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RESEARCH ARTICLE

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Understanding the information landscape in agricultural communities in rural Bangladesh

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Abstract

Knowledge sharing in rural agricultural communities is vital to the success of farmers and sustaining high yields. A range of actors in the knowledge landscape participate in knowledge sharing, and with this, a variety of complexities are introduced. In this paper, we report on a set of field visits, interviews and focus groups in various settings to understand this complex nature of the knowledge landscape. Our study was set within multiple locations within 20 miles North-East of Dhaka, the capital city of Bangladesh. Our findings highlight the high level of interconnectedness of different actors in the agricultural communities and the complexities involved in establishing trust of information. We report on the importance of fostering successful relationships within the communities and the growing strains of climate change.

KEYWORDS
agricultural communities, field study, information landscape, knowledge sharing

1 | INTRODUCTION

Agricultural communities in rural areas in the global South have long accessed traditional knowledge (i.e., that has existed within families and communities) to provide growing sustenance, income (Kanak Pervez et al., 2015) and resilience to climate events (Green & Raygorodetsky, 2010). Much of this tacit knowledge is handed down from generations to generations or through observations and peer learning as a part of daily-living. The introduction of exogenous knowledge (i.e., modern scientific knowledge, techniques, real-time data) such as chemical fertilizers, genetically modified crops and new farming techniques have increased yields many fold, albeit at risk of traditional knowledge becoming subordinated and potentially extinct.

More recently, it has become increasingly clear that preserving indigenous[1] knowledge is essential to ensuring long-term environmental protection, crop diversity (SDG-2.5 [Ahmed, 2004]), food security (SDG-2), sustainable development (SDG-11.A, 15.3) and resilience to climate change (SDG-13). It is also recognized that adopting such knowledge will lead to protecting and safeguarding the cultural heritage of generations of agricultural communities (SDG-11.4).

Previous studies have explored either the use of indigenous techniques for farming and environmental protection; or application of new and emerging technologies for agriculture. ICT4D as a field has only recently begun to engage with the ways in which indigenous knowledge and

[1]While it is important to acknowledge the nuances of the terms 'indigenous', 'traditional', and 'local' knowledge, in the context of this paper, we use these terms as a reference to knowledge that is not exogenous.

those protecting it employ ICTs (Hoque & Ashraf, 2015; Jimenez & Roberts, 2019; Myers et al., 2020; Pérez-García, 2021). Although these studies are a useful starting point for thinking about how indigenous knowledge can provide avenues for improving ICT4D, what has received less attention is how agricultural communities with some exposure to modern technologies can better manage and preserve indigenous knowledge on their own terms, and what tensions may arise as a result.

While this is a long-term goal, this paper is a first step towards understanding the current information landscape and how modern exogenous information is perceived by agricultural communities that still rely on traditional knowledge, but are also experiencing highly dynamic environments with changes in their communities, professions and weather events. This first step of studying knowledge landscapes is critical because it can assist us in identifying how information systems can be integrated in ways that do not subordinate indigenous knowledge, but rather complement it and help people's lives. A considerable interest has long existed in understanding the contextual factors that affect information behaviors (Fourie, 2019; Huvila, 2019; Savolainen, 2021). Information landscapes are helpful analogies as spaces affording the accomplishment of information practices, entwining physical and imaginary qualities and socially constructed spatial contexts of information practice (Savolainen, 2021). As such, the contribution of this paper is in highlighting the different contexts under which agricultural knowledge is shared, how new technologies and practices are embedded and the challenges that exist that can impact knowledge sharing within agricultural communities.

This paper is focused on Bangladesh, where local agricultural knowledge is fluid, shared among a constantly changing set of actors and communities. Large shifts in economic conditions are providing new opportunities opening up in freelance labour (such as Uber) or textile industries result in many farmers changing their occupations, while previously unsuccessful entrepreneurs may decide to be involved in agriculture (e.g., as a farmer or retailer). While the communities studied in this paper aren't indigenous (Hoque & Ashraf, 2015), many farmers in these communities practice traditional farming methods that have been passed down over several generations. Moreover, with the proliferation of mobiles and affordable smartphones, agricultural communities in rural Bangladesh can now access external data, resulting in an interesting hybrid situation where indigenous and exogenous knowledge mix.

The research question we would like to answer in this piece of work is 'how do farmers in rural Bangladesh gain agricultural knowledge and what contexts impact knowledge sharing and transfer?' We break down this question into three sub research questions:

RQ1. What actors and information sources participate in the information landscape in rural agricultural communities?

RQ2. How do relationships among the actors impact knowledge practices?

RQ3. What power dynamics exist, if any, in influencing how knowledge is shared among actors?

In answering these research questions, this paper explores the different social contexts and power dynamics that are encountered. In this paper, we present our findings on a field trip conducted in multiple locations within 20 miles North-East of Dhaka, involving interviews and focus groups with key actors and stakeholders in rural agriculture.

Our findings highlight the high level of interconnectedness among different actors in the agriculture industry, complexities in establishing trustworthiness of information, the importance of relationships within the sector and the growing strains of climate events in local agricultural communities. The paper is structured as follows: we initially present a review of the literature on agricultural information needs and the key factors for knowledge sharing, before highlighting the gaps in the literature. We then discuss how we conducted the field trips, interviews and focus groups and how the data collected was analyzed. We discuss our results within the context of our research questions and finally conclude the paper with a discussion on limitations and future work.

2 | INFORMATION AND KNOWLEDGE CONTEXTS IN AGRICULTURAL COMMUNITIES

2.1 | Agricultural information needs

In recent years, access to information has become increasingly critical for farmers in the global South as agriculture is becoming more knowledge-intensive (Deichmann et al., 2016; Islam & Grönlund, 2011). It is currently considered as a factor of production equal to land, labour and capital (Rao, 2007). Many studies suggest that the availability of relevant, reliable and timely information would help not only farmers to achieve optimum profitability of their farmlands, but also would bring sustainable agriculture (Aker, 2011; Babu et al., 2012; Kaske et al., 2018).

Farmers are therefore in critical need of different types of information throughout the year, as agricultural practices vary from one season to another (Aker, 2011; Mittal & Mehar, 2013). For example, during climate hazards such as cyclones, floods and storm surges etc., receiving accurate and timely weather forecasting can improve farmers' decision- making and increase their preparedness for extreme events, so that they are able to adjust their activities accordingly (e.g., plant late, harvest early, relocate livestock, etc.). Based on the information they receive, farmers can thus mitigate losses and protect their farm assets from potential damages (Islam et al., 2013; Kumar, Werners, Paparrizos, et al., 2020).

In addition to weather forecasts, farmers have other information needs such as identifying and procuring seeds, pesticides, fertilizers, agricultural equipment, disease control and pest management, understanding market prices and so on (Aker, 2011; Rao, 2007). Farmers rely on a variety of sources for their information needs, broadly grouped into two main categories: traditional and modern. Traditional knowledge sources mainly include friends and family, peer farmers, lead farmers, agro-dealers, NGOs, agricultural extension officers and advisors. Modern sources are a range of technologies that integrate ICT with its services such as telecentres, helplines, TV, radio, mobile phones and the Internet (Babu et al., 2012; Rahman, Haque, & Afrad, 2020). Such sources can be useful for farmers to learn about advanced agricultural techniques, deal with market uncertainty or take necessary actions to solve farming problems (Deichmann et al., 2016; Rahman, Ara, & Khan, 2020).

2.2 | Agricultural information challenges in the global south

Despite the availability of various sources of information, research shows that rural farmers in the Global South including Bangladesh base their agricultural decision-making mainly on indigenous knowledge, generally defined as the cumulative body of practices, experiences and beliefs that has been constructed through years of experiences and interactions, before being passed down from a generation to the next (Aker, 2011; Chowdhooree, 2019; Momodu, 2002; Naess, 2013). It is also described by (Ingram, 2010) as 'hard-earned knowledge' and is often tacit in nature, shared in local language through conversations, dialogues, instructions or even through folklore activities like dancing, songs, or storytelling (Lwoga et al., 2010). Although agriculture continue to be mechanized (i.e., using agricultural machinery) in Bangladesh, farmers' adoption of new technologies and modern farming methods are still very limited in most rural areas - a fact that is often attributed to low literacy, poor infrastructure, high cost and lack of awareness of existing modern agricultural sources (Aker, 2011; Haque et al., 2021; Rahman, Ara, & Khan, 2020). Farmers rely mainly on personal experiences and knowledge as well as interactions with informal peer groups (e.g., relatives, trusted input dealers and local retailers) for making important farming decisions (Asif et al., 2017; Islam et al., 2013; Kumar, Werners, Roy, et al., 2020; Rahman, Ara, & Khan, 2020). Knowledge emerging through social interaction tends to win over other sources of information because of reliability and accessibility of informal contacts (Mittal & Mehar, 2013) or for lack of a better source (Anadozie et al., 2022; Cole & Fernando, 2012). Overall, trust and ease of access are important to knowledge sharing, with observations showing that farmers are often more receptive to information coming from informal contacts (Deichmann et al., 2016). At the same time, some research highlights challenges in this form of knowledge sharing, such as selective sharing of information, refusal to share 'farm secrets'; and or biased knowledge being shared. Failure to share knowledge therefore means that relevant farming information remains hidden and risk possible loss in production (Aktar et al., 2010; Chowdhury et al., 2015).

While personal experience and local information are of the utmost importance for rural farmers in Bangladesh, evidence from the literature demonstrate that there are situations where personal experiences and local knowledge may fall short when a situation is difficult or unfamiliar (Islam et al., 2013; Jost et al., 2016; Rahman, Ara, & Khan, 2020). In their study of hydroclimatic information needs in the Lower Bengal Delta, (Kumar, Werners, Paparrizos, et al., 2020) stated that because of the increased hydroclimatic variability traditional knowledge of weather did not serve farmers to make accurate predictions. Farmers said "the current weather does not follow any traditional rules, and we often made wrong decisions based on our traditional understanding" (p.12). These miscalculations, often in many cases, can cost farmers heavily as it becomes practically unrealistic for farmers to revert their decision once they have already taken the steps. In his recent study on information seeking behavior, (Rahman, Ara, & Khan, 2020) found that such critical situations drive farmers to seek knowledge from multiple external information sources (e.g., as agricultural helplines), revealing behavior change towards new technologies and information.

Although the usefulness of indigenous/traditional knowledge and practice is unquestionable (Amin et al., 2021; Chowdhooree, 2019; Riveraferre et al., 2021; Sabar, 2012), there is potential for supporting farmers in the global South through modern technologies (Asif et al., 2017). The dynamic nature of farming requires a harmonious combination of different forms of knowledge, that can be both adapted to local contexts, as well as scientifically reliable to cope with environmental stresses (e.g., climate change) (Amin et al., 2021). Here the study does not draw a line between local and scientific knowledge. Rather, it moves beyond this past tendency to new understandings that view both types of knowledge as being 'hybrid', complementing each other rather than being competitors or rivals, and integrating the two would result in better economic benefits (Thomas et al., 2020).

Given the importance of understanding knowledge and learning processes towards achieving sustainable agricultural practices, there is a growing interest in studying the nature and complexities of farmers' knowledge (Thomas et al., 2020). The authors argue for the increasing need to move from individual farmer knowledge to understanding macro/micro relationships between different actors and scales (Stock et al., 2014), as a collective knowledge space. The complex, multi-dimensional nature of farmers' knowledge has also been studied in the literature, albeit in different perspectives. Farming, as a practice, is closely linked to space (Wójcik et al., 2019) and is shaped by the culture and economy of the area. Given this situatedness of knowledge creation and sharing intrinsically linked to place (Agnew, 2011), agricultural knowledge develops as a sum of knowledge resulting from many years of living in the space, socializing and collaborating with the space and community (Wójcik et al., 2019). The social contexts and actors in the place is also an important factor in developing farmers' knowledge (Thomas et al., 2020) - there might be reluctance in sharing knowledge with other farmers for maintaining a competitive advantage (Garforth et al., 2003). However, this reluctance might not exist for certain cases like conservation and environmental management, where farmers might be keen to share knowledge with their

neighbors (Riley et al., 2018) when facing risks (Sligo & Massey, 2007). A variety of social and socio-demographic characteristics may influence the adoption of innovative farming practices, products and technologies (Bagagiolo et al., 2022). For example, farmers sharing close social ties and professional/personal characteristics might be more likely to learn from one another (Pampuro et al., 2020). Recent studies argue that farmers are not merely passive recipients of expert advice from advisors, but also bring in different forms of knowledge (Ingram, 2010) that can complement expert knowledge.

Trust, at the same time, is key to knowledge sharing within agricultural communities, where farmers would be more likely to apply knowledge when it is from a source they trust (Fisher, 2013). Factors that are important for developing trust are longevity, consistency and regularity of contact (Fisher, 2013). In determining the trustworthiness of a source, (Riley et al., 2018) note the importance of capital status of farmers and the ease with which other farmers can observe this. Often, trust and social capital play a central role in assessing the credibility of information, particularly when farmers' observations conflict with new information (Wynne, 1996). (Thomas et al., 2020) also highlights other factors such as legitimacy (respectfulness, bias and fairness) and salience (relevance of information to a decision-maker) as being important in determining the value and take-up of knowledge in farming communities. The authors also note that these factors (such as place, social contexts, trust, social capital, credibility, salience, legitimacy) co-evolve over time and influence each other. Interestingly, based on their study of organic farming and conventional farming communities in Bangladesh, (M Hammadur Rahman & Yamao, 2007) notes that the type of farming practice can also influence the level of social capital (trust, bonding and bridging) and empowerment.

2.3 | User perspectives in agricultural information systems

A range of information systems and ICT4D solutions have been developed to support farmers and communities in the Global South such as mobile based agro-advisory services (Lokanathan et al., 2011), voice telephony-based information service (Futterman & Shuman, 2010), on-demand access to guidance by local experts (Schmidt et al., 2010) and so on. Despite these efforts, ICT projects often encounter a range of challenges (Zewge et al., 2014) and the benefits do not reach those who are most disadvantaged (Zewge & Dittrich, 2017), failing in achieving the goals of such projects (Venkatesh et al., 2019). A variety of reasons have been reported in the literature that can be attributed to this such as failing to capture the underlying motivations of intended users (Afful-Dadzie et al., 2022), lack of beneficiary participation (Walton & Heeks, 2011), poorly understood technology needs (Zewge et al., 2014). In this context, it is therefore important to consider stakeholders and their needs while developing ICT4D interventions (Islam & Grönlund, 2007; Karanasios & Slavova, 2019). At the same time, user behavior (DeLone & McLean, 2002) has been noted to act as a key factor in determining the success of a solution. Participatory design, as a result is often employed to develop ICT4D solutions, and various aspects such as degree of participation, capabilities of users, the role of governmental and community organizations impact on the success of these solutions (Puri & Sahay, 2007). Zewge et al. (2014) also argue that there is a need to distinguish between the application context of such solutions within rural and technologically developed societies, considering the differing economic, social, political and cultural contexts. At the same time, the process of participatory design itself requires a sufficient ICT literacy of participants in order to be effective (Maunder et al., 2007). Given these varied perspectives in developing ICT4D solutions, it is critical to develop a strong understanding of the key actors within the information landscape, particularly within specific spatial and applied contexts. As such, our exploration of the topic focusses on understanding these broader perspectives through a set of field trips, following which, we plan to investigate the development of specific ICT interventions.

3 | METHODOLOGY

3.1 | Study area and context

Agriculture plays an important role in food grain production, employment, food security and export in Bangladesh, helping drive the economy. As per Bangladesh Economic Review 2021,[2] a variety of crops such as rice, wheat, maize, potato, pulses, oil seeds, jute, vegetable and spices are grown in the region and the Government has developed several policies (such as Vision 2041, 8th Five Year Plan, National Agriculture Policy 2018, National Agriculture Extension Policy 2020, Masterplan for Agricultural Development in the South, Deltaplan-2100 etc.) to support the development of the agricultural sector. Several initiatives such as (i) improved and adversity tolerant varieties, (ii) natural disaster incentives for small and marginal farmers, (iii) subsidies for high yield varieties, (iv) agricultural assistance for farmers (e.g., fertilizers), (v) mechanization, development of irrigation systems, new cropping systems, integrated pest management systems, and transgenic crops, have been implemented. Such initiatives are aimed at agricultural expansion, quality control of produce, crop protection, development of marketing systems and ensuring fair prices. In order to gather an understanding of the information landscape of the agricultural communities, a field trip was decided to be appropriate

[2] https://mof.portal.gov.bd/sites/default/files/files/mof.portal.gov.bd/page/f2d8fabb_29c1_423a_9d37_cdb500260002/16.%20Chapter-07%20Eng%20Eng-21.pdf

as it provided opportunities for closer interactions with farming communities. Following an ethical approval process (reference number: 027266), approved on 19.08.2019 by The University of Shef Research Ethics Committee, details of the field trips were finalized and the field trip was organized. The interactions, mostly in the forms of semi-structured interviews and focus groups were designed as natural discussions around agricultural practices, how communities learned these practices and so on. Given the constraints around organizing field trips, for this stage of our research, we decided to focus around one specific geographical area 20 miles North East of Dhaka, in Dhamrai, Kalampur, Boratia and Kawalipara.

3.2 | Study design

The field trips involved six activities:

1. conducting an interview with 1 lead farmer and visiting their field. Lead farmers act as local source of knowledge, possess high experience and trusted among local farmer groups;
2. visiting a local produce sorting facility and conducting a focus group discussion with 4 farmers;
3. visiting a field to demonstrate crops grown by a seed manufacturer (Figure 1a);
4. conducting an interview with 1 farmer in their field (Figure 1b);
5. visiting two retailers selling seeds, fertilizers and pesticides (Figure 2) and conducting a focus group discussion (1 retailer and 4 farmers; 1 retailer);
6. conducting a focus group discussion with 14 farmers

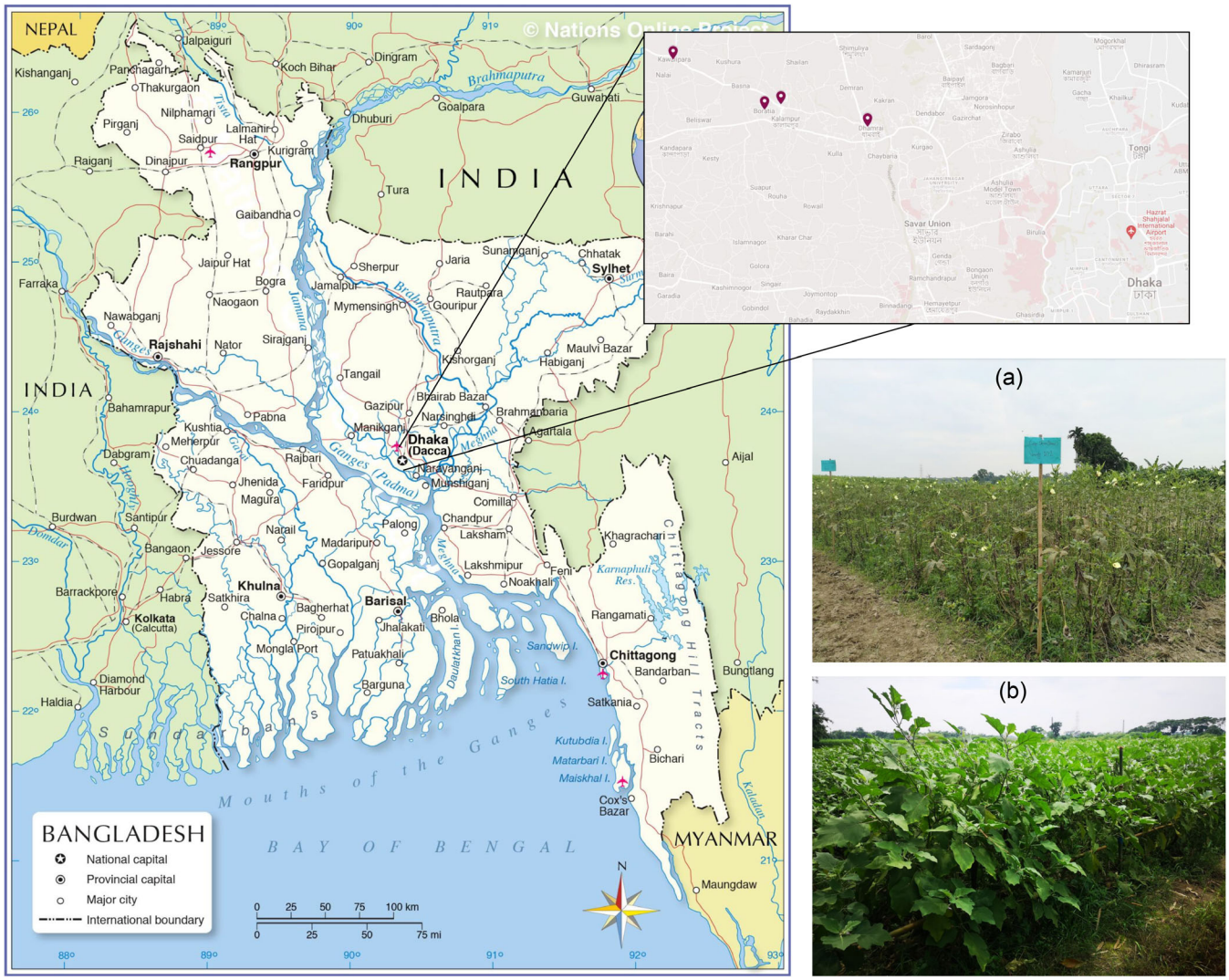

FIGURE 1 Left and top: Study area focussed in four regions 20 miles north east of Dhaka, in Dhamrai, Kalampur, Boratia and Kawalipara; right Centre (a): Demonstration area for okra seeds, prepared by seed manufacturer; bottom right (b): Using bamboo canes to help clear undergrowth in aubergine plants.

FIGURE 2 Retailers are a key set of actors in the information landscape, acting as sellers of seeds, fertilizers and pesticides as well as advisors to farmers; in the figure: A retailer shop selling a variety of pesticides (image on the left) and seeds (image on the right).

In all, we conducted interviews and focus group discussions with 24 individual farmers and 2 individual retailers in four locations (each participant took part in only one activity). Topics of discussion involved crops produced, previous occupation, new techniques learned by the farmers recently, how they learned new techniques, new sources of information they rely on, and what information gaps exist. The discussions were semi-structured, following a set of questions (attached as appendix) which were posed to the farmers and retailers as a way to guide the discussion.

3.3 | Analysis of data collected

The interviews and group discussions were recorded through a digital audio recorder. The main facilitator of the interviews and discussions took notes and observations, as conversions progressed. These primarily included key points of discussion, and observations made on the locations. Additionally, images from the field that indicated farming techniques employed by the farmers were collected. Data collected from the participatory sessions was uploaded to a secure folder that only the project partners have access to. Discussions were in the local language, Bengali and therefore, following the field visit, recordings were transcribed to English. The transcribed data was manually scrutinized and coded using inductive thematic analysis (Braun & Clarke, 2006). Inductive analysis means that the themes identified are strongly linked to the data themselves without trying to fit them into a pre-existing coding frame. As an exploratory study, a thematic analysis was considered to be a powerful and flexible approach for exploring patterns across quantitative and qualitative data, and understand the relationships between different concepts. The analysis started by reading and re-reading the transcripts iteratively so as to be familiar with all aspects of the data. This made it possible to identify repeated patterns of meaning in the data which were categorized and coded as themes. Pen and paper based analysis was used to aid this process. The thematic analysis produced five broad themes that enabled highlighting rural farmers' attitudes, practices and experiences in knowledge sharing in agricultural communities. These themes included farmer knowledge and skills, key information needs of farmers, use of technology, assessing reliability and trust of agricultural information, challenges in decision-making and sharing information. The table below shows an extract of the themes, codes and subcodes that emerged from the analysis. Appendix A presents a longer table of the thematic analysis, with interview/focus group excerpts of each code and theme (our original dataset contained multiple examples) (Table 1).

The next section presents the results of our data analysis.

4 | RESULTS

A thematic analysis of the interview and focus group discussion transcripts was conducted, aimed at identifying the key themes emerging during the conversations. Following the semi-structured discussions, we identify the primary themes around farmer knowledge and skills, key information needs of farmers, use of technology, assessing reliability and trust of agricultural information, challenges in decision-making and sharing information. It is however, crucially important to understand the different actors in the agricultural sector and how they interact with each other, particularly in the context of this study.

TABLE 1 Sample interview transcripts and field notes

Theme	Codes	Sub codes	Excerpt
Building knowledge and skills	Formal sources of information and knowledge	Retailers	*F10: If we go to buy seeds, the dealers also advise us about these. They tell us when to grow what seeds. We get to know methods like this. That's how we got some, as far as I got actually*
		Agriculture officers	*F4: We spray one packet of it with our sprayer, we mix it with 16 liters of water.* *R2: Who taught you this?* *F4: The agriculture officers come here.*
		Media (TV/Radio)	*F10: TV gives information too.* *F9: Yes. These also give information sometimes.* *R2: TV? How?* *F10: There is an agriculture channel*
		Demo events	*They do help sometimes but not with special care. Sometimes, they organize conferences, and the farmers attend those. Mainly, whenever there is a new technology, they provide demo products and free sample seeds for farming.*
		Farmer social interactions	*… Even, by discussing among themselves they are learning new techniques… SF1*
		Experimenting/ self-learning/ trial and error	*Of course, I have gathered many experiences. At first when I sowed my own seeds, I did not get much production. Later, when company seeds came the production was way better. But after hybrid we see that hybrid seeds give better production than any other seeds. I personally have used hybrid seed for the last 7 years. My production is way better than company seeds.*
	Informal sources of information and experiences	Observing /watching/ showing others	*… Like they are observing the neighboring lands and how the other farmers are getting better products and turnover; through that they are also learning" InterviewF*
		Intergenerational interactions	*"Since, my sons are helping me in the farms, they are learning on their own" SF1*

Unlike traditional farmers in specific regions like the Patra tribe in North-Eastern Region in Bangladesh who employ traditional farming techniques passed down over generations (Md Habibur Rahman et al., 2011), some of the communities involved in our study would be considered new farmers because several community members had been engaged in other occupations and businesses prior to farming. The nature of farming in the regions of our study is primarily business-driven, where farmers invest heavily on seeds and agricultural products, often relying on savings from previous years. Failed or insufficient harvests therefore is immensely detrimental to farmer finances and can often result in the breakdown of highly sensitive relationships in communities. Thus, some of these farmers' primary driving factor behind adoption of new farming techniques or choice of crop is the need for increased yields and improved profits. Less reliance on indigenous farming methods is driving farmers to take decisions that are harmful for plants and the environment. One of the farmers recalled an interaction with another farmer:

> "Once, I had sown gourd, I was told to use indigo on them. I asked, "Why should I use it? It is a harmful thing". He said, "using this will make the products look nice, hence, they will get high price. He said he would give a high price only for looks. So, why should I care? Why should I hesitate to use indigo for 20 taka [currency]".

Following this, another farmer noted: "We also spray shampoo over these, the shampoo that you use in the shower".

The communities rely on their past experiences and knowledge from other respected farmers, retailers, seed and agricultural product manufacturers for their own decision-making. This creates an interesting dynamic in the communities, where actors with information often have positions of power, while leaving new farmers or struggling farmers highly vulnerable to disinformation. New farmers often also need support in farming techniques, identifying the right treatments for diseases or even deciding which crops to grow. However, the growing impact of climate change and irregular weather patterns often already threatens agricultural production, and by extension, structures within the communities. We discuss these in more detail as our key findings below:

4.1 | Knowledge and skills

It is important to understand the variety of information sources farmers rely on when making decisions with respect to farming. Decisions need to be made on a variety of topics such as (i) which crops to grow; (ii) how many agricultural cycles will the farmers have for the upcoming year;

(iii) which fertilizers and pesticides to be used; (iv) which seeds and agricultural products (brands, crops, variety) will need to be sourced and from which retailers; (v) when would be the best time for farming activities (e.g., sowing, harvesting, fertilizing etc.); (vi) where would farmers get the best price for their harvest; and so on. While much of the knowledge required to make these decisions is gained over many years, some farmers rely on existing relationships developed with other actors in the agricultural sector (such as retailers or agriculture officers). For example, in the focus group session, upon being asked how farmers choose the seeds, one farmer (F10) notes the importance of these actors in their decision-making processes: "If we go to buy seeds, the dealers also advise us about these. They tell us when to grow what seeds. We get to know methods like this.". Another farmer (F4) mentions upon being asked how they decide to use fertilizers: "We spray one packet of it with our sprayer, we mix it with 16 liters of water.". When asked how they learned this, the farmer mentions "the agriculture officers come here", noting that there are regular visits made by agriculture officials in different regions to help farmers learn how to use new techniques or products.

There are a variety of ways farmers learn and share information about new techniques. One of the most common ways they learn new techniques is by discussing among themselves, as a part of sharing practice among the community. Self-learning and experimentation is another way farmers learn farming techniques. This is particularly valuable for farmers who are new to the profession. For example, a lead farmer mentions "Of course, I have gathered many experiences. At first when I sowed my own seeds, I did not get much production. Later, when company seeds came the production was way better. But after hybrid (seeds came into the market) we see that hybrid seeds give better production than any other seeds. I personally have used hybrid seed(s) for the last 7 years. My production is way better than company seeds". The same farmer notes the value in learning from observing the success of others is also another way they learn new techniques: "My sons are helping me in the farms, they are learning on their own. … Like they are observing the neighbouring lands and how the other farmers are getting better products and turnover; through that they are also learning". Another farmer notes "They are learning it through watching the process … For example, before, we needed 10–15 laborers to get rid of the weeds in the field. But now there is a medicine that we can spray after sowing the seeds and there will be no weed in the field. However, when we first came to know about it, the farmers were confused about using it since they thought that this medicine will harm the product. But now they have seen that it helps and farmers are using this technique as well". Some farmers also noted that the next generation of farmers also learn the same way they have learned (observations): "It's (they learn) the same way. The yields will be high if the seeds are sown in the beginning of the Kartik [October-November] month. It will be less if sown late, less if sown after 15 days"

Another way how farmers learn new techniques is through intervention by agriculture officers (often by force), as highlighted in this interaction (about how agriculture officers intervened when they observed that seeds were being sowed in lines without sufficient gaps):

F3: "The agriculture officers came and removed the lines; one line after every ten lines."

Interviewer: "The agriculture officers?"

F1: "Forcefully".

Interviewer: "Did they remove the lines forcefully?"

F3: "Nobody listened to them first, that's why later they came and removed the lines themselves."

F4: "The officers first told to remove the lines but people refused it."

F3: "It is not needed anymore after they found good results in the first year. Now the officers do not have to remove the lines forcefully."

F2: "The result is better with this new method".

On the other hand, retailers are also part of the information landscape. One of the ways they disseminate information is through word of mouth, believing that a good harvest for one farmer will help acquire new customers who, by observation, are interested in the products that brought success: "Everyone is interested. They will do it if you give the seeds. If the results are good you will automatically get the publicity". However, given the importance of retailers in providing seeds and agricultural products, it is interesting to note the position of power (some) retailers may enjoy. For example, in asking about how farmers gain knowledge from retailers, the lead farmer notes: "They (retailers) are very bad. If they do not want to help, they will say that one seed is not good even though it is…That is why at first you will have to influence them. When they are convinced, then you have no problem."

4.2 | Information needs of farmers

Given the range of agricultural decision-making processes required, farmers have varied information needs. Although not a thorough list, our discussions captured four different themes of information needs - fertilizer, crop yields, prices and diseases. A key source of information is retailers and shopkeepers: "We mainly help them to know about the planting and maintaining process of cultivation and the pesticide and fertilizer business owners help them with the techniques and management of the pesticide insecticides", as noted by a retailer. The retailer being interviewed also mentions that retailers support farmers in decisions around fertilizer use, which they ascertain by discussing with manufacturers: "Mainly the fertilizer management techniques as well as the pesticide management techniques are acquired from the business owners" (upon responding to the question of what information they provide to the farmers).

Given the need for maximizing profits for each harvest, it is important for farmers to procure seeds at a cost that is affordable, yet provide sufficient volumes of harvest. There is often a process of negotiation between retailers and farmers, some of which contributes to developing/establishing a relationship. For example, one retailer mentions: "You can know the price if you go (to) the shopkeepers. You can also know it from me. If you go to him, he might take 450 taka for a 5-gram packet. (I'd say) 'Uncle, please keep the price 450 taka for 5 grams;' take less profit this time.", highlighting that sometimes retailers would reduce their profits to keep customers.

The retailers also play an important role in supporting the farmers on dealing with diseases, as one of the farmers recalled: "At that time, I had sown Pumpkin; the plants were dying quickly. So, I went to him and told about the problem. He said he would come and see my plants. He came and checked the roots, there were no problem in roots, and the infection happens at the top and kills the plant suddenly. He said there is no treatment for it, but he gave a medicine, which did not work. So, he told there is no way around it. Plants will die like this. There is no way to save it.". Although the incident recalled by the farmer did not lead to a successful eradication of the disease, the account demonstrates the importance of a retailer providing support to a farmer.

4.3 | Use of technology

4.3.1 | New technologies and farming practices

Technology in agriculture has considerably benefited farmers in increasing their yields, growing higher quality products and sustaining their livelihood. As such, our participants mentioned a variety of technologies being used such as hybrid seeds, new farming techniques (like introducing gaps in lines of sown seeds), farming equipment (such as tractors), fertilizers and pesticides and so on. There are a variety of factors that have therefore motivated farmers to embrace new technologies, with many traditional practices not being used anymore. For example, farmers noted how technology has helped save time and bring new efficiencies in their farming practice: "The old farming techniques are not actually in use. Like before, the farmers ploughed the land with cows, now they are using power-tillers. In a short time, they are able to prepare the land more efficiently.", as mentioned by a farmer. The incorporation of new techniques has also helped farmers grow higher quality crops: "Because of lines, the land gets enough air and light, it is also easy to nurture. As a result, the production becomes good".

With new efficiencies, it is also possible for farmers to introduce a growing season in the year, as described in the following conversation:

F10: "There was so much struggle in the past. We used to have no work for three months".

Interviewer: "What did you used to do for those 3–4 months?"

F10: "Some people used to spend those three months by gossiping only. But, now there is no time for that."

F9: "Now, we do not have any time for gossip. Now there is a lot of work."

4.3.2 | Hesitancy and resistance

While on the one hand, farmers note benefits from the adoption of new technologies and techniques, there are a variety of reasons (primarily driven by misconception, confusion or uncertainty) which introduces resistance and hesitancy in employing new techniques. Incorporating new techniques may also imply that farmers would need to invest money into products, which could increase hesitancy. For example, product demonstrations by manufacturers are often led by individuals who have little experience of farming. One farmer mentions: "… Often, when the demo products are given to the councillors, they give them to those who do not have any farm or do not farm at all. So those people then sell those demo products. The farmer is then confused to invest in a new technique where he is not sure about the turnover". One farmer mentions how a large number of farmers would resist using a new product, even if they have been provided free samples: "not all farmers try the new techniques because of their confusion about the new product. Almost 50% of the farmers who get the new product sample, sell the sample in the shops and use the money to buy the product of their own choice". Spurious products also increase hesitancy among farmers, as explained by the lead farmer: "There is a problem. If there is a better seed in the market, there are some companies that replicate the seeds and we would not be able to determine which one was real and not. And the copied seeds are definitely bad and the farmers won't get the desired production". With a weak seed monitoring system, fake seeds are often used to cheat farmers, thereby increasing the likelihood of low yield and crop failure (Pervez et al., 2021). Another reason for hesitancy among farmers is misconception: "Before, the farmers did not want to use hybrid seeds. They did not even want to take their cows to the hybrid fields that would turn their cattle sick. Before, people had misconceptions and were confused. They thought these products do not have enough nutrition values in it".

It was interesting to note the different reasons why new technologies might be accepted by farmers, while at the same time, a range of issues could severely limit the acceptability of new techniques. Much of these issues might not be the technology itself, but the wider social or market contexts.

4.4 | Reliability and trust

In order to address their information needs, the community relies on a variety of information sources. Farmers benefit from informal communication such as advice from lead farmers or retailers, or discussions with other farmers. This informal communication also helps farmers learn which products to procure and which ones to avoid.

4.4.1 | Support from retailers and agricultural officers

Upon being asked about information that farmers seek at their shops (Figure 2 shows a retailer's shop displaying agricultural products), a retailer explains: "Nowadays, the farmers are wise, they know things very well. If I bring a new product to the market and it does well, then the farmers will circulate the news to everyone. The marketing happens automatically. But, if the product turns out bad, they will never go to that shop again. Farmers are like this, they discuss among themselves. They do the discussion here, at that side [pointing to a seating area at the side of the shop]".

Farmers also rely on agriculture officers for advice, while structured communication from manufacturers or representatives (as 'sales pitches') seek to provide further information on new techniques or agricultural products. As a result of this reliance on a variety of key actors, reliability and trust is critical to the community. Some farmers rely heavily with a high degree of trust on retailers and seed dealers, as explained by one farmer in the focus group: "Most of the time, I go to the seed dealer. Whatever crops I grow, I take advice from him about fertilizers. Then he tells us which one would be appropriate for which time. Whatever he advises us, we listen to him. Money is not an issue here, it may be a little more or less. That's it". The role of agriculture officials in disseminating critical information to farmers also raises trust concerns, as explained by a farmer during the focus group: "See, they are government employees. They do the minimum that is required from them and that is all. Mainly farmers search for them whenever they need help. Farmers go to their offices and then ask them whatever they want to know and they answer apparently".

4.4.2 | Use of media (TV, radio)

Another source of information for farmers is traditional media such as TV or radio, however, this does not always serve their needs. For example, weather reports from meteorological departments are not always accurate (or localized and specific to particular crops), and this uncertainty can sometimes undermine the importance of weather forecasts. The lead farmer (responding to the question if they get weather information from radio, and why they do not always rely), for example notes: "Yes I do. But we cannot blame them. Even they say that it is highly likely. Not 100%.". Receiving weather information from televisions is also a rarity, unless there are larger storms forecast. For example, the lead farmer elaborates on the weather information broadcast during the Cyclone Sidr: "[weather information isn't always broadcast on televisions] Not as much like radio. It is a problem, After every news there should have been a weather forecast. But there is only weather news on TV when it is important. Like during Sidr, we got the information from TV". The lead farmer elaborates that they make decisions based on how likely the weather forecast is: "When they say that it is highly probable then I get a little more careful.". Another source of information is the Internet, but many farmers do not possess smartphones or unable to use smartphones and therefore have to rely on their families for information, as explained by the lead farmer: "The younger generation gets it from the internet. My neighbours have wi-fi and [when it is really necessary for me] my son gets the information from them".

4.5 | Information and decision-making challenges

4.5.1 | Competition among farmers

With a wide range of formal and informal information sources, and a variety of decisions to consider, farmers are required to deal with a wide range of challenges. Competition among farmers is at times intense, often exacerbated by the need to harvest higher yields and better quality crops than neighboring farmers to secure higher prices than other farmers. As a result, at times, farmers explain that there is a reluctance to share personal experiences and success factors with other farmers. For example, in the focus group, Farmer 10 mentions: "We even give fertilisers at night. We don't say what fertilisers we use. We want all the benefits alone". Farmer 10 also mentions "I don't say which vitamin works good because I want to be benefited alone. This is it". This competitive nature of farming also might lead to misinformation being propagated within the community, as Farmer 7 explains "When I first grew my Cucumbers, I asked for advice from someone. He told me to sprinkle 2 packets of Urea fertilizers. No, I told it wrong. It was last year; I did Cucumbers for the first time. After few days, I asked for advice. He told me to sprinkle Urea fertilizers over the bushes. I did that on Thursday, when I went there on Saturday I found my plants dead; they turned white".

4.5.2 | Decision-making as a collective

Some farmers consider they have little choice as to what to grow on their crops, mainly due to geographical contexts such as their location in relation to other farmers. In response to the question on how flexible they are in choosing the crops they'd like to grow, a farmer explains "Sometimes, it's not possible. Let's say a big chunk of land has 10 person's land. If 9 of them decide to cultivate paddy, I will have to do it too. Because the paddy field is required to be thoroughly irrigated all the time. The land will always be moist and soggy". It is important to acknowledge such instances of decision making, where individuals resort to a decision based on others. This is particularly so, in the context of developing ICT interventions where solutions might offer recommendations specific to individual farmers (e.g., choice of crop), but decisions often might need to be made more collectively.

4.5.3 | Motivations and uncertainty

Another challenge for manufacturers (seed and agricultural product) and retailers exists in the take-up of new information - a varying level of motivation makes it difficult to share information among the community. For example, the lead farmer mentions: "[Seed producer X] said, listen, whenever we go to the field and we invite the farmers in a talk to help them (let's say this medicine for this disease), not a single farmer shows up. But whenever we call [Lead farmer], he is present there. He will attend the meetings and listen to what the companies have to say. He achieves something. And other people ask, what will they feed [in return for their attendance]? This or that? But [Lead farmer] says if I go there and learn something, that's my achievement. That's my big profit. This is how I attended meetings and learned. I listened to ten people say ten things and learned them all".

As mentioned earlier, farmers are challenged with a variety of information sources, with different order of frequency, and with varying levels of uncertainty. This further complicates the decision-making processes for farmers. Their reliance on their intangible understanding of nature might provide them with considerable knowledge of how the weather might impact their crops. However, they might still need to rely on weather before taking critical decisions, as described in this interaction with the lead farmer:

Interviewer: "When do you think that [knowing about the weather] is very important for you?"

Lead farmer: "When I see that the weather seems bad and if it rains I won't be able to do important chores, then we look for weather."

Lead farmer: "Let's say when I am about to sow seeds for vegetables. For example, I will sow some jute seeds for the leaves. If I find out that it's going to rain, I will postpone the sowing."

Interviewer: "Provide the information like this. Like [Lead farmer] said… the harvest depends on the weather. You were talking about coriander."

Lead farmer: "For example, Coriander. If it rains, coriander leaves will not grow."

Given the need for weather information as and when needed by the farmers, and the reliance on this information for decision-making, it is important to note the challenges that farmers face. Receiving information through newspapers, television or radio also introduces further costs to the farmers, many of whom might not have the necessary resources to invest, while at the same time, busy schedules for farmers do not allow them to seek information from more traditional sources like newspapers. A farmer highlights this in the focus group: "We know, but we don't have any time to read newspaper. Also, we cannot buy them [televisions] because we don't have much money". The farmer mentions: "Actually, this is a rural area, we don't watch much TV. We are always busy with our work".

A further challenge highlighted by the participatory research involves concerns around how agricultural practice is becoming less prominent. Upon responding to how the farmer's children are learning agricultural practice, the lead farmer mentions: "But nowadays, farming is decreasing since the sons now are working as van pullers instead of working in the fields and the daughters are working in garment industries". As such, growth and success in other sectors is a challenge for farming communities, resulting in the loss of agricultural knowledge and workforce, a critical concern for the lead farmer being interviewed: "this is why we cannot find any labourer nowadays". The lead farmer mentions: "They can listen to music and relax and perhaps eat betel leaves", reflecting on a different set of choices for the next generation.

5 | KEY FINDINGS

We reflect on our exploratory study with farming communities on their process of decision-making, and in turn, explore a variety of factors around their information practice, knowledge sharing, information sources and challenges. We summarize our key findings as means to answer our research questions and in doing so, discuss the implications of ICT and information systems interventions in these contexts:

RQ1. What actors and information sources are involved in the knowledge landscape in rural agricultural communities?

A variety of key actors such as agriculture officers, retailers, and agricultural manufacturers form an essential component of farmers' knowledge practice. Relationships with such actors are crucial to the success of farmers and, hence, introduce potential power dynamics. A combination of formal

and informal information sources contribute to the knowledge of the farmers. Formal information sources consist of weather forecasts, visiting agricultural officers, or even manufacturing company demonstrations, while informal information sources are other farmers, retailers and more senior, respected farmers. Traditional sources of information for example, agricultural officers or previously gained local knowledge and insights are trusted more than modern or ICT-based services for example, TV and radio. A variety of reasons could be attributed to this such as lack of resources and time, or uncertainty in information. However, the different actors in the information landscape, their information needs and context of stages in farming (Rahman, Ara, & Khan, 2020), and user readiness (McCampbell et al., 2021) would also need to be considered while developing ICT services.

RQ2. How do relationships among the actors impact knowledge practices?

Social relations between farmers and the key actors are central to knowledge sharing, publicity and information distribution within the agricultural community. Due to alternative employment opportunities offered in rural settings (in the regions of our field visits), relationships vary. Long-term relationships exist between established (often) multi-generational farmers and retailers, while short-term relationships often emerge as individuals venture into farming after working in other sectors. Field demonstrations and marketing activities arranged by agriculture produce manufacturers and learning from passive observation are vital for learning new farming techniques to be accepted by farmers and help to adapt new practices. Knowledge is also shared among farmers by peers and retailers when trustworthy relationships exist. Misconception, confusion or uncertainties often cause farmers to be resistant to adopt new knowledge in relation to new technologies. However, trusted individuals can help alleviate concerns around the new techniques, while at times, agricultural officers can intervene to demonstrate the value of new techniques. In developing ICT interventions, it is important to not only acknowledge and understand these relationships and how trust is built within the community, but also the constraints in time and resources for farming communities in employing innovations.

RQ3. What power dynamics exist, if any, in influencing how knowledge is shared among actors?

Our conversations identified several challenges that lead to witholding knowledge or, unfortunately sharing harmful knowledge. Some farmers can often be reluctant to share their personal knowledge and might share misinformation to ensure other farmers have poor yield. This, we believe, however stems from the competitive nature of the farming industry in the regions of our field visit – farmers, as entrepreneurs can be protective of their competitive advantage and may be reluctant to share their successes. Agricultural officers, on the other hand, are knowledgeable about scientific practice and new techniques and methods and provide advisory support to farmers and local communities. This position of power is also reflected when they intervene to introduce a new practice that farmers can benefit from. However, subsequent poor yields for other unrelated reasons (e.g., weather events) might lead to distrust in agricultural officers or even the scientific process. Farmers may sometimes base their decisions on collective choice rather than personal – particularly when neighboring farmers make a choice of growing specific products that impact on the land of individual farmers (for example, growing rice requires heavy watering, which spread on to other neighboring fields). Some farmers expressed dependence on younger family members to access digital information (through smartphones or websites) for up-to-date weather information. These power dynamics are crucial to understand while developing ICT interventions for agricultural communities. While the dynamics of power within agricultural families is beyond the scope of this paper, we acknowledge the risks to losing access to such information due to younger members of the communities potentially leaving their families to travel to cities for other jobs.

6 | CONCLUSIONS

We set out to understand the broader knowledge landscape in rural agricultural communities, in the view that it would eventually help us develop methods and strategies to ensure traditional knowledge is preserved among the community. Our research reports on a set of activities with farmers and retailers, in various locations and formats such as individual interviews and focus groups in fields, retailer shops and a local produce facility. This study is exploratory in nature, capturing the conversations to help us understand about the different actors in the knowledge landscape, the varied complex contexts in which knowledge is shared, and the different dynamics that impact knowledge sharing. Our study is therefore a first step and an initial attempt at understanding the various complexities associated with the information landscape, focussed on the specific region of study. The spatial context of our study would therefore be a limitation for our study, one that we hope to address in the future by extending our research to other geographical regions and engaging other individuals who have experience in different geographical contexts. The next limitation is that our study did not involve empirical research - however, we believe for an initial understanding of the factors and complexities in knowledge sharing among the community, an exploratory approach as ours is effective. A future longer term survey based approach to collect data from farmers is currently being planned as a longitudinal study, which could offer deeper insights into agricultural knowledge sharing practices. A final limitation is that our study did not consider other actors that impact on agricultural activities (e.g., labourers employed by farmers, family members and their roles in farming, wholesaler and consumer markets or even consumers) and farmers who leave the occupation to join other industries. While a follow-on set of field visits will involve a wider set of actors to deeper insights into the perspectives of other actors, we believe our approach of an initial exploratory research directly involving farmers and retailers is appropriate to help design further research activities.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

Data collected during the field trips (interviews and focus group transcripts) described in the paper is not available publicly.

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APPENDIX A: Thematic analysis with examples of how themes emerged from codes and sub-codes, which were driven by extracts from transcripts of the activities. In places, codes 'F(X)', 'R(X)', 'SF' have been used during our analysis to identify the type of individual – 'F' denotes farmer, 'R' denotes retailer and 'SF' denotes senior farmer

Theme	Codes	Sub codes	Examples
Building knowledge and skills	Formal sources of information and knowledge	Retailers	*F10: If we go to buy seeds, the dealers also advise us about these. They tell us when to grow what seeds. We get to know methods like this. That's how we got some, as far as I got actually"*
		Agriculture officers	*F4: We spray one packet of it with our sprayer, we mix it with 16 liters of water.* *R2: Who taught you this?* *F4: The agriculture officers come here.* *F3: The agriculture officers came and removed the lines; one line after every ten lines.* *R2: The agriculture officers?* *R1: Forcefully* *R2: Did they remove the lines forcefully?* *F3: Nobody listened to them first, that's why later they came and removed the lines themselves.* *F4: The officers first told to remove the lines but people refused it.* *F3: It is not needed anymore after they found good results in the first year. Now the officers do not have to remove the lines forcefully.* *F2: The result is better with this new method.*
		Media (TV/Radio)	*F10: TV gives information too.* *F9: Yes. These also give information sometimes.* *R2: TV? How?* *F10: There is an agriculture channel*
		Demo events	*"They do help sometimes but not with special care. Sometimes, they organize conferences, and the farmers attend those. Mainly, whenever there is a new technology, they provide demo products and free sample seeds for farming".*
		Farmer social interactions	*SF:… Even, by discussing among themselves they are learning new techniques… Interviewee*

Theme	Codes	Sub codes	Examples
	Informal sources of information and experiences	Experimenting/self-learning/trial and error	*Of course, I have gathered many experiences. At first when I sowed my own seeds, I did not get much production. Later, when company seeds came the production was way better. But after hybrid we see that hybrid seeds give better production than any other seeds. I personally have used hybrid seed for the last 7 years. My production is way better than company seeds.*
		Observing/watching/ showing others	*… Like they are observing the neighboring lands and how the other farmers are getting better products and turnover; through that they are also learning" SF* *R2: 5 years, okay. So, you thought it would be good to use hybrid since the beginning.* *F1: Yes, you get the idea of it with observations.*
		Intergenerational interactions	*"Since, my sons are helping me in the farms, they are learning on their own" SF* *"R2: Okay. You are taught all these, you learn these things. So, how do you teach these to your next generations?* *F10: It's the same way.* *R2: In the same way; teaching by showing.* *F12: The yields will be high if the seeds are sown in the beginning of the Kartik month. It will be less if sown late, less if sown after 15 days"*
Key agricultural information farmers require	Fertilizer management techniques		*Mainly the fertilizer management techniques as well as the pesticide management techniques are acquired from the business owners".*
	Higher yields crops/seed varieties		*"We mainly help them to know about the planting and maintaining process of cultivation and the pesticide and fertilizer business owners help them with the techniques and management of the pesticide insecticides*
	prices		*R1: You can know the price if you go the shopkeepers. You can also know it from me. If you go to him, he might take 450 taka for a 5-gram packet. Uncle, please keep the price 450 taka for 5 grams; take less profit this time.* *F10: What decimals of land can one packet cover? Focus group*
	Infection and disease		*F10 At that time, I had sown Pumpkin; the plants were dying quickly. So, I went to him and told about the problem. He said he would come and see my plants. He came and checked the roots, there were no problem in roots, and the infection happens at the top and kills the plant suddenly. He said there is no treatment for it, but he gave a medicine, which did not work. So, he told there is no way around it. Plants will die like this. There is no way to save it. (focus group).*
Verifying information and knowledge about new techniques	Determining relibaility of products		*R2: We are trying to understand the kind of farming you are doing here. When you get different kinds of information how do you work with those? Like, many come to you retailer shop to buy seeds, they are in constant touch with you, they seek advice from you sometimes. We have come to your shop to understand how you help these people with those things. We want to understand what kind of advice the farmers seek from you. When we first came here, we asked which products are in demand here, which ones are doing good or bad. What more information do you get from the farmers?*
Trust and reliability of information socurces	Trust in seed dealers		*"Most of the times, I go the seed dealer. Whatever crops I grow, I take advice from him about fertilizers. The, he tells us which one would be appropriate for which time. Whatever he advises us, we listen to him. Money is not an issue here, it may be a little more or less. That's it"*

(Continues)

Theme	Codes	Sub codes	Examples
	Distrust and perceptions of traditional media (TV. Radio) as good source of information		*Yes I do. But we cannot blame them. Even they say that it is highly likely. Not 100%.* *"Nope. Not as much like radio. It is a problem, after every news there should have been a weather forecast. But there is only weather news on TV when it is important. LIke during Sidr, we got the information from TV".* *That does not show that much. Like, journalists do in news programs, like you are doing it now, it shows which crops are doing well, and a little methods briefly. It is for 2–5 minutes, there is nothing to learn from there.*
	Distrust and perceptions of government officials and agricultural officers		*"See, they are government employees. They do the minimum that is required from them and that is all. Mainly farmers search for them whenever they need help. Farmers go to their offices and then ask them whatever they want to know and they answer apparently"* *"I do not know anyone from the agriculture office shows up in a year. If we go there it might" F10*
Challenges to knowledge building and transfer	Competitions among famers	Reluctance to share personal experinces and knowledge with others	*F10: We even give fertilizers at night. We do not say what fertilizers we use. We want all the benefits alone. (focus group)*
		Giving incorrect advice	*F10: I do not say which vitamin works good because I want to be benefited alone. This is it. (focus group)*
	Low motivation		*[Seed producer X] said, listen, whenever we go to the field and we invite the farmers in a talk to help them, let us say this medicine for this disease, not a single farmer shows up. But whenever we call [Lead Farmer Y], he is present there. He will attend the meetings and listen to what the companies have to say. He achieves something. And other people ask, what will they feed? Will they feed anything? This or that? But [Lead Farmer Y]says if I go there and learn something, that's my achievement. That's my big profit. This is how I attended meetings and learned stuff. I listened to ten people say ten things and learned them all.". [Lead Farmer Y]*
	Low level of digital skills particularly among older farmers		*The younger generation gets it from the internet. My neighbors have wi-fi and my son gets the information from then.*
	High cost and lack of time		*F10: We know, but we do not have any time to read newspaper. Also, we cannot buy them because we do not have much money".* *Besides these, we do not. Actually, this is a rural area, we do not watch much TV. We are always busy with our work. F10*
	Increase in non-farm employments may risk losing inherited experiences and knowledge		*But nowadays, farming is decreasing since the sons now are wohe fields and the daughters are working in garment industries*
Farmers' technology use	Factors enhancing farmers' willingness to learn about/ to take on new farming practices and techniques	Saving time	*The old farming techniques are not actually in use. Like before, the farmers plowed the land with cows, now they are using power-tillers. In a short time, they are able to prepare the land more efficiently. Interviewee*
		Jobs and income creation	*F10: There was so much struggle in the past. We used to have no work for three months* *R1: What did you used to do for those 3–4 months?* *F10: Some people used to spend those three months by gossiping only. But, now there is no time for that.* *F9: Now, we do not have any time for gossips. Now there are lots of works.*

Theme	Codes	Sub codes	Examples
		Better production	*F11: Because of lines, the land gets enough air and light, it is also easy to nurture. As a result, the production becomes good".*
	Factors enhancing farmers' resistance to take on new farming practices and techniques	Uncertainty and confusion	*However, often, when the demo products are given to the councillors, they give them to those who do not have any farm or do not farm at all. So those people then sell those demo products. The farmer is then confused to invest in a new technique where he is not sure about the turnover. SF*
		Misconception	*Before, the farmers did not want to use hybrid seeds. They did not even want to take their cows to the hybrid fields that would turn their cattle sick. Before, people had misconceptions and were confused. They thought these products do not have enough nutrition values in it.*
Farmers' decision making and planning	Farmers making decisions based on collective choice rather than personal.		*Sometimes, it's not possible. Let us say a big chunk of land has 10 person's land. If 9 of them decide to cultivate paddy, I will have to do it too. Because the paddy field is required to be thoroughly irrigated all the time. The land will always be moist and soggy. SF*
Bad farming practices	The use of harmful medicines and chemicals for better profits		*F10: Once, I had sown gourd, I was told to use indigo on them. I asked, "Why should I use it? It is a harmful thing". He told, using this will make the products look nice, hence, these will get high price. He said he would give high price only for looks. So, why should I care? Why should I hesitate to use indigo of 20 takas. (Focus group 1)*

APPENDIX B: Mindmap of themes and codes emerging from thematic analysis