

Understanding Information and Communication Opportunities and Challenges for Rural Women through the Sustainable Livelihood Framework

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Abstract. The inclusion of marginalized women remains a challenging issue in ICT-based development interventions. Rural poor, particularly women in Bangladesh, may not realize information-related benefits from digital technologies. This is due to multifaceted challenges such as poverty, inequality, inadequate infrastructure, lack of information and education, and restraining social factors like patriarchy. Using the SLF [5, 10], smartphone applications' impact on rural Bangladeshi women farmers' lives was examined in this study. We found that smartphone access acted as a vehicle to improving information access and communication opportunities, reducing rural women's vulnerabilities, thus improving livelihoods, facilitating better access to agricultural extension services and local markets, and promoting women's agency [22]. Using the SLF lens, our insight offers designing insight to understand barriers to information and communication opportunities for rural women in developing contexts.

Keywords: Mobile Phone, ICT4D, Information Access, Women's Agency, SLF.

1 Introduction

The concept of Information and Communication Technology for Development (ICT4D) has been a focus of debate because of its broad coverage and significant intensity of impact in the international development process [15, 16, 17]. More recently, attention has shifted to such issues as social inclusion, sustainable development and the impact of ICT4D to match the changing international development context [12, 17, 36].

The use of mobile technology, particularly by rural women in development contexts, has also emerged as a much-discussed research topic in the ICT4D literature [7, 14]. However, despite the rapid growth of mobile technologies, scholars argued that systemic poverty, inequality, and the exclusion of marginalized women's

issues in the post-2015 development agenda continue to remain significant in understanding complex development dynamics [7, 14, 15, 16, 17, 36].

While this socio-technical change has been occurring, the Sustainable Livelihood Framework (SLF) has been widely applied in development interventions by leading international Non-Governmental Organizations (NGOs) such as the Cooperative for Assistance and Relief Everywhere (CARE) and Oxfam [33]. The SLF is relevant because it helps to address the linkages between contextual vulnerability, societal structure, institutional processes, livelihood strategies, and outcomes for marginalized communities. In Bangladesh, the SLF has been used by international, national and local NGOs, government institutions, UN agencies, and other bilateral donors. Thus, because of the increasing importance of ICTs, there is scope to theorize further the ICT4D interventions concepts for strategic policy advocacy and sustained impact.

The paper examines the case of a group of marginalized rural women farmers and maize micro-entrepreneurs from Bangladesh and explains the role of smartphone applications as an empowering communication and information vehicle. Findings highlight structural changes brought about by smartphones to rural women's communication and information practices and their relationship to the livelihood elements of the SLF. This empirical research in Bangladesh provides insights for designing similar ICT4D projects in other developing contexts.

The paper begins by discussing the related literature. This is followed by an explanation of the core elements and relevance of the SLF as a conceptual model. The subsequent section outlines the research methodology and describes the comprehensive data collection and analysis process. The following sections present the findings, discuss, and provide future research suggestions. Finally, the paper concludes by highlighting the relevance of SLF in understanding the importance of information and communication opportunities and challenges for rural women's empowerment.

2 Related Literature

2.1 Mobile Phone and Women's Agency in Emerging Economies

Given the current rapid growth of mobile technology, ICT4D research needs to address the relationship of ICTs to complex multidimensional issues in international development [14, 16]. Furthermore, because of their relatively low cost, portability, and simplicity, mobile-based technology and mobile phones have become prominent tools for information and communication compared to other ICT devices, such as desktops and laptops [17, 36].

Accordingly, multidisciplinary research incorporating insights from sociology and ICT is conducted to understand the ICT4D change process, mainly in developing contexts in Africa and Asia, focusing on mobile phone-based development interventions [21, 26].

Understanding ICT4D intervention trends in developing country contexts are essential [14, 17, 30]. However, many developing countries struggle because of gaps in policy and practical challenges relating to rural communities' uptake [7, 29]. For example, rural women in Bangladesh still face issues with availability and access to smartphones due to cultural and other factors [2]. Therefore, a deeper understanding

of relationships between rural women's communication and information processes that occur via mobile phones in women's cultural and related contexts helps develop strategies to minimize the digital divide, and promote inclusive, sustainable development agendas.

Several studies have shown a positive correlation between ICT4D interventions (including mobile technology, e-inclusion, enterprise growth) and women's empowerment in promoting their agencies [4, 19, 21, 26, 34]. For example, researchers have noted a positive correlation between mobile phones and improvement in income level, housing conditions, living standards, awareness about health, agriculture and an overall improvement in rural women's lives in Bangladesh [31, 35]. For example, mobile phones can improve the living standards of rural women because there is a direct connection of mobile phone use in managing information flow, financial transaction processes, and better financial inclusion, such as 'bKash' mobile banking services in Bangladesh [20]. Similar studies of 'M-Pesa' in Kenya show the relevance of mobile money transfers for financial inclusion and business growth [25, 26].

However, only a few studies have analyzed the correlation between mobile phone applications, availability of information, growth of micro-enterprises [1, 4, 23], and the results vary from one to another. For example, a survey in Uganda shows how mobile phone usage can facilitate a positive change in the entrepreneurial ability of women by increasing their ability to handle emergencies, reducing transactional and trading costs, and minimizing risk factors [23]. However, at the same time, the survey indicates that a mobile phone may increase the domestic care work burden, and it may even increase domestic violence in some cases. Furthermore, there is no standard definition of micro-enterprise, and the numbers of employees may vary depending on the size and nature of the enterprise [9].

Research also shows that mobile phones can strengthen social capital in addition to business networks [1, 3, 7]. For example, research in Indonesia suggests that mobile phones provide the means to enhance social capital and resources for business activities; hence, they are counted as crucial resource capabilities for women entrepreneurs [1]. However, previous research also observed the blurred boundary between the business and personal use of mobile phones [8]. For example, rural women in Bangladesh use mobile phones for economic activities and maintain family relationships with improved social interaction [2].

Similarly, researchers have noted a gender dimension to women's access to mobile phones that reduces expected benefits [7, 11, 34]. Compared to men, women have less opportunity to use mobile phones because of social norms. Though mobile phones were considered a means to improve livelihood opportunities for women micro-entrepreneurs, in places like India, such a technological intervention could not address the broader social divisions within a society [6]. This body of research shows that while women's use of mobile phones is enhancing women's livelihoods and wellbeing, there remain structural, cultural, personal safety and labour inequality issues that limit opportunity for women.

2.2 SLF and International Development

Since 1990, the SLF has become a widely used development approach in Africa, Asia, South America, Central and Eastern Europe adopted by international develop-

ment agencies and NGOs such as Oxfam, CARE, the UK's Department for International Development (DFID) and the United Nations Development Program (UNDP) [33]. The SLF approach was initiated by Robert Chambers [5], a leading development researcher and theorist. He advocated for the SLF as a practical development model for the 21st century and defined the concept by adapting the World Commission on Environment and Development panel definition. The major elements of this framework include contextual analysis focusing on vulnerability, shocks, seasonality, different types of assets, such as physical, social, natural; the role of different institutions and stakeholders, such as governments and markets; livelihood strategies and outcomes.

The definition of livelihood in the framework is as follows [5, p. 6]:

A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term.

As a generic development program design tool developed before the ICT4D trend in international development, the SLF did not pay sufficient attention to broader macro-economic and political issues relevant to ICT4D interventions [10, 27]. Furthermore, a limitation of the current form of SLF is its lack of theoretical alignment with any development or socio-technical theory [33]. Consequently, there is room for academic researchers to apply this model for ICT4D research and theory development [10, 33] and offer practical design direction to development practitioners [27, 33].

3 SLF as a Conceptual Model

This paper offers critical insights into the significance of various social factors (communication and information culture and practice, power, class, gender and social capital) in designing socio-technical projects focusing on women's empowerment and other mobile-based development interventions in Bangladesh.

As discussed above, previous research suggested an improved scope for theoretical development of the SLF approach to use it as a tool to understand the role of ICT in reducing the vulnerability of rural poor to social and economic challenges [10, 33]. Researchers also emphasized the importance of in-depth empirical analysis to make the SLF a more robust tool.

We applied the SLF as a conceptual model to review the nature of vulnerabilities faced by rural women, their connection with social and economic structures, gender relationships within family and society to understand the role of smartphones in promoting women's agency.

As shown in Figure 1 below, the main elements of the SLF are: a) Vulnerabilities, b) Assets, c) Societal Structures and Processes, d) Livelihood Strategies, e) Livelihood Outcomes [18, p. 41]. These elements are briefly explained here:

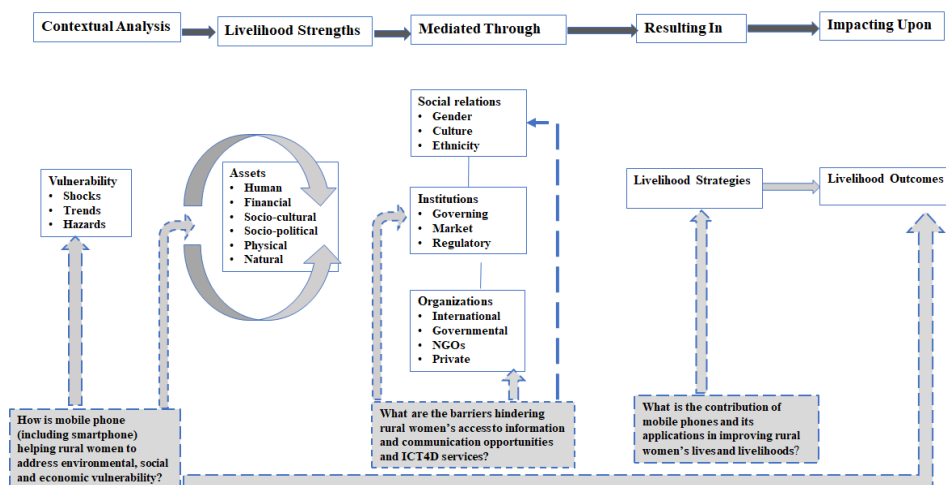


Fig. 1. Sustainable Livelihood Framework Adapted from Duncombe [10, p. 84]:

- **Vulnerabilities:** contextual vulnerability refers to the external factors that may affect people's livelihood and wellbeing. These may include natural disasters (e.g. flood and cyclone), trends (e.g. migration, financial crisis, COVID-19) or seasonality (e.g. food price hike).
- **Assets:** five types of assets are identified, namely financial capital, physical capital, social capital, human capital, and natural capital. Remittance, wage, mobile banking, micro-finance savings and credit are examples of financial capital. Physical capital may include housing or infrastructure, information and communication technology and tools, energy and transport. Social capital may include relationships within the community, collective effort and networking. Education, knowledge and skills, and health are examples of human capital. Land, water and aquatic resources, forests, wildlife are examples of natural capital.
- **Structures:** For example, different institutions and organizations from the public, private and NGO sectors, legal and financial mechanisms.
- **Social Processes:** processes include decision making and gendered social, cultural norms.
- **Livelihood Strategies:** livelihood strategies refer to both long term and short-term strategies. These may include forming a micro-enterprise group and networking with extension service providers.
- **Livelihood Outcomes:** livelihood outcomes refer to better wellbeing. This can be associated with more income, improved food security, better access to information and technology.

This conceptual model invites us to analyze and understand different aspects of a societal change process. Therefore, we considered the elements of SLF while examining the role of smartphone application-led interventions in rural Bangladesh. As a result, as shown in Figure 1, three questions were addressed:

- How are smartphones helping rural women to address environmental, social and economic vulnerability? This question aids in understanding vulnerability in contexts, rural women's capabilities, livelihood strategies and outcomes.
- What is the contribution of smartphones and their applications in improving rural women's lives and livelihoods? This question relates to understanding livelihood assets and livelihood strategies.
- What barriers hinder rural women's access to information and communication opportunities and ICT4D services? This question explores social relations and social structures and the role of different institutions and stakeholders.

4 Methodology

The research adopted a qualitative approach within the interpretive research paradigm, noting the importance of the interpretive case study method in ICT4D research [37]. We followed the exploratory case study method exploring unique and in-depth qualitative insights [28, 37] based on empirical data collected from the northern part of Bangladesh. A qualitative interpretive case study is relevant to ICT4D research as it provides the scope to test conceptual and theoretical models [28], generate nuance and tackle the notion of development in distinctly different ways [36].

The first author and field researcher is a Bangladeshi female, trained in social anthropology in Bangladesh and advanced ICT research methods from Monash University. Because of her experience in NGO management and fieldwork with village communities, she understands rural development and the national policy contexts in Bangladesh. During the data collection and analysis, she was conscious of unequal gender and patriarchal perception, hierarchy and power structure that exists within rural communities and between the communities and outsiders. She built rapport through informal communication before engaging in the formal data collection process. Language and basic understanding of local culture enabled her to ask follow-up questions to develop meaningful insights from interviews and focus group discussions. Considering possible effects on relationships between the researcher and research participants and noting the influence of the local NGOs and openness to overall information-sharing behaviour in the community, she compared and verified responses from different categories of research participants and used her field observation notes. Other authors with different national backgrounds contributed outsiders' perspectives to data interpretation and thematic analysis [32]. The research received ethics approval from the Monash University research committee, and informed consent from local communities was obtained.

4.1 Research Participants

Participants were rural farmers, maize producers involved in the PROTIC¹ project, and local service providers in Nilphamari Upazilla² (located in the northern sandy island region and identified as one of the most poverty prone and geographically vulnerable areas of Bangladesh [31]). A total of 100 marginalized rural women farmers received smartphones, online and phone information services and training through PolliSree (a local NGO) as part of PROTIC. The action research project was implemented by Monash University in conjunction with Oxfam, an international NGO. Some women also acted as maize entrepreneurs with financial and mobile application skills, collecting maize from farmers and selling them to maize wholesalers in the local market.

Research participants were selected using the purposive sampling technique, following a set of criteria developed by the first author and modified in consultation with PolliSree (which had trusted relationships with the rural women and local service providers).

The main selection criteria were leadership quality, living conditions, knowledge of mobile application use in agricultural production, and entrepreneurial activities. Data collection started with focus group discussions with rural women farmers, entrepreneurs, and their husbands. Then, based on the field researcher's observations, the most articulate and successful rural women were approached for in-depth interviews to understand the local situation better. Finally, local service provider participants were identified based on their roles, availability, knowledge and relationships with rural producers and entrepreneurs.

Table 1. Research Participants

Data Collection Techniques/ Participant Category	Interview	Focus Group 1	Focus Group 2
Women farmers and entrepreneurs	7	8	8
Local service providers	15	-	-
Women entrepreneurs' husbands	-	3	-
Total research participants	22	11	8

Table 1 shows that, in total, 22 research participants took part in semi-structured in-depth interviews while 19 participated in two focus group discussions. Three women farmers interviewed also took part in the focus groups. Three male farmers were included in one focus group with their wives supporting maize production and involved in the collective maize microenterprise ventures to learn their perspectives. In addition, 15 local service providers (including agriculture extension service providers, ICT4D service providers, NGO workers and maize wholesalers from the local market) were interviewed as part of the maize farming ecosystems at the village level. Comparison of responses from women farmers and entrepreneurs, particularly on

¹ Participatory Research and Ownership with Technology, Information and Change (PROTIC) is an ICT4D action research project

² An Upazilla refers to a lower level administrative unit in Bangladesh

vulnerability, livelihood strategy and outcomes while using smartphones provided more nuanced insight.

4.2 Data Collection and Analysis

Three types of data collection techniques were used: a) in-depth semi-structured interviews, b) focus groups, and c) field observations. The first author of this paper conducted a field visit in the northern part of Bangladesh from April to September 2019 to collect empirical data. The Otter and Voice Recorder apps on smartphones were used to record the interview and focus group data. Special attention was given to observe: seasonality in agricultural production; daily agricultural activities performed by rural men and women farmers; household roles played by rural women; women's relationship and status within family, community, market and local power structures. Before and after conducting individual interviews, interpersonal communication amongst women farmers with their family members, including husband and in-laws, was observed to better understand family dynamics and power relations.

Interview questions for the semi-structured interviews and checklists for focus groups with the rural female, male farmers and entrepreneurs were translated to Bangla to ensure comprehensible communication and high-quality data collection. During the key informant interviews, research participants responded to the following topics:

- type of mobile device and its applications used in daily life;
- changes in life observed after started using smartphones;
- the types of information and purpose of communication, e.g. interpersonal communication with family and relative, information and learning exchange related communication with social network and community, business communication with seller and buyers;
- challenges faced in using a phone;

While finalizing the questionnaire and checklist, the field researcher had several informal discussions with the local NGO staff to identify the correct terms to use those respondents would understand which would address the essential research concepts. Later meanings of such terms were co-created with research participants during data collection. For example, the concept of women's empowerment (*'narir khamatyan'* in Bangla) meant 'women's power', and 'ICT4D' meant 'advancement (*'unnyan'* in Bangla) with smartphones' in this research context. This initiative created a lively environment leading to a meaningful dialogue between the field researcher and research participants.

NVivo 12 plus was used as a data analysis tool to open data coding at the first phase and thematic coding during the second phase. Additional memos were developed at the data analysis stage to interpret data collected from the fieldwork.

5 Findings

We found that smartphones (including smartphones and its applications) acted as a communication and information enabler that increased women's agency [22]. The

smartphone was used to reduce vulnerability related to a disaster, improve livelihood outcomes, and connect women with the local market and local service providers. Overall, it helped to improve women's status. We have organized the findings into three thematic areas illustrating these points.

5.1 Mobile Phone as a Channel for Communication, Information and Consequently a Livelihood Asset and Strategy

The first notable and overarching findings show how access to mobile phones (including smartphones) improved women's wellbeing, including economic, personal, and social elements. Next, this section reports how smartphones were regarded as livelihood assets, and the use of mobile applications became a part of rural women's livelihood strategies.

The majority of the research participants acknowledged the positive impact of mobile technologies in rural women farmers' lives and livelihoods. The women farmers reported that ownership of smartphones made them feel confident, which acted as a gateway to knowledge and subsequent action. Through training provided by the local NGO, they learnt how to use smartphones to look for the relevant information they needed in their day to day life. A woman expressed her confidence with joy:

"I know how to use the Google search option and download apps from Google Play!" R (age 34), farmer

We also found that the rural women groups were not homogenous, and they were using different types of mobile phones and technologies. During a focus group discussion, a woman described:

"Some of us have 'button phones' [mobile phones with basic features], and some have 'touch phones' [smartphones] like me." F (age 31), farmer

Despite the difference in mobile device and technology level, all reported mobile phones as valuable assets.

We noted during a focus group discussion that most rural women mentioned using 10-12 types of standard features on their smartphones despite not having a formal education. They said:

"We use many apps, such as Google, Opera Mini, and ShareIt, and so on various [mobile] apps." focus group 2 participant

Another participant from the other focus group mentioned that smartphones and their applications are associated with their livelihood strategies. She said:

"We use [smart]phones for different purposes including agricultural production, communicating with others, and using Facebook. We use different features and apps, such as camera, clock, calendar, calculator, mobile apps for agriculture and education." focus group 1 participant

From the interviews, it was apparent that the use of smartphones was not limited to essential activities but also for what is often regarded as complementary use, such as entertainment and memory capture. For example:

“First of all, we use phones to communicate with others. We also use it for entertainment - we listen to music and songs, watch dramas, capture photos and watch those. We watch cooking shows on YouTube and learn new recipes.” F (age 31), farmer

We found that rural women valued their increased day-to-day interpersonal interactions with family members above other types of communication. During the focus groups and interviews, most women farmers also emphasized their sense of improved connections with family and relatives in neighbouring villages. This was explicit in the case of the husband or other close family members who went to any city within Bangladesh or outside of the country primarily for work purposes. Several women reported that, in such cases, they felt connected because of regular communication over smartphones. This positive emotion of being connected is reflected here:

“My cousin lives abroad. I can communicate with him through the Imo [mobile app].” S (age 26), farmer

5.2 Vulnerabilities and Coping Mechanisms with Information Opportunity

We found that rural women entrepreneurs faced multidimensional vulnerabilities and shocks regularly. Natural disasters such as floods and river erosions were challenging their lives and livelihood. Moreover, uncertain market prices such as sudden price fall or unpredicted illness or death of family members impacted their micro-enterprise operation.

A positive correlation was observed between receiving up-to-date information from the call centre via smartphones; becoming aware of implications of disasters such as flood, or extreme weather information, such as heavy rainfall or fog; and getting prepared to take appropriate actions to nurture their agricultural production, sharing updated knowledge with neighbours and extended family members in the locality.

a) Disaster Preparedness

We observed that smartphone access allowed rural women to address their information and communication needs when traditional cultural boundaries limit physical mobility. For example, some women farmers were exceptionally skilled in learning and sharing disaster preparedness information and became role models in their community while successfully saving their crops or livestock. As a result, others started to depend on them for updated information and followed their agricultural practice for better production. For example, one of the woman farmers explained that several neighbours approached her for information:

“Each day, at least ten people come to me to get service. Most of them want to know about the weather update and solve agriculture production-related problems.” F, (age 34), farmer

b) Increased Access to Information and Agricultural Extension Services

Women farmers explained that after receiving smartphones and training, they became aware of the government's available support and services, consequently regularly visiting the local Digital Centre to obtain those services. They checked information from the 'citizen charter' (individual entitlements from the government) and other mobile apps using smartphones. One of the respondents explained the categories of services they access:

"We go to the Union Digital Centre [lower level local set up to provide public digital service] on several occasions. For example, to obtain a birth certificate, to collect paper for land disputes, to take passport size photos for passport and visa, to get welfare benefits for widows and elderly people." F (age 31), maize entrepreneur

We found that smartphones helped them track allocation status to their community and created easy access to those with accurate information. Rural women said that this experience contributed to improving their confidence level. The quote below illustrates one woman, but other women farmers shared the same experience:

"Now I feel confident! I often make phone calls to the 'Union Parishad' [lower level local administrative unit to provide public extension service] members asking for updates on the local safety net [public welfare program] allocated to our village." P (age 26), farmer

Women farmers said that smartphones had saved their time and money to access public extension services for information or arrange visits to their agricultural fields and livestock. Some of them could never do it in the past or depended on male family members to do this for them. In addition, smartphones provided a means for women to navigate the social barrier of communication with male public officials.

c) Access to the Local Market

Both male and female entrepreneurs involved in the maize enterprise considered that smartphones saved their time and money. For example, while checking the market price with the retailers and wholesalers, they could compare the prices offered. In addition, smartphones helped them contact other farmers in the locality for maize collection instead of meeting them in person. Smartphones also saved their time and money by fixing appropriate times to collect and deliver bulk maize stock to the wholesalers. However, both categories of research participants mentioned that neither the wholesalers nor the farmers had any negotiation power over the big national companies, the leading player in the maize value chain.

5.3 Barriers Hindering Women's Access to Information, Communication Opportunities and ICT4D Services

We found that rural women faced various kinds of institutional and patriarchal social barriers utilizing their livelihood strategies, such as bureaucracy, uneven societal power structure, and patriarchal mindset. For example, we noted a strong negative gendered perception of women's physical capabilities shared by maize women farm-

ers and wholesalers, as essential tasks involved physical strength, i.e. carrying heavy weights and handling the bulk transfer of production.

One of the maize wholesalers said that often, women would ask their husbands to arrange the maize transportation and delivery. He explained that women's direct communication with people outside their relatives and family was not encouraged.

Thus, because maize wholesalers were male, direct communication between male wholesalers and male farmers instead of female farmers was more acceptable to conform to the social and cultural norms in a patriarchal society. He also mentioned circumstances when women who are not married or widows, in the absence of a male member in the family, communicate with them directly. He said:

"We collect maize directly from the producers. I have regular contacts with 120 maize farmers; most of them are men. Some four-five women are either widowed or divorced. They work on their own as farmers. Otherwise, women mostly help their husbands in farming. Women do not come here to collect money or fertilizer." A, (age 45), maize wholesaler

In addition, most maize delivery and business transactions were conducted in the evening where women were not supposed to travel, as explained by another maize wholesaler:

"Women cannot work as maize suppliers for us. The delivery of maize and the payment transaction takes place in the evening or night. Women cannot travel at that time, but their husbands can do that. Men are in charge of managing maize collection from small farmers and dealing with financial transactions." K (age 60), maize wholesaler

The rural women micro-entrepreneurs considered smartphones and their applications helpful in addressing the challenge of social constraints on mobility by creating an alternative mechanism of networking with the market and financial institutions. Most research participants noted the overall positive impact of smartphones, which directly contributed to increased networking, improved livelihood outcomes and better social acceptance within society. For example, a young woman entrepreneur mentioned how she balanced the social norms, maintained contact with the local market and managed personal debt. She said:

"I do not need to go to the market to sell my product. This [smart]phone is helping me to communicate with the market, staying at home and earning more. I feel thrilled when I can return money to my father-in-law, which we borrowed a few years back." P (age 26), farmer

6 Discussion

Our discussion is organized in three thematic areas in the following subsections to expand our findings and indicate possible implications.

6.1 Understanding the Communication and Information Affordances via Smartphones as Livelihood Assets and Strategies

We found that the SLF is useful for examining the role of smartphones in reducing vulnerability, connecting rural women with local economic and power structures, institutions and processes. As a result, their vulnerability to environmental and social causes is reduced. Similar findings were also advocated by Duncombe [10].

We found that smartphones and phone applications are acting as significant factors helping to diversify rural women's livelihoods, such as agricultural production and maize enterprise development. Smartphones acted as a vehicle for information access, leading to crucial decisions, such as getting prepared for floods, extreme heat, or heavy rainfalls to preserve their agricultural production. This observation relates to Giger's [12] concept of 'information capabilities' concerning ICT use. He explained, "... 'informational capabilities' refers to the combination between a person's existing livelihood resources in terms of information (informational capital) and his/her agency (ability) to strengthen these assets and to use them in such a way that the use of information can help a person to transform his/her options in life in order to achieve the 'beings' and 'doings' a person would like to achieve." [12, p. 8].

The model allows for systematic tracing of the livelihood outcomes resulting from the use of mobile technologies. It shows, for example, how human assets, enhanced by mobile use, are empowering women in navigating through and, to some extent, transforming structures and processes within the village level.

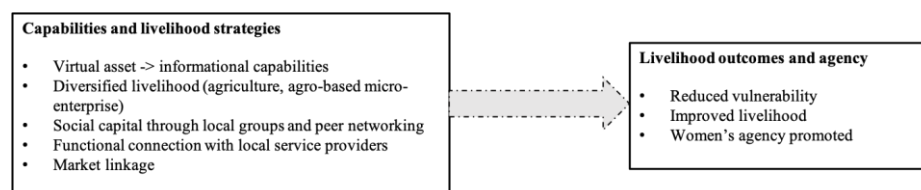


Fig. 2. Information access via smartphones leads to livelihood outcomes & women's agency

According to the SLF model (Figure 1), smartphones can be considered a physical asset. However, considering the affordability and significance of mobile technologies in rural women's lives and livelihood, we propose to add another category of asset, namely 'virtual asset' referring to rural women's expertise on mobile applications use and its relationships to the concept of 'informational capabilities' [12]. These capabilities and strategies materialize through women's capacity to appropriate the virtual asset, i.e. information afforded by the use of mobile applications. Given the significance of mobile technologies as a virtual force in the developing world, this is a substantial chance for the assets contained in the proposed SLF model.

6.2 Livelihood Strategy, Outcomes and Agency of Rural Women

Our findings show that increased information access and knowledge about smartphone apps helped many rural women make informed decisions, provide better access to available public agricultural services, and establish market relationships.

The research showed how access to communication and information played an essential role in promoting women's agency for individual achievements, within families, and collectively in their communities.

We found that women's interaction with the virtual asset and capability provided by the communications power of smartphones, and their apps in particular, resulted in a 'material agency' [24] and influenced the change process in the rural society in the Bangladesh context. Women were able to use smartphones to achieve livelihood outcomes by increasing their knowledge, through market access, public agricultural extension, and financial services, and opening up avenues for informed decision making. Consequently, women's agency and smartphone affordances lead to their informational capabilities and improved livelihood outcomes as explained in Figure 2.

These preliminary results show the potential of this framework in enabling a richer analysis using the SLF as outlined in section 3.

6.3 Information Access Issues for Women

Based on the findings, the following observations on issues relating to women's access to information can be identified:

- a. During the data collection process, rural women referred to some factors hindering their smartphone access. These included patriarchal social and cultural norms, which constrained their use of mobile phones for networking and learning. International empirical data confirm this issue.
- b. Although the gender gap of mobile and mobile-based internet use is narrowing, and the price of a smartphone device is diminishing day by day, a majority of marginalized rural women cannot afford to buy one. Research participants received smartphones through the PROTIC project, which formed the background of this study. However, they could still not afford to buy or repair the device at the end of the project.
- c. Poor infrastructure, e.g. inadequate electricity supply and internet connectivity, create obstacles to using smartphones and the internet. In addition, research participants mentioned that they have to travel to the local market to get their mobile charged and pay fees for that.

These observations are confirmed by international empirical data that women still face challenges, namely lack of literacy and digital literacy, the cost of mobile handset particularly in case of a smartphone, the cost of internet use and the disapproval of families for mobile and internet use by women [13, p. 49]. Thus, while an ICT4D intervention project may initiate rural women empowerment by providing access to information and other services, barriers still exist, from social barriers to ICT infrastructure and cost issues hindering their access to opportunities, which will affect their livelihood outcomes [31].

7 Limitations and Future Work

This paper emphasized understanding the enabling contribution of mobile phones and their applications in improving marginalized women farmers' livelihood outcomes. Of course, we recognize that our insights are based upon a small group of people chosen for an ICT4D project. However, it captured perspectives of rural communities, which provided valuable lessons in different designs and applications of such projects [31]. We modified the SLF model by conceptualising smartphones as both physical and virtual assets with women's agency in a particular context and validated its relevance. While based on qualitative data, this model can be tested further in other rural developing contexts to gather insight for inclusive digital development for women and other excluded groups [10]. This analysis can be a reference point to help other academic researchers to develop a theory-based understanding of the underlying issue in addressing ICT impact in other vulnerable contexts.

8 Conclusion

The SLF and reflective research can be applied as a valuable lens to look deeper into the gaps and underlying causal relationships of ICT4D interventions. We demonstrated the relevance of the SLF model to explain vulnerability, livelihoods strategy, and outcomes for rural women in Bangladesh.

As an example, the paper shows how smartphones and their applications can be vehicles for communication and information, which enable the women farmers to reduce vulnerability related to disasters, increase livelihood outcomes, connect them with the local market and local service providers, and improve their overall wellbeing. Our findings draw attention to the importance of understanding challenges rural women farmers face in digital development due to economic and social structural barriers, such as inadequate infrastructure and patriarchy. Furthermore, it demonstrates the significance of smartphones in affecting interrelated empowerment dimensions of rural women's wellbeing, livelihood and identity.

This empirical insight will likely be transferable to similar resource-constrained and vulnerable community contexts. Moreover, this insight can assist international development stakeholders, such as governments, NGOs and ICT4D implementing institutions, to make strategic decisions to design and implement mobile phone-based development interventions.

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