Fresh Insights: User Research Towards a Market Information Service for Bihari Vegetable Farmers

Matt Ziegler
University of Washington
mattzig@cs.washington.edu

Lokesh Garg
Digital Green Foundation
lokesh@digitalgreen.org

Shailesh Tiwary
Digital Green Foundation
shailesh@digitalgreen.org

Aditya Vashistha
University of Washington
adityav@cs.washington.edu

Kurtis Heimerl
University of Washington
kheimerl@cs.washington.edu

ABSTRACT

Agricultural market information (MI) services provide smallholder farmers with convenient access to price information and have demonstrated potential to improve their incomes. Some recent evaluations of MI systems, however, have shown disappointing results and brought forth many complicating factors. Cautious of the mixed literature, we investigate the potential effectiveness and likely limitations of an MI service for improving livelihoods of smallholder farmers in the context of Loop, a shared transport-to-market-service for farmers. We conducted interviews with 17 farmers and 3 commission agents in Buxar, Bihar (India). Consistent with "information scarcity" and "information asymmetry" theories, we report how many farmers in this area regularly use mobile phones to check prices for choosing markets and negotiating transactions. Participants reported increases in the numbers of traders and price stabilization since the arrival of mobile phones. However, we found many other diverse factors that often outweigh the importance of market prices and inhibit market access, including market capacity, time, unfamiliarity with new markets, personal relationships, attitudes towards risk, credit relationships, and physical danger. Finally, to probe which of these additional factors might be addressable using an MI service, we present exploratory findings from preliminary user-interface studies.

KEYWORDS

Agriculture, Markets, Farmers, India, HCI4D, ICTD.

1 INTRODUCTION

Following the rapid worldwide adoption of mobile phones, many organizations have begun offering ICT-enabled agricultural market information (MI) services to smallholder farmers; these services aim to provide convenient access to price information across different markets. Implementers believe that MI services can improve marginalized and smallholder farmers' livelihoods via the economic mechanisms of "information asymmetry" and "information scarcity" [8, 13, 29]. Improved knowledge of prices, in theory, can help farmers select better markets and sell crops at higher prices via improved negotiating power against traders. Evaluations of MI services have produced mixed results, however [5]. While in some cases evaluations demonstrated increases in prices or incomes [10, 15, 17, 24], others found no such significant effects [4, 9, 14, 20].

The negative findings have called into question many of the popular assumptions about how rural markets work and how farmers use price information. Follow-up work has investigated other important factors that influence marketing decisions and sometimes take priority over prices, such as unfamiliarity with other markets [20], commissions charged by agents [14], aversion to risk [8], personal relationships in markets [4, 8, 20], and simply having a lack of alternative markets [6]. Findings like these underscore the complexity and diversity of these marketplace ecosystems and the importance of location-specific user research to better understand the needs of the variety of stakeholders when building MI systems.

Mindful of the limitations of MI services, our research examines a potential MI service extension of Loop [21], a shared transport-to-market service for smallholder farmers selling vegetables and perishable produce. Loop collects produce each morning from participating farmers and transport it to markets, where it is sold. Farmers are paid for their sales on the same day. Participating farmers benefit by saving time, reducing transport costs through pooling, realizing higher prices through new market discovery, and bargaining with larger quantities of produce.

We chose Buxar, Bihar (India) as a case study because farmers in Buxar sell vegetables in many small heterogeneous markets; whereas many other Bihari regions are dominated by a single massive wholesale market. To examine the potential effectiveness and identify design considerations for an MI service, we interviewed farmers and commission agents about their marketing behaviors and sought farmer input using interface prototyping exercises.

Suggesting potential benefits of an MI service in this location, our interviews show that the information scarcity and information asymmetry models do, in fact, seem to hold true for our studied population. Participants already frequently used mobile phones to check market prices, and they used the price information to choose markets and negotiate with traders. We received reports of significant changes in the markets since mobile phones became widespread around 2015: substantial increases in the numbers of vegetable traders, increased activity in local markets, and stabilization of market prices. Although some participants directly attributed these changes to mobile phones, we cannot isolate the effects from other factors such as improvements

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in road connectivity that occurred concurrently. Contrasting with other studies in which interviewees reported no such uses of market price information [8, 28], our research underscores the importance of localized user research for MI service design.

Participants also reported other important factors which impacted their marketing behaviors, which helps us to define limits for the benefits of price-information systems: time and convenience, unfamiliarity with new markets, personal relationships, market gluts and price crashes, production volume, attitudes towards risk, credit relationships, and physical danger. Some of these factors inhibit market access, and we conducted user studies with MI system prototypes to explore which of these barriers are addressable; we report a variety of user experience findings primarily focused on helping farmers access new markets by providing information about price volatility, market capacity, business connections, and transport costs. We conclude by discussing the potential uses and limitations for an MI service in Buxar and offer design recommendations for improving market discovery and access to market information.

2 RELATED WORK

We now situate our research in a body of related work analyzing information asymmetry and scarcity in agricultural markets, investigating prior evaluations of MI services and highlighting factors that affect the adoption and use of these services.

The proliferation of mobile phones and the Internet gave rise to a new generation of MI services in the 2000's, largely backed by the private sector and trade associations [32]. In addition to prices, many of these new services provide production information—such as weather forecasts and pest alerts—and include mechanisms for online trading between buyers and sellers. Some prominent examples are FarmBee in India (formerly Reuters Market Light) [1]; Esoko, which operates in many African countries [12]; and mFarm in Kenya [22].

MI services have received considerable attention in development circles and hype in popular media due to their compelling story and potential for poverty reduction [8]. See, for example, the 2013 Guardian article that enthusiastically reported how *"smallholder farmers stymied by lack of information can see realtime market prices for their produce, and now they want to sell to Tesco, too"* [31]. Organizations such as USAID [32], the World Bank [3], and the GSM Association [2] have released publications lauding the potential and encouraging the adoption of phone-based agricultural MI systems.

2.1 Information Asymmetry and Scarcity

The prevailing economic theory of MI systems is that they benefit producers by reducing market inefficiencies caused by information asymmetries and scarcities.

The *information asymmetry* theory describes the difference in information assets between traders and producers. Traders, having better knowledge of market prices than producers, take advantage of producers' ignorance to buy below market price, thereby taking a large cut of producers' profits [13, 23]. MI services can increase producers' bargaining power by providing them with price information and the resulting opportunity to recover some of the traders' margins.

Information scarcity presents another type of market inefficiency: maldistribution of goods between disconnected markets. This theory posits that a lack of information about market supply leads to price crashes and wastage via oversupply, and price spikes and scarcity via undersupply. The availability of price information theoretically leads to more efficient distribution of goods by letting producers and traders sell in markets with higher prices and, in turn, redistributes goods to markets where they are more scarce [29, 30]. In what is now a canonical ICT4D study, Robet Jensen [18] measured a stabilization of prices across fish markets upon the arrival of mobile phones at a site in Kerala and showed increased fisher profits due to a reduction in wastage. Jensen reported that some fishing crews called agents at multiple markets and decided where to land based on prices, also benefiting others via resulting price stabilization.

2.2 Evaluations of MI Services

Recent evaluations of phone-based MI services have produced mixed results [5]: some demonstrated significant changes in participants incomes, prices, or marketing behaviors, while others found no such effects. In evaluations of Pallinet in Bangladesh [17] and TradeNet in Sri Lanka [20], farmers reported receiving higher prices from the services, but both studies reported only on farmers' perceptions. In studies that measured sale prices, findings were more mixed: a randomized controlled trial of an SMS-based price service in Peru reported price increases for some perishable crops [24], but a similarly structured study in Colombia reported no such effect [9]. One trial of Esoko saw a substantial increase in prices for yams but no other crops [15], while a different trial of the same service saw such increases for maize and ground nuts [10]. Similarly, an evaluation of Reuters Market Light (now FarmBee) identified no significant increase in prices [14].

Although some evaluations found no significant changes in marketing behaviors [4, 17, 20], others found effects of increased negotiating power against traders [10, 15, 24]. The 2012 RML evaluation reported that the group given a Reauters Market Light subscription had increased tendency to sell at markets instead of farm-gate traders [14].

Several researchers have examined how usability and literacy barriers affect the adoption and use of MI services. For example, Wyche and Steinfield [35] examined an SMS-based MI service and reported severe usability problems, including difficulty sending and reading text messages, sensitivity to the cost of sending SMS messages, language barriers, unreliable connectivity, difficulty remembering the codes required for requesting prices, and farmers' perceptions of mobile phones as *"social items"* rather than information delivery platforms. In the 2012 RML trial [14], a full 41% of the 422 households who were offered an RML subscription for free never used it, and the authors cited reasons for this outcome that included: illiteracy, devices' inability to display the Marathi script, and failure to send the sequence of SMS messages to activate the service. In Islam and Grönlund's evaluation of the AMIS service in Bangladesh[17], 80 of 100 of users reported difficulty using the Roman script to access the SMS user interface.

2.3 Factors Affecting Use of Price Information

These negative evaluations have uncovered a wide range of complicating factors that limit producers' benefits from price information. For example, the 2010 AMIS study reported that many farmers were reluctant to explore new markets because of unfamiliarity with their business mechanisms [17]. In the 2011 Tradenet study, many users were reluctant to change traders because they relied on them for information and credit [20]. The authors of the 2013 Esoko evaluation hypothesized that farmers got increased prices for yams but not other crops because bargaining played a bigger role for yam marketing than for other crops [15].

To characterize the limits of market information systems, several years after Jensen's previously mentioned landmark study [18], Srinivasan and Burrell [28] conducted ethnographic interviews at Jensen's original Kerala site and detailed the mechanisms by which fishers used price information. They found that only large boats tended to choose a landing site based on prices, the value of their large catches being more sensitive to price fluctuations; smaller crews most often just sold at the nearest market, prioritizing rest after a long day of work. At a second nearby site, they found only small fishing boats and dangerous topography that constricted landing sites, showing that the necessary conditions for price information to lead to livelihood improvements probably did not hold true there. From ethnographic studies at sites in China and Uganda, Burrell and Oreglia [8] reported that while their informants had many other uses of mobile phones for farming and fishing, they *"consistently disclaimed any practice of acquiring market price information for the purpose of comparison between markets (by phone or other means)"* for a variety of reasons, such as already knowing prices from extension agents or other fishers, giving importance to preserving relationships with traders, and aversion to taking risks.

These results emphasize the need to conduct more location-specific research, identify additional local factors that influence farmers' marketing decisions, and evaluate the role ICTs can and cannot play in addressing them. In this work, we identify processes, workflows, and factors that influence market choices of farmers in the Buxar district. We found that farmers commonly used mobile phones to check prices, select markets, and negotiate deals with traders.

Among ICTs for agriculture marketing, there is a paucity of research that addresses farmers' unfamiliarity with markets or disparities in marketing skills. We are not aware of any MI services that provide information to help familiarize users with local markets, such as market sizes, price volatility, seasonal variations, operating times, or vegetable processing advice, key foci of our effort.

3 BACKGROUND

To contextualize this work, we now provide details about the shared transport-to-market service Loop, identify key stakeholders in Bihari vegetable markets, and describe the structures of these markets.

According to the 2011 Indian census, Bihar has lowest literacy rate (61.80%) and highest population density (1,102/km^2) of any Indian state (excluding union territories) [26]. The 2015-16 National Family Health Survey in Bihar found that 89% of rural households had mobile phones, only 59% of households had electricity, and 46% of households owned agricultural land [25].

3.1 Loop

Loop is an integrated program working to improve smallholder farmers' livelihoods via improved connections to markets [21]. It offers a daily door-to-door vegetable pickup service for participating farmers. Vegetables are sold in the market, farmers are paid the full price on the same day, and SMS receipts are sent to them for transparency. Participating farmers benefit by saving time, sharing transport costs, gaining access to new markets, and negotiating with bulk quantities. Farmers never have any obligation to sell through Loop; they can choose each day whether to participate or sell their goods through other channels. Farmers always have the option to accompany the vegetables to market, but they usually choose not to. Because Loop records every transaction, the system already has accurate daily price data for many markets, making it a suitable foundation for a market-information system. As of November 2018, Loop is operating in 4 Indian states and 9 Bangladeshi districts and has conducted over $14M USD in transactions for 80,000 metric tons of vegetables from 26,000 farmers.

In the version of Loop operating in the Buxar district, farmers who want to send produce with Loop contact the village *"aggregator"* each night. The aggregator arranges transportation based upon the quantity of vegetables. The following morning, the aggregator collects the vegetables, accompanies them to market, and conducts transactions with traders or commission agents. Farmers and aggregators jointly decide which market to visit every day. Loop provides smartphones to aggregators with which they enter transaction data and contact traders, commission agents, and transporters. We note that Loop operates under several different business models, and that the role of aggregators differs in other locations.

3.2 Key Marketplace Actors

Bihari vegetable markets have diverse structures and can feature a variety of actors:

In-market traders: In many markets, retail traders buy produce during the morning rush that they then sell to consumers throughout the day. Some markets have local traders who charge farmers a small fee for using their scales and help them attract traders by drawing large volumes together. During high-production seasons, traders from distant locations visit many markets en route from one city to another and buy and sell produce based on prices, often specializing in a few types of vegetables.

Commission agents: These agents, known locally in Hindi as *Gaddidars*, do not technically buy vegetables, rather they leverage their business networks to sell vegetables on behalf of farmers, charging a fixed-rate commission per kilogram of sold vegetables. Key responsibilities of commission agents are negotiating good prices for farmers, attracting traders by aggregating big quantities from many farmers (see Figure 1), and maintaining good relationships with all parties. Many farmers have long-lasting relationships with these agents, selling most of their produce through only one agent. Commission agents commonly provide other services to farmers, such as supplying credit or paying farmers immediately in cash when payments from traders are delayed. While commission agents are not present in every market, they dominate some.

Farm-gate traders: Some traders buy directly from farmers' fields, skipping local marketplaces altogether. They often supply

Figure 1: A commission agent's stall with several tons of cauliflower for sale in Samastipur market.

labor to farmers for harvesting, processing, and packing vegetables. Some areas have farm-gate traders who buy produce from farmers and sell in local markets, often paying farmers slightly less than market rates but bearing the transport costs. During high-production seasons, some areas have long-distance traders who buy at farm-gate to circumvent market fees but demand higher quality produce.

Aggregators: Aggregators are farmers who conduct transactions for Loop. In Buxar's version of Loop, they collect produce from farmers, transport it to markets, conduct transactions, and send payments to the farmers.

3.3 Vegetable Markets in Bihar

Bihar's vegetable markets vary widely in size and have heterogeneous structures. Most farmers sell at wholesale markets, dealing in bulk to traders who shuttle the vegetables to other wholesale markets or to separate consumer-facing retail markets. Some markets are mixed wholesale and retail but many are distinctly one or the other. Prior to 2006, Bihar legally required many crops to be sold through public auction at state-owned APMC markets before reaching consumers. Bihar abolished its APMC markets in 2006 and the planned replacement system was never implemented, leading to a proliferation of private markets (which were illegal under the previous law but nevertheless common) [19].

The Buxar district of Bihar, where we conducted our interviews, is characterized by a smattering of small vegetable markets with no single large market that dominates the landscape. All markets are privately owned, and the proprietors collect fees from traders, commission agents, and farmers. The vegetable markets teem with small buyers and sellers, and we encountered no large corporate procurement channels. To our knowledge, Bihar has no government service for checking market prices. None of the farms or markets we visited had refrigeration facilities.

While some markets have traders and commission agents who rent stalls, in other markets farmers set vegetables on the ground and wait for traders to approach them (Figure 2). During busy hours, traders move through the markets, inspecting qualities and negotiating prices. There is no standardized quality grading system. Laborers hired by traders and commission agents load and unload vehicles, often handling hundreds of sacks every day, each typically weighing about 60 kilograms (kg).

Figure 2: Farmers stand by their vegetables in Dharhara market, waiting to be approached by a trader.

Prices: Prices float up and down based on supply and demand, are very difficult to predict, and occasionally spike or crash within minutes. Rates are negotiated as a price-per-kg. Most vegetable crops have only a short window of 2–4 days when they can be harvested and must be sold immediately to prevent spoilage, leaving farmers particularly vulnerable to short-term price shocks.

Transportation: For very small quantities, farmers often carry vegetables to market on foot, bicycle, or motorbike. When volumes are low, some farmers farmers jointly hire vehicles and usually all accompany the vehicle to market. Farmers commonly hire transportation from owners and drivers of small- and medium-sized vehicles (with capacity of 700–2500 kg) who commonly live around the villages. During high seasons, many farmers have enough vegetables to hire their own vehicles.

Cuts for spoilage: After weighing the vegetables, traders and commission agents generally cut the measurements to account for spoilage (*e.g.*, a trader might cut 5 kg from a 70 kg bag and pay only for 65 kg). Vegetables that spoil faster receive a higher spoilage cut. The amount cut also varies by market, commission agent, and trader, and such variations can impact farmers' earning significantly.

Gender: Few women farmers buy or sell produce in the wholesale markets in Buxar; negotitations between agents, traders, and farmers are largely handled by men. Some regions in Bihar have more women participating in markets than others; several farmers told us that poorer families are more likely to have women working in the markets.

4 FARMER INTERVIEWS

To better understand the potential uses and limitations of an MI service, we interviewed farmers and commission agents about their marketing behaviors. We chose Buxar as a case study because farmers in this area sell vegetables in several different small markets, whereas many other Bihari regions are dominated by a single enormous market.

4.1 Methods

We conducted semi-structured interviews with 11 farmers (denoted F1-F11), 6 Loop aggregators (who are also farmers, denoted A1-A6), and 3 commission agents (denoted G1-G3). To capture diverse responses, we sampled farmers and aggregators from six different villages in the Buxar district of Bihar. Five farmers were selected

randomly from the Loop user database [F5, F6, F7, F8, F9], and the others were recruited using convenience sampling; we interviewed farmers who were available when we arrived in their villages.

All interviews were conducted in Hindi, which was spoken and understood well by all interview subjects. The interview team consisted of two people: a regional manager for Loop who already had working relationships with the aggregators and spoke fluent Hindi, and a research intern for Loop who understood basic Hindi. To avoid pressures and biases from "public performance interviews", we tried to hold one-on-one interviews in private settings, but many of our interviews nevertheless drew groups of observers. We audio-recorded all interviews except for those with commission agents, who all declined to consent to recording likely from fear of damaging business relationships. We took detailed notes for all interviews.

We developed semi-structured interview questions in advance, informed by prior informal conversations with farmers during Loop's long-term field efforts. Our interviews investigated a wide range of topics, such as phone usage, price checking tactics, market changes over time, relationships with different market actors, access to credit, and Loop service usage. In most interviews though, we covered only subsets of the questions due to time constraints. At the time of our interviews, Loop had operated in the Buxar district for about five months. We asked these questions about marketing behaviors before and after beginning Loop use, and in the interest of generalizability this paper reports mostly on behaviors before Loop.

We transcribed audio recordings and translated interview transcripts and field notes to English. We reviewed and analyzed data immediately after conducting each interview, and the insights obtained from our data analysis added more questions to each subsequent interview. We subjected transcribed audio recordings and field notes to thematic analysis as outlined by Braun and Clarke [7]. A subset of authors participated in the coding process; they engaged in regular discussions and iterated on the codes until consensus was reached. We now outline key themes that emerged from our analysis of interviews with farmers, aggregators, and commission agents.

All of our participants were men. Although Loop has some female farmers, most often men handle vegetable marketing in this region. Moreover the fact that all interviewers were male made it difficult to recruit female farmers, in part due to cultural taboos that restrict women from conversing with unfamiliar men.

Farmers were aged 20 to 61 (median age: 36.5) and had education levels spanning from seven years of formal education to a master's degree in Sanskrit (median: nine years of education). Reported farm sizes ranged from 0.4 to 3 acres. Most farmers owned land; three reported having some land on lease. All farmers grew vegetables on their land, and some grew wheat seasonally [F1, F7]. While some farmers reported agriculture as their only source of income [F7, F9, F10], others also relied on earnings from dairy cattle [F5], remittances from sons working in Dubai [F5], and wages received from electrical work [F8]. We neglected to collect demographic information from aggregators and commission agents.

Four farmers had smartphones [F3, F4, F6, F8], five had feature phones [F2, F5, F7, F10, F11], and two had no phones but had registered for Loop using their fathers' numbers [F1, F9]. All aggregators were provided smartphones by Loop, and all three commission agents had smartphones. Among the smartphone users, some used the Internet and had accounts on Facebook and WhatsApp.

4.2 Acquisition and Use of Price Information

Many participants reported that they and many farmers in the Buxar district used phone calls over mobile phones to access price information and used it to choose markets and negotiate better prices with traders. We also received reports of vegetable traders using mobile phones to buy and sell between markets. Participants consistently reported that they never used SMS, Facebook, or WhatsApp for vegetable marketing. We are not aware of any government helpline service for vegetable prices in Bihar, and participants consistently denied having heard of one [F5, A3, G1, G2, F8, F10].

Price information sources: Most participants reported using mobile phones to access prices by sending or receiving voice calls [F1, F4, F6, F8, F10, F11, A2, A4, A5, G1, G2, G3]. An aggregator (A2) stated: *"I call and check prices frequently... Every day, different markets, different times."* While some participants checked prices daily [F11, A2, A4], others checked only on occasion [F2, F8].

Some farmers reported that they usually didn't check prices before going to market, and had different reasons not to find it worthwhile [F2, F7, F8, F9, A3]. For example, F7 did not check prices before going to his local market, since he knew that it usually had good rates. Similarly, F3 did not check prices because he trusted local traders: *"They never quote too little."*

Price sharing among farmers appeared to be widespread. Many interviewees reported getting prices from others in their village, frequently from in-person conversations [F1, F5, F6, F8, F10, F11, A1, A2, A3, A4]. For local markets at least, this finding is consistent with Burrell and Oreglia's claim that price information often is not scarce [8].

Many farmers reported making phone calls to commission agents to check prices [F2, F4, F6, F10, F11, A2, A4]. All participating commission agents also reported getting regular calls from farmers. Since commission agents act only as intermediaries and do not actually buy vegetables, farmers reported calling them only to check market rates but not to pre-arrange deals. A commission agent, G3, stated that *"20–25 farmers call me every day"* during both high and low production seasons, and that farmers call to check prices but never to discuss quantities. Some farmers reported freely calling several commission agents to compare prices [F4, F6, F11, A2, A4]; however, F2 reported that many farmers in his village were constrained by their relationships with commission agents and were obligated to bring produce if they called to check rates. Farmers having stable relationships with commission agents told us that the agents nearly always quoted accurate prices [F1, A2]. Some farmers reported that unfamiliar commission agents sometimes mislead farmers by quoting prices higher than the real prevailing price to draw farmers to their market [F1, F2, F8, F10].

Farmers reported calling both in-market and farm-gate traders to check prices and make verbal deals to sell over the phone, agreeing on a quantity and a price [F8, F10, A5]. Sometimes, as in the case of F8, traders also call farmers when they need vegetables; they offer a price and tell farmers the quantity to bring.

Market choices: A few participants reported checking prices at several markets before deciding where to take their vegetables [F10, F11, A2, A5]. For example, A5 shared that he sold his produce to retail traders at three local markets and called each market to check prices and make a verbal agreement about rates before going.

Similarly, F10 reported calling a commission agent to check prices at a distant large market to decide whether to go, and then checking prices with other agents after he arrived at the market.

Negotiation: Many farmers reported using price information in negotiations, comparing traders' rates against markets and against other traders [F2, F6, F7, F8, F10, F11, A3, A4, A5]. For example, F7 stated: *"We negotiate with farm-gate traders based on the previous day's market rates. We offer 2 rupees above yesterday's rate, and then the traders negotiate it down to 1 rupee above yesterday's rate."* In another example, F8 said that he called traders in the large, far-off *Ara* market to negotiate with local traders, since rates were always ₹2–8 higher there.

Arbitrage: Commission agents reported that traders regularly used mobile phones for arbitrage, leveraging price information to buy produce in one market and sell it in another. For example, G3 shared that 5-6 outside traders came to his market daily during peak season and called in the mornings to check prices. Commission agent G1 also reported calling other markets daily to check prices and arrange deals with traders.

4.3 Changes in Markets After Mobile Phones

Several participants reported significant changes in vegetable markets since 2015, around the same time when mobile phones reportedly became widespread in this area [G3, F11]. These changes include big increases in the numbers of traders, shifts in market activity, and stabilization of prices. Some participants directly attributed the changes to mobile phones [F11, A2, G3]. For example, F11 stated: *"Earlier, before mobile phones were here, not many traders came. But now that they know the rates, they come here to buy vegetables."* Some participants noted that improvements in road connectivity around the same time also likely played an important role [F4, F11, A4] as well as shifts in trader patterns due a bridge becoming impassable [F4, A4].

Many participants reported a large increase in the number of traders since about 2015 [A2, F4, F7, G3, F11]. For example, A2 noted that only 2–4 farm-gate traders used to come to his village daily, and the number had increased to about 15–20 at present. Because of increased trader activity in local markets, some farmers shifted from selling in distant markets to local ones [F4, F7, A4]. Farmer F7 had gone to the large, distant Ara market until 3–4 years ago, saying: *"The traders from Ara market are coming here now, so there is no point in going to Ara market."* Conversely, some other farmers who had previously used only local markets began selling at distant markets because of new contacts with agents [F11].

We heard some reports of price stabilization since 2015: some participants reported fewer supply gluts and price crashes [A2, G3]. According to G3: *"Before having mobile phones, traders had better margins because not many people had price information. Now everybody knows the prices."*

Farmers told us about a variety of marketing heuristics they used for price discovery before the availability of mobile phones. A2 told us that he watched where other farmers sent vegetable trucks from his village and then sent his vegetables in other directions to avoid oversupply. F4 stated that he went to far-off markets at the beginning of a harvest of a particular crop because demand was high then and supply low. A2 (and other farmers) explained that when the winds arose from the east and brought humidity for 2–3 days, production and quality increased; traders knew this too, so these winds also brought the distance-traders to local markets.

4.4 Non-Price Factors Impacting Marketing Decisions

Though price information was a key factor that influenced farmers' marketing decisions, participants also reported many other factors, such as market capacity, production volume, time, convenience, unfamiliarity with markets, personal relationships, connections, risk, credit relationships, and physical danger. We now report on some of these factors.

Supply gluts and market capacity: Participants reported that markets occasionally became overwhelmed by large amounts of produce. In such scenarios price crashes were common and farmers could not sell any vegetables, leading to severe losses. Many farmers mentioned market capacity as an overriding concern: the most important factor for their profitability was their ability to sell their entire stock of vegetables. Some farmers expressed reluctance to try new markets due to fears of price crashes. Since such crashes were frequent in some small local markets during high production seasons, many farmers viewed either selling produce to farm-gate traders or going to bigger far-away markets as safer options [F2, F10, A4]. A2 shared: *"If the market here has more harvest, then we go to distant markets. I have learned a lot by selling vegetables over the years. Let's say I have 2 quintal [200kg] of tomatoes, and if I get to know someone else has 5 quintal, then I know that the rate for tomatoes is going to drop. It's a competition cycle."* The capacity of a market depends roughly on the number of traders. In export-driven markets, outside traders come seasonally, so capacity varies over the year [F7, F8, A2].

Production volume and seasonality: We observed that farmers' marketing behaviors varied with their production volumes, which depended on their farm sizes and seasonal changes. When production was high, volume often exceeded the capacity of local markets, so farmers made the investment to try more distant markets with higher capacities [A4, F8, F9]. When volume was very low, some farmers did not find it worthwhile to put effort into marketing, so they opted for convenience: they stuck to local markets, sold to local traders, or simply sent their produce to market along with another farmer [F3, F5, A3, F6]. F8 told us: *"I never make any decision on prices. When the volume is low I go to Dumri market; when it's high I go to Nayabhojpur market."* F5, a farmer with small volume, regularly took a two-hour train to Patna, the capital city, to sell his vegetables in a retail market because it was too difficult to sell small quantities in wholesale ones. Vehicle capacity presented another constraint; during peak season insufficient vehicles were available for hire, so vegetables went to waste [F10].

Time and convenience: Market trips could be immensely time-consuming for farmers, and one of the biggest barriers to using alternative markets was simply that it took too long. During high production seasons, farmers commonly went to market every 1–3 days [F2, F6, F8]. Traveling to distant markets was reported to be a major time investment: some farmers reported making trips with 2–4 hours of transport time each way [F2, F5], and sometimes traveling the whole night [F4, A2].

Once at the market, they often waited for traders to buy their produce, which on good days took 30 to 60 minutes [F1, F6]. However, during high production season, the sales often took much longer. Farmers reported spending 3–5 hours to sell their produce [F6, F8]. F1 said: *"When there is a lot of harvest, sometimes it takes the whole day to sell."*

Some farmers reported selling to farm-gate traders because of convenience. Farm-gate traders often supplied labor to handle the cutting, packing, and other processing; this saved the time and hassle of going to the market [F3, F5, F10]. F3 explained: *"Now that these people do it, I just give it to them... I could not manage with everything. I am growing old."* Many farmers also cited convenience and time savings as reasons for using Loop [F3, F5, F7, F8, F9].

Unfamiliarity with new markets: Farmers reported that lack of familiarity with new markets was a significant barrier against trying them. Diversity in market structures and operations made selling in a new market a daunting task, and missteps could lead to big losses. For example, A6 shared why some farmers were hesitant to try new markets: *"If farmers have to go to a distant market on a hot day and the stock is unprepared, they might reach there late. If they reach late, the market will be down by then. If I reach late, then who will take my stock? He [the agent] will say you have come so late."*

Several farmers stressed the importance of gathering information about a new market before bringing vegetables there to sell, such as which commission agents were good, how much volume the market could handle, who the major traders were, whether vegetables came from outside, which vegetables sold well, and the peak operating times throughout the year [F1, F4, A2, A4, A6]. When asked what advice he would offer to other farmers, A2 replied: *"The farmers need to go to the markets and study the customers, prices, and quality of harvest. Without studying and experiencing it, one cannot learn."* He later told us: *"They should have a trusting relationship with the commission agents, and should know about the market's operations, such as rates and processes; all these things, so they can handle the market's intricacies and fetch good prices. Farmers should be informed about the markets well before going. If farmers are not well-informed and only make decisions on the basis of prices, it will not be good because every market has different operations."*

In-market connections: Participants told us that having connections in a market made selling produce much easier by providing information and help [F1, F4, A2, A4, A6]. We heard several stories of farmers trying new markets for the first time because they had formed a connection with a commission agent [F1, F2, F8, F11]. F11 told us that he had never sold at any distant markets before getting a mobile phone, and he recently started going to the distant *Bhasti* and *Bharadpur* markets after getting phone numbers of commission agents there from a local trader. Similarly, F2 tried going to the far-off *Sikanderpur* market after meeting a Sikanderpur commission agent who had come to his village. Apart from just information, connections were valuable for other support. During our interview of F1, another farmer interjected: *"When we go to Buxar market, we know the commission agents. If they are taking money, then we can fight for our money because we know them. With a different market, we don't know the commission agents; we don't have any power to exercise there. So we don't prefer those markets."*

Relationships with commission agents: Some farmers reported long-lasting relationships with commission agents, only selling with 1 or 2 consistently [F1, F2]. In these relationships, commission agents often expected loyalty, since collecting big volumes from many farmers was important for attracting traders. F4 told us that a farmer changing agents created a bad reputation in that market, and agents were less likely to extend credit or value that farmers' business: *"All goes wrong if you keep switching commission agents."*

Many interview subjects stressed the importance of trust between farmers and commission agents [F1, F2, F4, A2, G1, G2, G3], because they are mutually dependent on each other to maintain their reputations, exchange accurate information, and uphold deals. Commission agents told us about efforts that they make to build relationships with farmers, such as calling to ask about their families [G3] and giving farmers gifts like tea, Sprite, and flashlights [G2].

Sometimes despite these relationships with commission agents, farmers sold to other traders under the table. For example, F1 reported that once he was inside Buxar market he was expected to sell with his commission agent there, but to avoid paying the agents' commission sometimes traders would wait on the road outside the market and approach farmers before they entered.

Other farmers reported no such commitments to commission agents and sold freely via different traders and agents based on price only [F7, F8, F9, A5]. We heard many responses like: *"Whichever commission agent is giving good prices, we prefer to go with them.'* [F9]. F5 told us assertively: *"We want the price, we don't want a relationship."*

Risk: We encountered different attitudes towards risk-taking during our interviews. We speculate that wealthier farmers have better access to markets because they are more comfortable taking risks, with a financial safety cushion to fall on when things do not work out. Poor farmers are probably more constrained, more often choosing what they perceive as the safest option.

Some farmers discussed price crashes frankly, seeming to accept them as a part of doing business [F4, F5, F6, F8, A2]. For example, F5 stated: *"Yeah, I have had to return home with the stock... If today I get a bad rate, I might get a good rate tomorrow."*

Farmers F1 and F2, on the other hand, appeared much more hesitant to take risks. When asked why they seldom tried markets other than Buxar, they expressed concerns about spending too much to go to those markets without any guarantee that they would get good rates, and they recounted stories about visiting new markets in the past and finding worse prices.

The infrastructure of vegetable marketing in Bihar distributes risk between all the different actors. Commission agents and traders absorb some of the farmers' risk. A main benefit of selling through commission agents is that they usually pay farmers cash immediately when the produce is sold to a trader. Payments from traders are sometimes delayed [F4, F9], since traders send cash through intermediaries or pay only after selling the crops at another market, which usually takes 1–2 days but can take much longer when prices crash [G1, G3]. Commission agents in this way insulate farmers from price crash risks. Local farm-gate traders often pay less than market rates, but in return they bare the transportation cost and the risk of price fluctuations. F3 told us: *"I am too old to take care of the market things; traders are a luxury because they take the risk."*

Credit: After taking loans from commission agents at planting time, some farmers were obligated to sell their vegetables through that agent [F1, F4, G2]. Commission agent G2 explained that when

selling vegetables for farmers who have credit from him, he withheld ₹1–2 per kg of the payment for 2–3 days and then paid the rest to the farmer only when he returned to sell more vegetables. F4 told us that commission agents sometimes offered him credit, but he refused so that he was not obligated to sell his produce through the agent. All three commission agents who we interviewed insisted that they did not charge interest on loans to farmers; instead, they used the loans as a way to create business. F1, however, told us that he payed ₹20 per ₹100 per month in interest to his commission agent.

From our interviews, the prevalence of these credit relationships between farmers and commission agents was unclear. Only one participant (F1) reported taking credit from agents. However, commission agent G2 told us that he gave credit to about 20 of every 100 farmers he dealt with, usually in amounts of ₹10,000–₹20,000. F2 told us that his commission agent gave him ₹500–₹2000 advances for personal expenses but not larger loans. Participants reported having access to various other sources of credit, such as local moneylenders [F6, F8], relatives, and neighbors [F7, F10]. None of the farmers interviewed reported getting credit from vegetable traders.

Danger and Bribes: The peak activity of most big markets is in the early morning, and when the market is far away farmers have to travel at night to reach in time. Many farmers in our study area expressed reluctance to travel at night because of danger. Some farmers worried about getting robbed [F6]. F2 and F10 stopped going to distant markets because of police bribes. F10 shared: *"There was a problem with the police that resulted in a hassle to go there. On the way, there are two police vans by the road in the night checkpoint, and they ask for ₹200–500. There are about 10–15 such checkpoints. You end up giving about ₹3,000 for the vehicle and about ₹1,500 to the police, so any difference in market prices is a loss to us."*

4.5 Summary of Interviews

Participants reported diverse marketing strategies; some farmers regularly called connections to sell vegetables at many different markets, while others were bound to a specific commission agent in their local market or opted for the convenience of local traders. We recorded reports of many, but not all, farmers who used price information to choose markets and negotiate with traders, as well as reports of traders who used mobile phones for arbitrage between markets.

We collected anecdotal reports of changes in markets around the same time that mobile phones became widespread in the area, including increased numbers of traders, shifts in market activity, and stabilization of prices. Other factors influencing farmers' marketing decisions included market capacity, production volume, time, unfamiliarity, personal relationships, risk, credit, and danger.

5 MARKET INFO APP: PAPER PROTOTYPES

To explore which market-access factors could be addressable with an MI service, we next conducted a cognitive walkthrough and lightweight usability study of a series of low-fidelity system prototypes, built off of Loop, and using Loop aggregators.

As seen in our interviews and demonstrated by other Loop deployments, Loop farmers often accessed markets that were previously not practical due to time savings and the pooling of transport costs. We thus focused on the use case of farmers considering new, unfamiliar markets, and the subset of market-access barriers that we believed to be most addressable via an information service including market contacts, price volatility, market capacity, and transportation.

5.1 Methods

We designed four iterations of paper prototypes and tested the prototypes with nine Loop aggregators. Most participants were selected using a convenience sampling methodology for being present while conducting other Loop-related business; a few were selected for being engaged Loop users. Sessions were conducted in the Buxar and Samastipur districts of Bihar. For testing, we asked participants to imagine a hypothetical situation in which they had to choose between unfamiliar markets to sell their vegetables, and navigate the paper prototypes with mocked-up data to find information and make a decision. We carefully observed participants while they interacted with the prototypes and asked them to speak their thought processes aloud. Using the prototypes as a conversation piece, we held open-ended conversations with the participants about how to improve the designs and what other features they would like.

Participants typically had more education than other farmers: all were literate and had experience using smartphones. The interview teams consisted of one or two Loop staff who spoke fluent Hindi and had prior working relationships with many of the aggregators, and one Loop research intern who understood basic Hindi. Many participating aggregators already had experience with R&D processes, having previously participated in experimental Loop pilots. Since prior work has noted high levels of response bias when evaluating prototypes in HCI4D contexts [11, 27, 36], we used the "social proof" method to prime participants, finding it surprisingly effective for soliciting critical feedback [33]. Using the method to encourage criticism, we told participants at the onset of the evaluation sessions that previous participants had found the screens confusing, did not understand what the buttons did, and did not find the features useful.

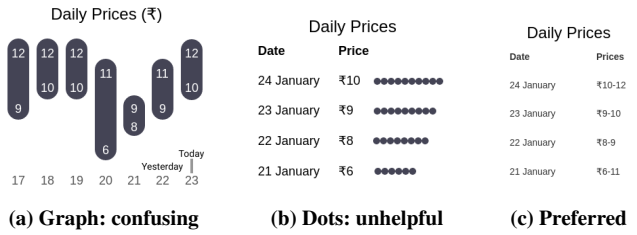
5.2 Findings

Here we present our results that suggest avenues for addressing some of the market-access barriers uncovered in our user research.

Price stability and market capacity: To help users know how stable or volatile prices are at a particular market, we experimented with interfaces for showing historic prices. We asked four aggregators how many days of past prices they wanted to see, and every participant consistently answered that they wanted to see prices for the last 2–4 days to understand whether prices were stable. Participants reported that showing more dates would be unnecessary; they could not predict future prices from past prices, and assessing stability of market prices was the only use case.

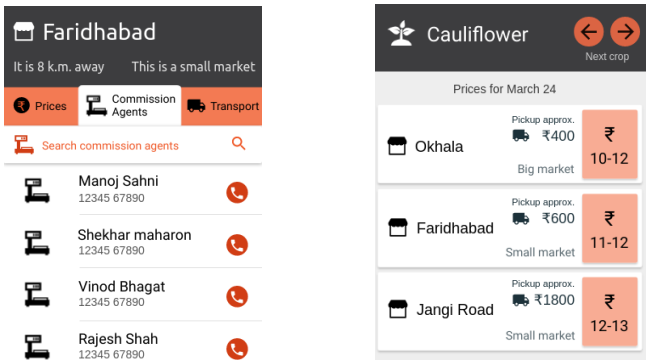
Graphs and visualizations are frequently used to show historic prices in many other contexts, but we found them not to be useful in this application. Bar graphs (Figure 3a) confused participants; other visualizations (3b) were easier to understand, but participants still reported finding them unhelpful and unnecessarily complicated. All participants preferred the simplicity of seeing the prices in tabular form with no visualization (3c).

To communicate market capacity, we showed screens labeling markets as 'big market,' 'medium market,' and 'small market,' showing these labels for multiple markets together so users could use



(a) Graph: confusing **(b) Dots: unhelpful** **(c) Preferred**

Figure 3: Presentations of past market prices, to show market volatility. All users preferred 3c. (Figures are translated from Hindi to English for this paper.)



(a) Mock screen showing commission agents for a market. **(b) Prices screen for one crop, showing market sizes and transport costs**

Figure 4: Example screen mocks shown to participants

markets they already knew as a reference for unfamiliar ones (Figure 4a). Most users responded positively to this feature, but we received feedback that some market sizes varied by season, and that we should note which markets had outside traders who came seasonally.

Transport costs: During the usability tests with hypothetical scenarios, we asked users to find the market with the best payoff after factoring in transportation costs. We watched several users struggle to calculate payoff estimations, having to keep track of many different numbers. We considered awkward payoff-calculator interfaces that required significant data entry from users, but we found it more effective to simply show the cost of sending a pickup truck to each market side-by-side with the prices (Figure 4a). Since only one or two crops usually dominate a day's market trip, this screen gave users the necessary information conveniently in one screen. Farmers commonly hire many different types of vehicles with different costs, but we opted to show only the cost of a pickup truck on this screen because for distant markets it is rarely cost-effective to send any vehicle smaller than a pickup.

Contacts: Since many farmers cited the lack of contacts as a barrier to exploring new markets, we showed a simple contacts page for commission agents at each market (see Figure 4b). We asked participants how they would choose which agent to contact and discussed options, such as a rating system for agents, or showing biographical information such as vegetable specialties. Several told us that when scoping out a new market they looked for agents with the most customers since that meant they were likely to be good agents. In addition to contact details of commission agents, several participants told us that they would like contacts for other Loop aggregators who delivered to different markets so that they could learn from each other. Some participants stated that they would simply prefer Loop to recommend a commission agent to them, and that they would trust the recommendation.

We learned through this exercise that some factors—including price volatility, transportation and payoff calculation, and agent contacts—are addressable through a mobile app or similar service. However, other important information for vegetable marketing is complex and difficult to capture in the structures of an MI service, e.g. specific quality and processing information for each crop at each market, or the fact that one particular market shifts to night time for several months during the winter. These factors may be better addressable through other media.

6 DISCUSSION

We set out to understand the potential benefits and limits of a market information service in Buxar, Bihar. Results from our interviews and prototype exercises show how the arrival of mobile phones has brought changes to Buxar's vegetable markets, and examine the many factors that influence farmers' marketing behaviors. We end with a discussion of design considerations for MI services and other strategies to address market-access barriers.

6.1 Information Asymmetry and Scarcity

Consistent with the theories of information asymmetry and information scarcity, we found evidence in the Buxar district showing that conditions seemed favorable for improved market efficiency due to better availability of price information. Farmers frequently used their mobile phones to get price information from different markets, some using the prices to choose a market and negotiate with traders. After the widespread adoption of mobile phones in the area, farmers reported market changes consistent with the information scarcity theory, with more traders moving vegetables between markets and fewer price crashes. We also heard reports of farmers using price information to negotiate higher prices from traders, consistent with the information asymmetry theory. Especially when compared to other research that did not find such conditions in other locations [8, 28], our work reinforces the importance of localization in the studies of MI services.

6.2 Usefulness of an MI Service

Many farmers used phone calls to access prices and other market information from their social connections. Would designing a dedicated MI service offer substantially more benefits to farmers than simply having mobile phones alone? Our findings indicate several potential benefits in favor of the former. Marketing is hugely time-consuming for farmers, and an MI service could eliminate the need to make calls to multiple markets. Not every farmer has market connections for checking prices over the phone, and an MI service could reduce this barrier. An MI service could also help to provide discretion and avoid social obligations for farmers such as F1, who

reported feeling obligated to sell to a certain commission agent if he called that agent to check the prices. Commission agents sometimes quote misleading rates to farmers, but an MI service could provide more reliable information.

However, many barriers to market access are simply not addressable by an information system, like as danger, time, and credit. For some other factors—like price volatility and unfamiliarity—an information system could provide some assistance, but the complexity of vegetable marketing presents challenges.

6.3 Future Work and Design Considerations

Apart from the information scarcity of prices, we demonstrated through our interviews the many other barriers that keep farmers from accessing other markets, such as personal relationships, price volatility, physical danger, credit, time, unfamiliarity, and lack of marketing skills. Although we probed some of these barriers with early-stage prototypes, much more work is needed to evaluate which barriers are actually addressable using information and communication technologies.

From our interview and prototyping work, we are optimistic that including some non-price information into an MI service could be helpful in this region. We found positive reception for indications of market capacity, price variability, and contacts of commission agents and traders at unfamiliar markets. Although the prototyping exercises were rewarding to examine factors and their presentations, we will be able to answer many questions only by testing with full implementations. For example, although many farmers indicated they would be comfortable calling unfamiliar traders and commission agents in new markets, only a deployment could reveal whether farmers and aggregators would indeed use this feature of the MI service.

We found that farmers often share prices around their villages and make joint marketing decisions. However, most existing MI services target individuals. There is an opportunity for more research about collaborative uses of market information.

Especially because few women can be found in Buxar's wholesale vegetable markets, additional work is needed to better understand the roles and needs of women engaged in vegetable marketing.

Our participants showed striking discrepancies in marketing skills: some were incredibly savvy, experienced marketers who gave us many tips and leveraged connections at dozens of different markets; many other farmers were inexperienced, constrained, and risk-averse. Because of the richness and complexity of vegetable marketing strategies, gaps in these skills are probably not well addressable by a market information service and better suited to other media. For example, it may be fruitful to draw upon Vishwanathan et al.'s work on consumer marketplace skills [34]. They developed a participatory, in-person market literacy course in south India that covers topics like checking weights, understanding price notations, developing relationships with merchants and customers, basic accounting, and avoiding credit and associated costs. Along this vein, some Loop aggregators have suggested organizing 'field trips' to different markets to learn how they work. Similarly, multimedia approaches—such as mFarm's experiments in using community-led video education to help users learn to use their MI service [35]—could be expanded to cover more marketing skills.

6.4 Study Biases

Our sample was not random and not fully representative of the area. All farmers we interviewed used the Loop service and likely had some different characteristics relative to non-users. Notably, our sample included no women. All farmers and aggregators also used Loop as a source of income, and they likely did not want to say anything that could damage that relationship.

6.5 Ongoing Work by Loop

At the time of writing, Loop has started early-stage pilots of an SMS- and IVR-based market price service and trials of a smartphone application built from our prototypes (Section 5). Through these prototypes, we hope to build an MI service that can change the marketing behaviors of Loop farmers, solicit farmer feedback about features, and further develop our user interfaces.

Loop has other ongoing projects to address market-access barriers outside the reach of an information system. One project coordinates multiple villages for more cost-effective transportation. To address market unfamiliarity, Loop has a pilot to explore how participatory user-generated videos [16] could be leveraged to familiarize users with aspects of different markets, for example, demonstrating the best way to cut cauliflower for a particular destination. Ongoing pilots with digital payments allow farmers to send produce to distant markets without the risk and delay of sending cash back.

7 CONCLUSION

We have shown that farmers in Buxar commonly use mobile phones to acquire price information for bargaining and market choice, suggesting the usefulness of a market information service to reduce information scarcity and information asymmetry. We report on factors that limit the usefulness of market price information, including time and convenience, unfamiliarity with new markets, lack of connections, personal relationships, price crashes, production volume, attitudes towards risk, credit relationships, and physical danger. We present further results from exploratory user studies for addressing specific barriers to market access including market capacity, price volatility, market connections, transportation, and payoff estimation.

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