the symptoms thereof, that the medical assistants were set to work with. To state the obvious, this can be traced back to the WHO SRQ-20.

On a critical note, one may see the screening efforts as a medicalization of social problems. Indeed, scholars have argued that rather than dealing with social and material inequalities and the problems camp-life can produce, service providers may often medicalize the refugees' very serious and credible

problems and thus obscure the root problems of refugee existence (e.g. Fennig and Denov 2018; Savic et al. 2016). This is an apt critique as long as it does not miss the point that even though dealing with mental health may not address the systemic unfairness of refugee life it may ease pain and suffering and, for example, lift parents out of apathy and give them some energy for their children. It is not a case of either/or, but a holistic approach that is called for. That is, mental health issues (structurally induced or not) must be addressed along with an effort that can improve living conditions, livelihood, education, and the prospect of the refugees in general (see also Fennig and Denov 2018).

Finally, then, further research may be done to advance our understanding of the dance of numeration and attunement to moods in medical practice, and we have yet to unearth its full theoretical and conceptual implications. What we have attempted in this article is to unpack an amalgam of numeration and attunement to moods in mental health practice in the Kutapalong refugee camp and draw out some implications for medical anthropology. While the immediate concern of the study has been how numeration and attunement to moods may fuse in medical practice in a refugee camp, the study may prompt more research to describe the dance of numeration and bodily experience. Future research on numeration-attunement in healthcare may be done with further details, insights and with a view to temporality. For example, further pinpointing how the different kinds of numeration and attunement to moods is part of the temporal order of medical practices would, we think, be of benefit to the field.

Notes

1. This article draws on findings and analyses presented at the The 8th International Conference on Infrastructures in Healthcare: Digitalization and Personal Health Data, 23–24 September 2021, University of Agder, Kristiansand, Norway (i.e. Christensen and Ahsan 2021). Furthermore, the project from which the ethnographic material is derived is also mentioned in Christensen et al. (2020).
2. This article, then, overlaps with the agenda of datafication studies and studies of "what numbers do" but not completely so, and for example an in-depth exploration of how the data travels and has agency for the psychologists, counselors, the project management, the camp management, external partners and so on is for another article in our view. We aim to focus more narrowly on "how is the screening of the refugees for mental health issues by the medical assistants in part achieved through numeration and in part through attunement to moods?."
3. To provide a compelling critique, and, ultimately, a partial defense of Heidegger's account of mood exceeds the scope of the present article. However, note that within philosophy objections have been made against Heidegger's account, including that he does not sufficiently, clearly, or consistently distinguish between (and often conflates) attunement, mood, and what may be considered emotion. Furthermore, his own account of moods is (too) limited in that it only considers a few moods at length such as anxiety and boredom (see Freeman 2015).
4. The Majhi is a local leader selected by the community to represent those that live within a camp block.
5. See Tay et al. (2018) for a detailed discussion of Rohingya idioms of mental distress.
6. This interview technique was somewhat out of the ordinary according to our empirical data and not something the medical assistant had been trained to do.
7. One may critique the screening efforts as a medicalization of social problems – an individualization of systemic problems in the camp (e.g., over-crowding, lack of income, lack of access to education, boredom, statelessness, curbs on movement, and uncertain future). We return to this below.

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