Article

Sociotechnical Transformative Effects of an ICT Project in Rural Bangladesh

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Abstract

The purpose of this article is to provide lessons from the field about an Information and Communication Technology for Development (ICT4D) project (Participatory Research and Ownership With Technology, Information and Change [PROTIC]) concerned with the use of mobile phones by women in remote villages in Bangladesh. The Bangladeshi government considers that the role of ICT in social and economic transformation is significant for the country's development. International nongovernmental organizations (NGOs) also regard ICT as important but are challenged as how to use them effectively for their programs and how to deal with long-term sustainability, digital divides, gender, and cultural issues. This article considers the PROTIC project as a modeling force for innovation and pressure on established sociotechnical structures. In this analysis, we follow what Donner defines as the "interrelationship" perspective, as applied to ICT4D. In particular, the notions of niche, regime, and landscape will be used to frame the changes that a village-level project may activate or respond to at the micro, meso, and macro levels of sociotechnical interaction. A mixed methods approach has been implemented during the 4 years of the project to monitor its outcomes, including interviews with project participants, reports of monthly consultations and training with villagers, extensive surveys, analysis of the Facebook profile of the project, and field notes and interviews with local NGOs and international NGO staff. Results show that the women villagers have undergone a transformation in attitudes, skills, and practices associated with mobile phone use. Transformations at individual and community niche levels have in

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turn influenced the conceptual framework of local and international NGOs and have also contributed to the reorientation of other regime actors, such as universities, major NGOs, and the government. Methodological constraints as well as the complexity of conducting international fieldwork with multiple actors will also be discussed.

Keywords

multilevel perspective, sociotechnical regimes, ICT4D, transformative effects, ICT and gender

Introduction

This article presents lessons learned from PROTIC (Participatory Research and Ownership With Technology, Information and Change), an international Information and Communication Technology for Development (ICT4D) research collaboration between Monash University and Oxfam, in Bangladesh. PROTIC took place from 2014 to 2019.[1] In particular, this article considers the project as a source of innovation and pressure to established sociotechnical regimes (Geels & Schot, 2007). The analysis of this case serves to frame the potential transformations that ICT4D projects may bring within the Bangladesh scenario and to offer guidance for project design in similar contexts.

In this analysis, we follow what Donner (2008) in his extensive review on mobile use in the developing world defines as the "interrelationship" perspective, as applied to ICT4D. That is, multilevel "socio-cultural factors are treated as both determinants of the design of the system, and as factors which are influenced by its introduction and use" (Donner, 2008, p. 150).

In the following sections, before presenting the case study, the background to mobile technology and development in the Bangladesh context will be introduced. The sociotechnical perspective and the participatory approach that provide the overarching framework for this contribution will then be presented.

Empirical Background

About 80% of Bangladesh's population of 160 million is crammed into an area about 1/3 the size of Italy. The people are mostly village-based agriculturists who are challenged by frequent physical isolation caused by seasonal flooding and environmental fragility. Their livelihoods and daily nutrition are primarily dependent on seasonally dependent agriculture or aquaculture. Another 20 million, most of whom are also low income, live in the dense capital of Dhaka. In fact, Bangladesh "is not so much a land upon water as water upon a land" (Novak, 2008, p. 23). Geographically, it can be regarded as a fertile, mostly low-lying riverine floodplain south of the Himalayas,

dominated by the massive Ganges–Brahmaputra delta. Unexpected weather events, earthquakes, and climate change have strongly negative impacts on food security and sustainable livelihoods for the country (Asaduzzaman, 2016; Uttam, 2016). At the same time, the equitable distribution of ICT benefits to all poses new challenges and concerns (Rahman, 2013).

According to the Bangladesh Telecommunication Regulatory Commission, as on December 2015, there were 133 million mobile phone users, increasing to 162.5 million by the end of August, 2019,[2] though people may possess more than one phone or SIM card, or share devices. Most users appear to have cheap phones (as low as US$10), though increasing numbers have cheap internet-enabled devices that are on sale in countless shops. At the end of August 2019, the total number of internet users reached 98.1 million, and 92.4 million of these were from mobile phones.

ICT interventions in development, however, are not just a matter of infrastructure and diffusion of technologies. As elsewhere, adoption is bound up with strong and local "social-cultural factors." In this case, despite the rhetoric about participation connected with ICTs, Bangladesh is characterized by a hierarchical and collectivist cultural orientation and adherence to traditional norms (Dutta & Islam, 2016), where "the individual relates to a few very important in-groups, organized in concentric circles (e.g., nuclear family, extended family, clan, city, state)" (Triandis et al., 1988, p. 24). Women's needs are secondary to collective needs, the needs of the partner, his family, and other villagers. In this environment, women's lives are also overwhelmingly carried out in the private sphere, while men are linked to the public sphere of work and the market and opportunity.

Individualistic Western models for gender empowerment only provide limited insight into this situation because they do not sufficiently appreciate the collective orientation and potential pathways for women within their culture (Rai, 2011). Additionally, the emphasis is on critiquing domination over women without proposing forms of resistance and transformation appropriate to the cultural context (Kabeer, 2012). Doctoral research in progress as part of PROTIC identifies the context-specific components of women's empowerment to promote women's empowerment through ICT in the context of rural Bangladesh (Figure 1).

Theoretical Background: The Multilevel Perspective

Research literature has demonstrated that transformations occurring at personal, interpersonal, and societal levels should be considered along with technical transformations as determinants and outcomes of the active social appropriation of communication technology by end users (Contarello et al., 2007; Donner, 2015; Taipale & Fortunati, 2014).

With this in mind, we argue that the multilevel perspective (MLP) described by Geels (2010) and Geels and Schot (2007) to illustrate sociotechnical transformation dynamics can provide a comprehensive framework to interpreting the changes that ICT4D projects may activate (Romijn et al., 2010).
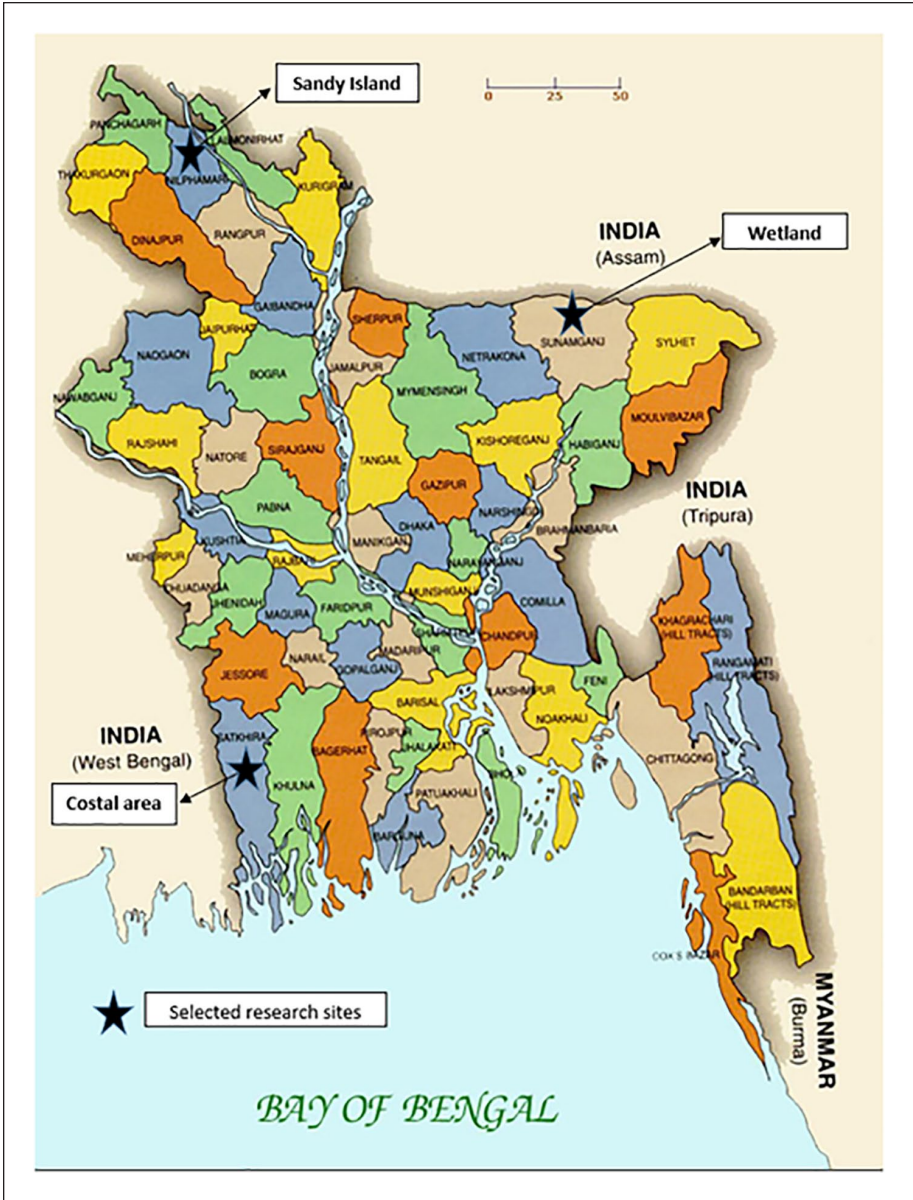
Figure 1. Bangladesh—the large stars indicate approximate project locations.
Note. Adapted from Hossain et al. (2016).

In particular, the notions of *landscape*, *regimes*, and *niche* help frame the changes that a development project may activate at the macro, meso, and micro levels of inter-action (Figure 2).
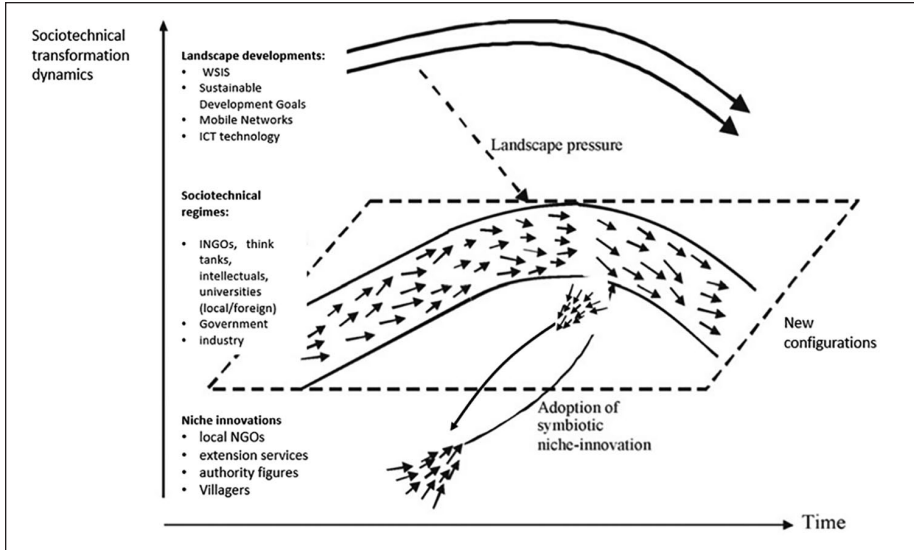
Figure 2. Sociotechnical transformation dynamics.
Note. Adapted from Geels and Schot (2007, Figure 5).

At the highest, exogenous level, *sociotechnical landscapes* are not deterministic but provide "deep-structural 'gradients of force' that make some actions easier than others" (Geels & Schot, 2007, p. 403). In the development context, this includes international policy statements (Sustainable Development Goals, World Summit on the Information Society) or global technologies, such as new generations of mobile phones.

At the meso level, the concept of *sociotechnical regime* accommodates a "broader community of social groups and their alignment of activities" (Geels & Schot, 2007, p. 400). In the Bangladesh development context, Dhaka-based international NGOs, local think tanks, and local or foreign universities, government, and industry contribute to define a regime—that is, a limited pattern of interaction, use, and development of technologies.

At the *micro or niche level*, a specific role is recognized to the niche innovations, which "are carried and developed by small networks of dedicated actors, often outsiders or fringe actors" (Geels & Schot, 2007, p. 400). Niches are often regarded as key places where innovations are developed and tested and eventually constitute a challenge to established regimes. According to the strategic niche management approach, successful niches activate three processes: They give voice to visions and shape shared and tangible expectations of participants, they build strong social networks, and they enable active and reflexive learning processes that move from individual changes into broader social transformations (Raven et al., 2010). It is important to avoid a bottom-up, niche-driven bias and to recognize the role that endogenous and exogenous actors have in sociotechnical dynamics.

With this aim, the theoretical framework suggests a variety of change mechanisms. In Bangladesh, for example, market dynamics are leading to increasing diffusion of mobile internet connections, at the same time the government is acting to provide regulatory frameworks. Moreover, we argue that a niche-oriented project like PROTIC can activate shared meanings, norms, and individual cognitive schemas. NGOs and development agencies, public intellectuals and activists, industry (e.g., specialist telcos), extension services, or local authority figures such as politicians or religious leaders and villagers play a fundamental and culturally significant role as they mediate between the exogenous context and the regime actors (Lewis, 2016). They may identify and propose alternative practices as well as may impose structural and cultural constraints or foster the empowerment of niche innovators already present (Shove & Pantzar, 2005).

To further clarify which form of transition is activated by interactions among the actors that operate at different levels, it is also important to reflect on time and nature of interaction. Timing has been described as the opening of windows of opportunities for transition, which can be fully developed only if the actors are ready, interested, and have the material and symbolic capabilities to recognize the affordance. The nature of interaction refers to distruptive or reinforcing relationships among actors.

Combinations of these two criteria may lead to the simple reproduction of the status quo, when the landscape reinforces the dynamics of the regime, and the endogenous dynamics are coherent with already established norms. Alternatively, depending on the disruptive pressure that the landscape exerts on the regime and on the level of development of the niches, four different transition pathways have been identified:

1. Transformation, which occurs when the external pressure for change is moderate and when the niches are not fully developed. Societal pressure groups, activists, or outsider intellectuals, activists, and others, may interact with regime insiders and lead to importing new knowledge and reorienting activities accordingly. This transition path is thus characterized by regime adaptations that do not disrupt the basic structure of the system.
2. Reconfiguration, which gives more emphasis to the role of the niche, where new solutions are developed and then exported to the entire system. In this process, despite the fact that the actors may remain the same, power relationships may be restructured leading to a more substantial change in the system architecture.
3. Technological substitution, which is activated by the copresence of niche innovation and external shocks, disruptive or avalanche transformations. The effect of this disruptive relationship cannot be absorbed by the regime, like in transformation or reconfiguration, and brings to technological substitution.
4. Dealignment and realignment, which is charcterized by sudden and large changes in the landscape, makes previous sociotechnical systems collapse. The absence of alternatives leads to the emergence of opportunities that compete until one specific innovation becomes dominant, leading to a new realignment and reinstitutionalization of the system.

Taking into consideration the direct mechanisms of transition, and the four main categories described above, we also reflect on whether and how the PROTIC project has particularly interacted with the Bangladesh sociotechnical regime or the landscape because of the engagement of international universities and an international NGO. Ideally, PROTIC promotes sociotechnical change via bottom-up, participative, niche innovations in conjunction with support and interaction at the regime level through project partners and collaborators.

Case Study

The PROTIC's aim is to improve agricultural and related knowledge and skills of rural Bangladeshi communities. It has a specific focus on engaging women, in different parts of the country, with the aim to reducing their dependency on others for information or support.

The first community is in the far northwest of Bangladesh, on the river Teesta near the border with India, on a sandy or *char* island in the Dimla local government area (*upazilla)* in the Nilphamari district. The people here are very vulnerable because of the constant changes to the river banks with frequent erosion and flooding. People living in this area are heavily dependent on river flows and seasonal paddy crops such as rice and maize. The village area is approximately 6 km^2 with a population of around 3,500.

The second community in the coastal area is situated in the southern mangrove region in the Shyamnagar local government area in the Satkhira district. Its economy is based on aquaculture and small farming. One of the main problems in this area is represented by increases in salinity, due to climate change and the spread of shrimp farms, which affect cultivation. In 2009, it was devastated by cyclone Alia. The village area is approximately 5 km^2 with a population of around 4,000.

A third community located in a *haor* or wetland in the Tahripur local government area in the Sunamganj district had been involved at a later stage of the project. They also grow crops (rice, maize). The village area is approximately 2.5 km^2 with a population of 3,000 spread over three mounds. Nearby control villages were also studied to examine the effects of the spread of ICT in rural Bangladesh beyond the project itself.

PROTIC's main strategies included the following:

- Distribution of smartphones to 100 women in each project village
- Group training on technological devices and one-to-one explanation on specific problems
- Monthly meetings aimed at providing a community-based participatory feedback loop for the project
- Implementation of Bengali language SMS service providing timely and accurate information and training concerning crops/livestock/disease alerts, crop planting calendars; also providing information on social benefits
- Use of a call center to answer questions concerning agriculture and farming issues

A number of researchers and practitioners constituted the PROTIC team, including researchers from foreign and Bangladeshi universities, the Bangladesh country branch of Oxfam (a major international NGO), a Bangladesh specialist communications telco, and a number of local NGOs, which developed the training and activities in the field. Moreover, researchers regularly spent time in villages and in Dhaka to discuss the project with participants, local NGOs, other international NGOs, and local government and central government officials such as agricultural extension officers. Consultations were not just aimed at collecting data but at actually shaping the evolution of PROTIC as a transformative enterprise (MLP transition pathway Number 1).

Mixed Methods Approach and Sources

Given the complexity of the project, and different anticipated outcomes, a mixed methods approach (Creswell & Plano Clark, 2011) was implemented to monitor how the project unfolded and the transformations it activated at the niche, regime, and even landscape levels. The methods included surveys, in-depth interviews with participants, ethnographic observations of off-line and online interactions, and the analysis of secondary data such as staff reports and internal documents (Sarrica et al., 2019; Stillman et al., 2020).

In-depth episodic interviews with women in the age range of 18 to 55 years were conducted in the northern and southern villages after 1 year (2017) and 2 years (2018) from the start of the project. Eighty interviews were analyzed with NVivo to examine participants' interactions with the devices and the possible emergence of an innovation niche in which the technological device could trigger new individual and community practices.

Monthly meetings for the village women were organized by the PROTIC project as a form of community consultation. Audio recordings were made of all these meetings. However, due to resource constraints, only recordings from September 2017 and from January 2018 were selected and analyzed according to the framework of Raven et al. (2010) to understand voice, expectations, networking, and learning processes in niche evolution. These 2 months were chosen on the advice of the NGO workers because they appeared to be richer in data in comparison with other periods due to periods of training and availability of people in the agricultural cycle.

A broad baseline survey was distributed to 649 respondents in the two main areas ($N = 160$ in Area 1; $N = 489$ in Area 2) to examine mobile practices at the household levels before PROTIC started. Subsequent surveys were conducted in 2016 with 388 respondents ($N = 190$ in PROTIC villages and $N = 198$ in control villages) and in 2018 with 438 respondents ($N = 293$ in PROTIC villages and $N = 145$ in control villages) with open and multiple-choice questions concerning meanings associated with mobiles and smartphones, mobile knowledge and practices, and capabilities and well-being.

We also analyzed Facebook posts from women included in the project. Based on the recommendation of Oxfam staff who observed that the southern villagers had generated more content, probably due to the enthusiasm of the local community development

Table 1. Synoptic Table of Levels Examined, Data Collected, and Procedures of Analysis.

Level	Actors including	Data	Procedure
Landscape	International organisations, international NGOs, international scientific community, major ICT players, and internet providers	Secondary data (e.g., SDG goals, World Summit on the Information Society, project proposal evaluation procedures, international NGO's reports and internal documents, international scientific workshops)	Hermeneutic (interpretative analysis)
Regime	International NGO Bangladesh branch, Bangladesh government, Bangladesh media, universities, public intellectuals and advocates, communications telco, national ICT players, and internet providers	Secondary data (e.g., national NGO's yearly reports and plans, government policies and statements, newspaper articles and media, national scientific workshops)	Hermeneutic analysis
Niche	Local government and elected officials, local NGOs, local village women participants, local inhabitants	Extensive surveys (2015 and 2016), qualitative data (field notes, monthly reports, three-monthly group meetings, episodic interviews with participants), social media postings and interviews (Facebook)	Qualitative and quantitative analysis, content and hermeneutic analysis, quantitative analysis, content and hermeneutic analysis

Note. NGO = nongovernmental organization; SDG = sustainable development goals; ICT = information and communication technology.

workers, we analyzed that village[3] and the data generated from the beginning of January 2018 to the end of July 2018. At first, we manually extracted and collected both the textual and visual contents, and then we categorized the corpus of data both qualitatively and quantitatively. This allowed us to determine topics most likely to be propagated within the profile, to explore local knowledge in more detail, and to investigate more in depth the online social interactions.

Finally, a hermeneutic analysis was conducted on secondary data to examine changes within the involved institutions and to identify traces of sociotechnical transformations at the regime level. The mix of data analyzed and its sources can be represented as follows (Table 1).

Field interviews were conducted by contract or Oxfam-affiliated staff in the Bangla language. Survey and interview materials were translated from English into Bangla by Oxfam staff or contracted workers and Monash PhD students. Inevitably, there was a

Table 2. PROTIC as a Learning Space, Self-Reflective Data Collected, and Procedures of Analysis.

Consortium	PROTIC team including research staff from international and local universities, project staff from international NGO, project staff from local NGOs	Qualitative data (reflexive interviews with research staff, structured workshops with local NGOs, field notes) Secondary data (training reports, steering committee minutes)	Critical analysis and reflexive ethnography

Note. PROTIC = Participatory Research and Ownership With Technology, Information and Change; NGO = nongovernmental organization.

degree of data contamination due to the difficulty of managing and controlling such work in the remote villages of Bangladesh from a distance—from Australia/Italy as well as from Dhaka. This issue, and the intercultural complexity of the research environment, is discussed in more detail in other publications under review. The project team was very conscious of the influence of cultural, structural, and other factors, including the socialization of research subjects whose livelihood depends on a positive relationship with NGOs to only offer positive opinions. We were also conscious of our position as outsiders in positions of perceived authority and our own research and cultural assumptions. However, the separate work of PhD students of Bangladeshi origin and continuing discussions with Oxfam and other experts on problems in field research in the country suggest that our results, despite collection problems, are strongly indicative of certain trends.

Moreover, looking at the project as an ongoing learning space or information ecology be "[a] system of people, practices, values, and technologies in a particular local environment" (Nardi & O'Day, 1999, p. 49), we argue that the people directly involved in PROTIC can be considered at the same time as subjects and objects of change involved in a double hermeneutic (Giddens, 1987, pp. 30-31). The language and concepts brought forth by each party influence the beliefs, language, and actions of the other. ICT4D of this type is not a one-way process. All parties in PROTIC are part of a consortium of different interests, which strives to achieve transformation at different levels, and that includes themselves as social actors. Their different relationships and orientations also make them part of the landscape (e.g., international researchers), regime (e.g., international NGOs branch managers and other staff, members of the intellectual class), and niche (e.g., local NGOs staff). We thus applied a self-reflective attitude to investigate the mutual exchanges between PROTIC team and their environments (Table 2).

Results

Learning Process and Emerging Practices

Data from questionnaires, interviews, and monthly meetings show that from being reluctant to use technology, more women are now confident and able to use the

smartphones in different ways, from getting agricultural information to accessing government services, from searching for market information to finding resources for children's education. PROTIC participants became more skilled using technical language regarding different functions of their phones as well as advice for animal and agricultural production and health that had been conveyed by SMS or in person. Data from questionnaires and interviews further suggests that women's agency brought about opportunities for self and group development. Enhanced skills, although gained initially through trainings given by the project, was further fostered by confronting new problems and actively seeking solutions from family members and others.

Together with individual learning, monthly meetings played an important role in the social learning process. There was a change in village agricultural production with a reported increase in 2019 agricultural production and knowledge on organic farming. With time, many participants started keeping the off-line backup of the information they are getting from the project. Some of the women started maintaining notebooks and some started writing the SMS on brown paper sheets for their small community-based organizations so that others could access and use that information (Frings-Hessami et al., 2020).

The social learning process, which is well established off-line, is less evident with regard to using social networks. Preliminary analysis of Facebook data shows that 139 posts were published during 7 months, with the highest number in February ($N = 51$). The majority of the posts contain one or more photos ($N = 101$), which could be an indicator of a preference for visual storytelling. However, use of the Facebook profile tends to replicate the hierarchical off-line structure and presents difficulties of engaging people in a bottom-up manner (Korten, 1980). It requires leadership from the lowest level that navigates through hierarchy. Those who participate actively in posting ($N = 32$) represent 23% of the friends of PROTIC Coast profile and are mainly active community-based organization members (PROTIC participants), other posts are published by NGO workers and by the Oxfam Project coordinator themselves. Despite this top-down approach, particularly significant and useful were the posts dedicated to rural education and on-site meetings. These were often also reposted during the 7 months, analyzed and documented through numerous photos of the participants.

Voice and Expectations

Questionnaires and monthly meeting consultations were found useful for understanding participants' expectations along with the support required from the project. Data from 2016 and 2017 questionnaires as well as from 2017 monthly meetings show that participants were almost unable to articulate any expectation with regard to the smartphone or the internet, described at best as "enhanced phone" or with generic expressions such as "can do everything."

Data from 2018 questionnaires show that in the control villages respondents did not have expectations since they just "haven't seen it" (47.6%) or took a passive stance "information can be received through smartphones" (23.4%). Despite the low response rate (around 20%), respondents from the PROTIC village have a more articulated

image, even if the most frequent answers show a certain vagueness (i.e., "now every-thing is in my hand," 13.7% of respondents). Other responses include a positive atti-tude ("good phone," 19.8%), schema of basic skills (i.e., "can be operated through touch," 8.2%), and concrete expectations such as "access to Facebook" (6.8%), "video calls" (4.4%), and "access to information services on agriculture and health" (3.8%).

Moreover, transcripts of 2019 monthly meetings show that participants were more vocal in communicating their expectations from the project in the future. In other dis-cussions with project staff, women suggested that future projects could provide health apps for the community, showing their capacity to develop concrete expectations and translate the acquired competencies to new domains such as health information for adolescent girls.

Networking

Personal and community networks are strong in Bangladeshi culture; in this project, they were evident between the women, their family, relatives, and the wider commu-nity. Acts of sharing were also evident in various activities. Data consistently show that smartphones were included in these social networks, and most notable is the shar-ing of information, applications, and the phone itself.

Questionnaires and interviews show that after acquiring a phone, communication with family increased, including relatives on the woman's side of the family. Along with that, through smartphones women started connecting with other women involved in the project from other parts of the country and sharing ideas with them. Moreover, some of the participants started to be in contact with government agricultural exten-sion officers through smartphones. A few were now also in touch with local govern-ment officials.

Collective empowerment was evident as women were seen by their community as information hubs. Trainings and visits from project actors may have initially resulted in individual empowerment, but their knowledge transformed (MLP transi-tion pathway Number 1) community knowledge through group interactions and collective learning. The project information and learning were not limited only to the project participants, rather these were shared with other community members occasionally, and sometimes nonproject participants also joined the monthly meet-ing consultations.

In contrast, despite the positive results of off-line networking, the content analysis (Altheide & Schneider, 2013; Weber, 1990) conducted on the Facebook page showed that the level of online involvement is not very high. Interactions between "friends" were rather low and sporadic. However, the practice of tagging was widely used to draw the attention of other people to posts or pictures. Lack of text could refer to care-ful abstinence from making comments. Thus, concerns over personal reputation—a very important matter in the village environment—could have made them reluctant to post too much about themselves. It is much easier to post something about agriculture or a religious festival than something about oneself.

Resistance to Change and Indications of Niche and Regime Transition

From the start of the project, there was optimism about the project, including the use of an action and participatory research approach by all those involved (Rahman, 1991). However, there was an issue about what was being reported to the researchers about the project's transformative niche effects or regime realignments. One NGO worker said,

> NGOs don't often understand the real context of what they are doing. I see the problem of simplistic program design and implementation from overseas models. There are rich and poor people and different stakeholders. But if you only meet and work with the poor then you aren't actually working with the whole community to solve a community problem.

This tension between regime rhetoric and niche practice was reflected in the fact that the local NGOs exerted far more downward control on the project than expected. The international NGO and its local NGO partners continue to call communities "beneficiaries," which reflects a traditional dependency relationship: local communities depend on them for support and the NGOs depend for support from donors and permission from government to conduct projects or research. One informant from an NGO put it like this:

> We need to be honest, but our NGOs are very conventional, and try to manipulate the learning—they tend to give us the positive approach. One day I asked them, don't you have any negative reports—No, no no—which I don't believe.

Despite this, there was a strong upward influence and realignment or reconfiguration (MLP transition pathway Number 2), at a policy level for the international NGO (Oxfam). This is reflected in the way that symbolic stories about the project have resonated throughout the international NGO and beyond into its local and international networks and into government. Management publicly speaks of changes in information knowledge and skills at the niche level as well as significant regime reorientation about the international NGO as an information, knowledge, and skills organization enabled by ICT in the future.

As well as this, a local research network, the first of its kind, has been established with representatives of NGOs, universities, and policy institutes.

Conclusions

PROTIC has been presented in this article to make a case for the sociotechnical transitions that can be activated by ICT4D projects. In fact, with regard to digitalization, a project like PROTIC can be used to protect and strategically build innovations and social networks, until windows of opportunities for transition open, and the niche gains momentum for negotiating and innovating shared meanings, norms, and individual cognitive schemas (Raven et al., 2010, Galli & Fasinelli, 2020).

As stated at the start of this article, theoretically, we see PROTIC as a niche modeling force for innovation and pressure on established sociotechnical structures and regimes (see Figure 2), and underdeveloped niches that can engage in a degree of innovation. There is subsequent sociotechnical regime adaptation to new knowledge and emerging activities (MLP transition pathway Number 2).

PROTIC started the development of a niche that couples new technological skills with innovative meanings and practices. The niche, however, still had to grow and fully structure itself. Important is the way activities, learning programs, and support were designed to create positively-gendered situations that allow women to develop their confidence, acquire new skills, and improve their economic situation. The project's approach, with call centers and close collaboration with local NGOs and Oxfam as well as agricultural experts, afforded the women with extended information sources and also capacity to build communication skills. Women's sense of agency, motivation, and purpose emerged beyond traditional cultural constraints. Expectations and capabilities, which were initially unexpressed, were voiced and new practices enacted, for example, by directly calling local officers, sharing information with other women, or by keeping for the first time an archive of information received.

At the sociotechnical regime level, PROTIC itself acted as a way to sharing knowledge and reorienting activities symbiotically flowing from the niche. The success of method and practices elaborated at the niche level has been embraced by the NGOs actors, which operate also at a national and international level, reorienting their policy practices and research orientation. It is also possible that these changes will spread to other regime actors (e.g., policy makers, stakeholders), thanks to the influential role of international NGOs in Bangladesh context. It seems thus possible for the establishment of reinforcing relationship, rather than disruptive ones, between local innovation and the national agenda to develop at the highest political levels.

At the highest level of the sociotechnical landscape, brought about by ICTs, moderate external pressure is the one played by the changing landscape, with a progressive penetration of cheap smartphones in rural Bangladesh. However, the effect is not just technological, as the research here demonstrates. It clearly links into broader sociotechnical transformations and innovations.

Despite these sociotechnical changes, we also found a common challenge reflecting the hierarchical and gendered traditional environment, which may hinder the permanence of the innovation niche described so far beyond the project and its positive transformative effects. For all the emphasis on participation in the project, in fact, the local NGO workers tended to direct and remain in control of activity and discussions. We also know that the village women were more guarded in their responses, and this has inevitably affected the quality of data. Both local NGO workers and the villagers were also reluctant to report problems and difficulties. Only when the family (husband, wife, relatives) and the close network of villagers were ready and accepting, could there be a "window of opportunity" to take advantage of the capacities developed within PROTIC and of the positive symbolism attached to the smartphone and to the internet. We also saw that there were cultural and language issues that hindered the efficient movement of information between researchers and partners in Bangladesh

and other countries, and also, the foreign researchers (Australia, Italy) were highly conscious of the mutually transformative process of research with the communities in Bangladesh.

Research challenges of this sort are not new and points to the well-documented history of failure or limited outcomes in ICT4D initiatives due to the lack of nuanced and realistic "fit" between technology and local social and political environments (Avgerou, 2010; Heeks, 2002). The MLP model in this case would appear to have the potential for highlighting barriers and sensitizing actors to the role of players and structures at different levels of international development. As a model for ICT4D development, the MLP offers project planners (academic, institutions, policy makers) a perspective that takes into probe and evaluates intentions for social–technology systems between key players at different levels of society. This avoids a top-down approach. Cultural interactions, perspectives, and nuances can be examined at different levels of activity, from niche innovations to the relationships among players at the regime levels, to global technological trends and innovations.

However, a limitation of the article is that it has not undertaken analysis or theorization concerning the link between different forms of power and ICT in the developing world. In this regard, the MLP represents an opportunity from which to further investigate questions of institutional and social power, national and international forces, and issues of repression (and gender repression) in developing societies.

As a theoretical model, the MLP adapted for ICT4D could be fruitfully applied, for example, with critical theories of technology because it offers three dimensions (landscape, regime, niche) in which to apply critical theories of power, gender, or neo-colonization. To take another perspective on the question of power, actor network theory could be fruitfully applied to study the relationship between the artefact in the field and the responses by different actors, again, at different levels of geographic and virtual social order (Diaz Andrade & Urquhart, 2012). Similar opportunities also appear to be linked to the application of critical realism as a means of revealing structural links and causes between different stakeholder levels (Heeks & Wall, 2017). Other researchers may see other fruitful opportunities, considering particular domains of interest, including non-ICT, theoretical spaces relevant to development discourse (Chae, 2014).

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Notes

1. The project was funded by a private foundation and received ethical clearance from both Monash University and Oxfam.
2. http://www.btrc.gov.bd/license-statistics
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