ABSTRACT
This paper describes the process of design and implementation of an ICT-enabled agricultural advisory service to farmers in Bangladesh in areas where there is scarcity of public agriculture extension services. This system was developed and created based on a need assessment study under Agriculture Extension Project implemented in the south-western region of the country. The need assessment study was conducted with farmers, extension agents and relevant agricultural experts, and identified that an ‘infomediary’ enabled with a smartphone application that connects them to expert agriculturist’s advisory services can be an efficient and effective mechanism for providing solutions to farmers’ queries. This application, eventually named the Farmer Query System (FQS), is helping reduce the communications gap between an expert agriculturist and rural farmers, and augmenting the capacity of Agricultural Extension agents to provide services to a wider range of solutions with greater efficacy.

General Terms
Design, Experimentation, Agro Advisory Service

Keywords
Agriculture; Bangladesh; Smartphone; Informediary; Innovation; Farmer Query System; Application; Information

1. INTRODUCTION
The majority of the population in Bangladesh remains disproportionately in rural areas, where agriculture is the main source of livelihood. Agricultural sector is the largest GDP contributor of Bangladesh (35.7% of total GDP), which also remained the largest employment sector with 60% of total workforce of the country (Hossain, 2003). Hence agriculture plays a significant role in country’s economy and livelihood. But one of the primary challenges of the agriculture ecosystem in Bangladesh is the absence or limited presence of expert consultation in rural vicinities.

According to the ‘Agricultural Extension Manual 2010’ by Department of Agricultural Extension in Bangladesh an extension agent, the person responsible for providing agro advisory for farmers, has to support more than 1200-1500 farm families in his area. Given the working hour and resource available to the extension agent it is a mammoth task for them to provide adequate support to each farmer. As a result, farmers are forced to take advice from people who are not experts and are prone to being misled or exploited, which hampers the overall productivity of the country and affects the livelihoods of farm families. To address the problem several non-ICT initiatives has already been taken by various government and private sectors, such as door to door services by extension agents, published materials on agriculture, field demonstration etc. But the emergence and rapid spread of mobile technology and connectivity even in rural areas offers the opportunity to use m-Services as a tool to address the knowledge scarcity. In this note, we describe how we identified such a solution in the Farmer Query System and developed it to provide on-demand agro-related consultation to rural farmers.

2. OBJECTIVE OF THE STUDY
ICT informediary backed by expert agriculturist’s advisory services can be a gateway for effective and authentic solution for farmers. How Smart Phone Application can solve farmer’s cultivation challenges and also bring him closer to an agriculture expert for necessary real-time information in an inadequate agriculture extension service system.
3. BACKGROUND

3.1 ICT infrastructure for Agriculture in Bangladesh and Policy Relevance

Ministry of Agriculture (MoA) in Bangladesh has developed National Agriculture Extension Policy 2012 which aims to provide e-Agriculture services to farmers. There are 09 (nine) core principles and 26 (twenty six) pillars of National Agriculture Extension Policy (NAEP) 2012. One of the core principles is digitalized agricultural extension services (e-agriculture) and two of the twenty six pillars are development and strengthening Farmers Information Advisory Centre (FIAC) as “one stop service center” for agriculture. Section 11 of NAEP also indicated that ICT (specifically web and mobile technologies) will be used for linking marketing system with production system. Digitized databases and management information system will be set up at sub-district, district and national levels. Mobile based text messages and voice messages will be utilized for early warning on pest and disease outbreak, natural disasters as well as to disseminate critical information. Subsection 49 established demand Responsive Research-Extension-Farmer linkage. (Draft National Agriculture Extension Policy 2012)

According to Bangladesh Telecommunication Regulatory Commission a total of 119.6 million people are using mobile phones with top-up and scratch card facilities for buying airtime. (Bangladesh Telecommunication Regulatory Commission) The coverage of mobile network is 98 percent across the country. As, the 2G and 3G internet facilities are in place so mobile internet subscriptions has reached 40 million. (Bangladesh Telecommunication Regulatory Commission)

So, the infrastructure – policy, bureaucratic and technical – is largely in place to deliver ICT-based agricultural services to farmers. However, while farmers sometimes use their mobiles to call for agro consultation, no efforts were there to systematically leverage ICT for strengthening public and private extension services.

3.2 Digital Extension Services in Bangladesh

Department of Agricultural Extension (DAE) in Bangladesh has approximately 14,000 such extension workers for their field level advisory services. The responsibility of these staff is to make agricultural information more accessible to farmers, but they do not have access to modern communication devices apart from their personal mobile phones. Public and private bodies have undertaken some initiatives, but with significant limitations:

a) Agriculture Information Service Department (AIS) of the government has a small but dedicated service through their website, but the contents is not updated frequently and queries are not systematically addressed. The problem remains that farmer or extension worker cannot make web-based queries without access to laptop or computers.

b) AIS also has a toll-free call center, but the content database is not sufficient to respond to most queries.

c) AIS also has agro-based radio programs in national radio and through their two community radios. But they do not cover the whole country for live consultation services.

d) Bangladesh Rice Research Institute (BRRI) had developed a Rice Knowledge Bank (BRKB). The contents are inaccessible for farmers as it is web-based, and also is limited only to Rice. Besides, contents are uploaded as PDF, which are not easily indexed or searchable.

e) Soil Resource Development Institute in partnership with Katalyst developed a Fertilizer Recommendation Software to assist farmers with the accurate information for different crops based on location and soil type. This links very quickly to a soil and land use database to give contextualized recommendations to the farmer. While a great achievement, PCs are still needed to access the information from the field. Moreover, it gives an average recommendation on fertilizer since Bangladesh has 30 agro ecological zones. Multiple soil patterns can be found within the same territory, so average recommendations are often not sufficient for farmers.

f) Some telecom operators in Bangladesh are giving agro consultation support through their call centres. Banglalink introduced a service called “krishijigyasha 7676”. By dialing the short code 7676, a Banglalink customer reaches a call centre, where staffs provide answers and suggestions to queries related to agriculture, vegetable and fruit farming, poultry, livestock, fisheries, etc. To use this service a farmer just needs to dial 7676, talk and get expert’s advice on the problem. The service is very expensive for farmers and experts do not have access to an agro content/database for consultation support.
4. LITERATURE REVIEW AND GLOBAL PRACTICES OF FARMER ADVISORY SERVICES

In Tanzania farmer accessed information through ICT channels like radio, television, mobile phones especially among the communication channels used, radio was ranked high like 97%. (Mtega & Msungu, 2013). mA Farmer initiative funded by USAID in India and some African countries shows that queries from mobile device users are connected to a call center and fed into a database, and an employee or extension agent call in to provide an expert response. (Vignare, 2013). Muthiah, Prashanth, Umadikar, and Karthikeyan (2013) showed the Indian Institute of Technology, Madras’s Rural Technology and Business Incubator (RTBI) in India developed a multimedia agricultural advisory system (MAAS) which shows farmer can raise a query using their mobile phone to an agricultural expert. When a farmer calls, a call centre like interface with personalized information pops up at the expert’s end who views the farmer’s dashboard and analyses the situation and query based advice is provided to the farmer.

In Philippines Farmers’ Text Center (FTC) SMS service provides technical knowledge to rice farmers as well as agricultural extension workers. Farmers and extension workers can send in photos of their diseased or pest-infested rice plant via MMS.

In India m-Krishi initiated mobile application where registered farmers users install the m-Krishi application suite on their handsets which allows transfer of information in a rich content format to the farmer’s low-end mobile handsets. They also have voice call system for illiterate farmers who can make a query from a cell phone using voice-specific functions.

Indian Kisan Call Center (KCC) – an initiative from Ministry of Agriculture. The purpose of these call centers is to respond to agricultural and related issues raised by farmers, instantly, in their local language. There are call centers for every state, which are expected to handle traffic from any part of the country.

In Uganda, there is a service called Farmer’s Friend which is piloted by Grameen Foundation’s AppLab and powered by Google SMS. Farmers can search for agricultural tips through an SMS-based database, covering crop and livestock, pest and disease control information, planting, storage and harvesting tips, as well as regional weather forecasts. It is successful at a limited scale in the sense that there are no field level extension services in Uganda from the government.

All these initiatives are largely supply driven where SMS or instructions are sent to farmers directly as unsolicited information. These systems have some challenges where the visual symptoms and contextual data is not available for the agricultural experts. In demand driven call centre model, farmer needs to pay and also many of the farmers sometime cannot explain their problems through voice call. So, call centre agent do not have the option of identify proper challenges only by hearing from farmers.

5. METHODS AND DATA SOURCES

This is an exploratory research where field level digital data has been used which came through an android application. The solutions of those queries were given on particular farmer problem where government based field level advisory services is unavailable. This study was based on USAID funded Agriculture Extension Support Activity project in the south western region of Bangladesh. This pilot study was conducted by mPower - the ICT partner of the project in 4 of the regions under the project location.

22 infomediaries such as public extension agents, agri input seller, ICT leader (innovative farmers), AICC infomediaries from 22 areas (where there are 13000 farmers approx) had an android mobile handset with built in farmer query mobile application with a questionnaire. The recorded queries of farmers through the device were sent to a central server using internet connection. An agriculture expert can look at the information on a web-based interface with pictures and direct infomediary by providing solution accordingly in real-time.

The data sources were primary. Total 22 infomediaries bearing an android handset recorded 1585 queries in a period of 4 months. Those queries are answered by remote agriculturist. Besides, 8 case studies were done including user of the application (Total 4) and also farmer (Total 4) who used the information in their agriculture fields.
6. INITIAL CHALLENGES OF LINKAGE AMONG FARMER, PUBLIC EXTENSION AGENT AND AGRICULTURE EXPERT

Sub-Assistant Agriculture Officers (SAAOs) are the main frontline Agriculture Extension Work (AEW) who deal with farmers directly. There are other types of AEWs, our research found numerous challenges faced by AEWs in their workplace:

6.1 Poor Communication and Transport Facility for Frontline Public Extension Agents:
Department of Agriculture Extension of Government of Bangladesh provides Bangladeshi Taka 500 (USD 6) to go to farmer household for giving extension service. So for them, it is hard to cover 1200-1500 farm households frequently. Besides, very few of them are given motorbikes to cover a big area of farmers.

6.2 No Foundation Training for Public Extension Agents
GoB does not provide any foundation training to front line extension agents (SAAO). After their selection, they are involved in the field at the last semester (3 months) of their diploma graduation as an intern. During that intern period they work with their superiors although it is not formal and after completion of internship they are placed in the field as Public Extension Agents. So, these public extension agents cannot always solve the problem of farmers in critical agricultural cases as they are not full phase agriculturists and even they do not get any foundation training.

6.3 Scarcity of Agriculturists in Village level
Our research has found that one or two agriculturists who are called Upazila Agricultural Officer (UAO) are placed in the sub-district level. These UAOs are the supervisor of SAAOs. They do not get time to visit the farm household to provide agriculture extension services in a regular basis. So, there is very few linkage with farmer and Agriculturists.

6.4 Farmer’s hunt for Extension Service from Traditional System
As there are few SAAOs and UAO service in the farmer community, so these farmers usually go to experienced farmers and to input sellers whenever they find any problem in their plants or any cultivation challenges.

That is why Smart Phone based Farmer Query System can play a vital role through infomediary. Through our literature studies and need assessment, we found that pictures of plants along with plant affected data and GPS location of farmers’ field is very necessary for demand driven advisory services. Farmers often cannot tell their real problem, so a call centre agro agent or expert sitting remotely cannot identify real problem accurately. Compared to traditional extension services and other private initiatives, it takes very fewer times to answer which impact a lot in the field. We have also seen that fewer extension agents cannot serve whole community and that’s is why this FQS is build in such a style, any person who can read or can access phone will be able to act as infomediary. They can be farmer, extension agents, telecentre agents or input seller.

7. DISCUSSION

7.1 Development of Farmer Query System and Its Technical Features
Farmer Query System enables a local agriculture extension agent to capture a farmer’s problem using a mobile application and directly send through mobile internet to an urban-based expert for immediate feedback. The expert looks at the problem on a dashboard and responds through either a phone call, SMS or voice message.

Farmers are drawn to this kind of a service model since there are very few government agricultural experts available at the field level. Under the circumstance, they welcome the fact that this model gives them the opportunity to place their query directly to an authentic government or licensed agricultural expert through a local extension agent. A local extension agent can take the form of a government extension agent, a local rural telecenter entrepreneur, or even any person in the community with a smartphone, which has our freely available mobile application installed.
7.2 Novelty of the System
Most traditional agro-consultation services allow for farmers to directly call an agricultural expert through a voice call. So, that model does not work too well since the expert is often not be able to give meaningful advice without a systematic description of the problem and related information such as, what type of land, what a farmer harvested immediately before, what amount of fertilizers have already been given, a pictorial description etc. Figure 2 and 3 shows the features. This Farmer Query System allows for systematic capture of the problem through an algorithm and also takes pictures of the problem to allow an expert to give a much more targeted recommendation. Another unique feature of the system is that it allows expert recommendations to go to farmer in the form of a voice call, or SMS or voice message. The system also allows different kinds of analytics to be automatically generated based on which policy interventions can be planned.

7.3 Features of the System

7.3.1 Simple User Interface of Mobile Application
The infoedaries are not highly tech savvy people and that is why this system is designed in the method of human centered design (HCD) so that any user can feel easy to use. The questions for the query in the application is placed based on farmer-extension agents conversation methods. It has pictures and GPS location tracking system.
so that the problem can be captured in a systematic way. More than 20 available crops are listed to make sure that farmer can find their crops easily.

7.3.2 Web Interface for Agricultural Expert in Call Centre to Provide Recommendation

The queries sent through infomediaries can be seen by agricultural expert in the form of agricultural records in a web interface. The call centre agriculture agent can see the picture of affected crops and GPS location. The location can let him know about the agro ecological zone of Bangladesh. It helps the agent to identify the specific problem such pest and disease attack and others. Moreover, the system helps the agent to push recommendation through web interface. They can answer seed selection, fertilizer recommendation, weather information, weed management, pest and disease attack, cultivation technique and harvesting related queries through the system.

7.3.3 Web Dashboard for Managers to Monitor the Service and Outbreak of Agricultural Problems

Managers and agricultural researchers can track the queries and calculate the outbreaks through visual dashboard by generating reports. Region and area based color coding can make them understand about day to day problems of the farmers. Through this dashboard they can identify problems related to plant and soil and can prioritize their agricultural research and intervention.

7.4 Target Market

Farmers in need of an authentic solution to their agricultural problem are the target users. Among 160 million people of Bangladesh agriculture employs 45% of total labor force of the country who are directly or indirectly in need of on demand agricultural information and resides in rural area. But to meet this information demand government has employed only fourteen thousands extension agents which created a vast gap among demand and supply. So, there is a need of getting actual expert’s services. From our need assessment study, we found that
farmers tends to go to input seller or nearby farmer for consultation. But they are not expert to field level situations. That is why FQS is developed as an ICT tool to address those challenges. Farmer Query System (FQS) is a major improvement on other initiatives that it can serve plenty of farmers with only one expert agriculturist remotely. Besides, as the price of smart phone is getting reduced drastically, so a smart phone application with query recording system is linking farmers directly with an expert through an infomediary. So, smart phone and its app can be a game changer as infomediary needs not to be an expert for recording. Any farmer, field agent who can access a phone or can read and write can easily play this vital role. So, this demand based query is bridging farmers with an Agro Expert. Information is coming within very short period of time, so an expert can give real-time solution within a moment. In other advisory services, there is a challenge in sending pictures, sending GPS information, FQS has made it easy for remote expert for consultation through voice call, sms and email.

7.5 Types of Users and Business Concepts
This system has been developed through a funding from USAID as Agriculture Extension Project under a food security program. This service is currently free for the farmers and the agricultural consultations are being provided by government and non-government agricultural experts. This system is expected to take over by the Bangladesh government’s Department of Agriculture Extension and Agriculture Information Service (AIS) department. The long-term sustainability of the initiative is to house the service under government premises, which is already under process since this USAID funded project is directly supported and supervised by the government. Right now, the government already has a toll-free call center with agricultural experts who respond to direct voice call queries from farmers. The plan is to enable this existing call center to respond to queries coming from the field through Farmer Query System mobile application, which systematically captures the problem along with pictures when needed. This allows for government extension agents, who are given smartphones by the government, to place queries to the government call center. In case there is no government extension agent available due to their low numbers, a local private intermediary can also place the query on behalf of the farmers and make revenue from the farmers. This system is piloted with different types of infomediaries namely Field Facilitator of the Project, Innovation Farmers (ICT Leader), Agro Input Seller, Agriculture Information Communication Centre (AICC) - Telecentre Agents.

a. **Field Facilitator:** They are the frontline staffs of the project funded by USAID and implemented by Dhaka Ahsania Mission, CARE Bangladesh and mPower Social Enterprises Limited. They work very closely with farmers for forming the project group of beneficiaries and activity towards farmers. Each of the field facilitators are liable for 12-15 farmer groups and each group contains 25-30 farmer members. Total 8 field facilitators are given Android based smartphone with FQS application.

b. **Innovative Farmer (ICT Leader):** ICT Leaders are farmer beneficiary group members who are literate and educated enough to record the query of his group from the field level. They are selected as ICT leaders after forming of farmer group in the project. Based on some criteria, such as a minimum literacy, have experience in mobile phone accessing, interest etc. total 7 ICT Leaders were selected for this FQS application pilot.

c. **Agriculture Input Seller:** Input sellers are the businessmen in the community who sells fertilizer, pesticides, seed etc. In a Bangladeshi settings, farmer tends to go to input seller for to buy the agriculture materials and they also believe to take agriculture extension service from them. Total 2 input sellers were taken for FQS Application pilot.

d. **Agriculture Information Communication Centre (AICC) Agents:** These agents are the initiatives from the Department of Agriculture Information Service (AIS) from the Government. These AICC’s are agriculture based telecentres and AIS has provided ICT equipment. AIS also provided training to two agents to run these centres as rural cybercafé and agriculture based telecentres in an entrepreneurship model. Total 10 AICC agents were taken for FQS Pilot.
8. INITIAL FINDINGS FROM THE PILOT STUDY

8.1 Type of Users in Sending Queries

The idea of this research is to find out whether FQS Application through infomediary can serve the purpose of the farmers in a resource poor extension service in the country side of Bangladesh. Total 1585 queries were sent through smartphone by 22 infomediaries in a period of 4 months. The project took four different types of infomediaries category to test the service. Out of the types of categories, 50% of the queries come through AICC telecentre agents and these telecentre agents are basically farmer group member and the centres evolved from Farmer Club. To democratize information and decentralize the access of agriculture information, the project tried to capture the queries sent by ICT leader or innovative farmer and total 14% queries were come through them. The positive thing of giving smartphones to these ICT Leader is to disseminate information within their group of 25-30 farmers so that group members can easily get the recommendation from call centre expert. The agriculture input seller’s service is not that satisfactory as they are busy with selling their products but they are limiting their selves as an extension informediary. These input sellers were given smartphone because farmers frequently visit those shops to buy agricultural inputs. There could be a sustainable business case through this input sellers as there are financial capital involved between farmers and input sellers.

8.2 Crop Wise Query

This specific project works on specific value chain crops such tomato, jute, mung bean, chili, ground nut and water melon farmer group. Through a value chain study, the project identified these as the major crops cultivated in the area. But after launching of the

<table>
<thead>
<tr>
<th>Type Of User</th>
<th>Total User</th>
<th>Total Web Data</th>
<th>User Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>AICC Telecentre Agent</td>
<td>10</td>
<td>793</td>
<td>50</td>
</tr>
<tr>
<td>ICT Leader (Innovative Farmer)</td>
<td>4</td>
<td>219</td>
<td>14</td>
</tr>
<tr>
<td>Agriculture Input Seller</td>
<td>2</td>
<td>56</td>
<td>4</td>
</tr>
<tr>
<td>Field Facilitators</td>
<td>8</td>
<td>517</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total User=24</strong></td>
<td></td>
<td><strong>Total Data=1585</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 6. Crop Wise Farmer Query Data
FQS Application, the research found that farmers asking questions on different crops since most of the farmers grow more than one crop. There are also different crops are cultivated in three season of Bangladesh. From figure 6 we can easily see that most of the queries came on rice which is 34% since this is the main staple food of Bangladesh people. 26% queries were came on cultivation challenges of other crops. The analysis tells that few crops are listed in the application form. So, more crops need to be listed for FQS as there is a demand from farmers.

8.3 Patterns of Farmer’s Query

![Figure 7. Patterns of Problem Query](image)

The digital data came through from the field identify that most of the farmers are facing pest and disease related queries. Out of 1585 queries in a period of four months, total 763 data came for pest and disease related problems. The project is working in the coastal and salinity area. Due to climatic and weather condition, pest usually attack the plants in those areas and salinity causes different types of fungal disease. Most of the shrimp farm are based in the south western area of Bangladesh and this sort of farming needs plenty of salt for aquaculture. So this salinity decreases soil nutrient. That is why due to lack of soil nutrient and soil resistant, pest and disease attacks more.

8.4 Satisfaction Level after Getting the Recommendation from Call Centre

![Figure 8. Usage of Recommendation](image)  ![Figure 9. % of Satisfaction Level of Recommendation](image)

With the farmer query system we are able to communicate farmer’s problems to experts in a very step by step manner along with pictures. But the system needs to include more crops. My group farmers usually come with vegetable related query but the list of vegetables are less. So, many of the times I cannot record their query and get feedback from call centre agent.
Out of total 1585 queries came from farmers, 76% farmers applied the diagnosis and recommendations done by the call centre agents. The system shows that there is a need to get agriculture extension messages through some system as the farmers do not get the public extension service at their door steps or in the agriculture field. Out of those farmers 79% told that the service was good and 17% shows about their medium level satisfaction. From figure 9, 4% were dissatisfied with the service they got from the call centre. Either the recommendation was wrong or those were not captured correctly by the infomediaries.

9. CONCLUSION
Eliminating farmers’ challenges to ensure national food security and nutrition are vital for Bangladesh. At the same time addressing farmers’ challenges through infomediaries and remote agro expert can play a vital role in extension services where there is lack of knowledgeable field level government extension agents. Through the pilot research, Farmer Query System (FQS) showed promising early results which suggest its feasibility in developing country contexts like Bangladesh. Through our experiences and operational research in this pilot, we can conclude that FQS is helping democratize the power of information by gathering and addressing farmer problems in near real-time. By addressing day-to-day challenges of farmers around pest, disease, seed etc. this system has the potential to help impact food security and nutrition in the future. As different technology interventions in developing countries reaching from readiness to an end, it is relevant at this stage to see how the design and implementation of an ICT based solutions like FQS may facilitate and create a bridge between farmer and agriculture expert through an infomediary - who might not be an agriculture expert, rather a hub for creating impact in agriculture.

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