Digital Platform for Data Driven Aquaculture Farm Management

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ABSTRACT

Besides meeting the domestic needs of cheap animal protein, Indian fisheries, is source of livelihood for 14.5 million fishers [1]. During FY2014-15, inland fisheries grew at 7.9%, fetching US $5.5 billion in foreign exchange [2]. But aquaculture farming requires lot of care, including periodic observations of the weather, water quality and feed consumption. Drop in feed consumption, coupled with low temperature, may be an early indication of a disease. In FY13-14, shrimp production fell in Southeast Asian countries due to spread of Early Mortality Syndrome (EMS) disease, reducing export by 50% [3]. Hence farm data is crucial for daily data driven crop health monitoring and management. But it's very difficult to manually assimilate such bulky data and extract information impacting real-time decision making. This is especially challenging when each farmer manages multiple ponds, spread out over a distance and with no or low speed data network.

mKRISHI® collaborated with farm managers, government regulators and farmers to develop "mKRISHI® -AQUA" service, in an iterative, multi-phase development process. This service helps in data collection, compilation and presentation of the patterns in visual format, enabling decision on further operations (such as feeding) in a more real-time manner compared to paper based operation.

CCS Concepts

• **Applied computing → Computers in other domains → Agriculture**.

Keywords

ICT; Aquaculture; Shrimp, Mobile; mKRISHI AQUA; MPEDA;

IndiaHCI'15, December 17-19, 2015, Guwahati, India
© 2015 ACM. ISBN 978-1-4503-4053-3/15/12…$15.00
DOI: http://dx.doi.org/10.1145/2835966.2836277

1. INTRODUCTION

India is rich in biodiversity and is blessed with a long coastline region, which has paved the way for various marine activities. Fisheries play an instrumental role in the socio-economic development of the country. It contributes to about 1.4% of the national GDP [4]. Few years ago, fishermen in India used to depend on traditional marine fishing for their livelihood. But due to over-exploitation of marine fish, they face scarcity of fish to meet the ever-growing demand in the market. With the increase in demand of inland fish species like shrimp, lobster, etc. in the international market, aquaculture proves to be the best alternative occupation for fish farmers. Aquaculture refers to raising shrimp, lobster, crab, etc. commercially in tanks or ponds. India is considered as the second largest producer of inland fish, with an annual production of 9.06 million metric tons [5].

In our study we found that Aqua farming should be done in controlled conditions. Farmer needs to keep a record of water parameters like salinity, pH, etc. and also of the feed consumed by the marine life periodically in order to monitor survival and growth of species [6]. This generates lot of data which must be processed by a computer to get reports and enhance decision making. Hence an ICT based solution, "mKRISHI® -AQUA", was developed which can replace manual record keeping with digital data entry. "mKRISHI® -AQUA" is an Android app which provides an easy tool for book-keeping, weather forecast and graphical records. This mobile application has been developed by TCS Innovation Lab Mumbai's Digital Farming Initiative (DFI) in collaboration with Marine Produce Export Development Authority (MPEDA). MPEDA is a Government body functioning under the Department

of Commerce. They provide training to aqua farmers, conduct inspection of marine products and also promote the marine products in overseas markets.

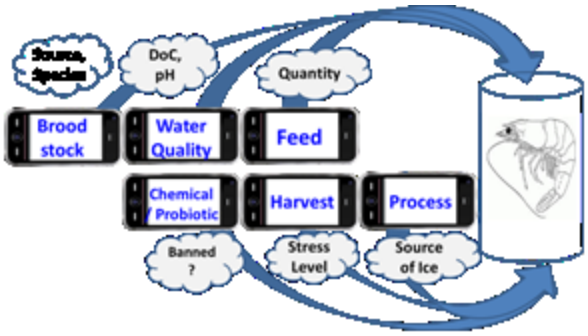

Figure 1. Data Driven Aqua Management

A pilot was conducted and the service was rolled out to the shrimp or prawns cultivators in Southern Gujarat. This paper captures our learning and experience gained while designing "mKRISHI® -AQUA" solution.

2. BACKGROUND

As mentioned in Figure 1, aquaculture cultivation progress from stocking the seedlings to harvest. During this average 120 growth period farmers need to daily capture data on the feed consumption, shrimp weight gain, survival sampling, total ammonia and nitrite–nitrogen concentrations range, etc., [7]. For all these farmers need to monitor each farm or pond 2-4 times a day. Each observation instance involves capturing major four types of parameters, each covering 6-8 distinct data fields and 3-4 repetitive fields like date, time, location, etc. Hence, they document the observations for 20-30 unique data fields and 12 to 15 repetitive fields. Depending on the farm size and breed type (tiger prawn or shrimp), the entire observations are repeated for 2 to 6 times within 24 hrs. Hence, this exercise may generate 220 field observations per pond per day. Eventually they need to convert this paper data in soft copy on a computer for a final analysis. This delays the pattern extraction and relevant decision making.

There has been attempt to capture such observations. Asadi et al. [8] used remote sensing and GIS to evaluate aquaculture impact on land uses. Vijay et al. [9] provides potential areas of shrimp farming using GIS and remote sensing technology. Most of these researches collect data using satellite image. A medium was required to collect ground data from farmer and combine it with GIS data to develop prediction model. Hence an ICT based solution was designed and developed. The desktop software solutions like AquaViewer Monitoring and control apps are linked to the respective sensors [10]. These restrict the users to buy these costly sensors and the corresponding software. Mobile applications like AquaBrahma provides services like Hatcheris and Agro input supplier search and market price indicators [11]. Aquanetix provides a cloud based web application. Users need to connect to internet and use it from computers to access and enter data. This can be a challenge when there is no internet or mobile data network. Also this service is in English [12]. India being a multilingual country, very few people from rural area can read and understand English [13]. Hence, mobile application mKRISHI® - AQUA is developed in local language. Whereas for stakeholders like exporter and government agencies a web based service in English was developed which enabled them to do complex data analysis.

3. EXISTING PROCESS

Aqua farming is practiced by all kinds of farmers – small and marginal ones, relatively larger farmers and those who do it on commercial scale. Depending upon the farmer, process of record keeping varies. Small farmer who possess few hectares of land are unable to capture all parameters. They maintain small notebook and are able to capture mainly feed information or water test parameters. By monitoring feed consumption data periodically, they anticipate the growth of shrimp and accordingly plan their next feed cycle, expected harvest date, etc. Relatively large number of farmers maintains a complete white board (Figure2) or a paper register capturing all the parameters. These registers are kept in the farm itself and whenever the farmer performs any activity like stocking, feeding, sampling, checking water parameter, etc. the data is captured in this register which they refer at the time of deciding the next feed and sampling timing

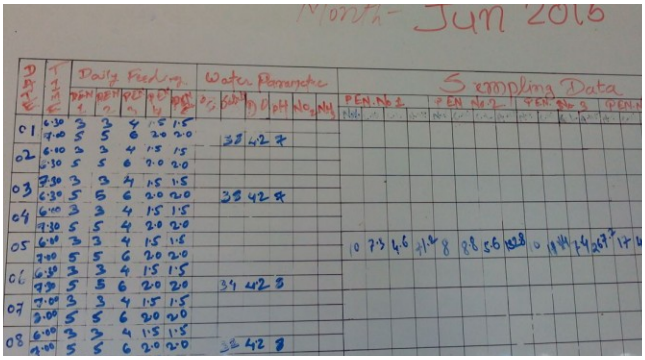

Figure 2. Sample Data of Farm Register

The farmers practicing aqua farming on a commercial scale possess large farms. These farmers appoint laborers to take care of their ponds. These laborers capture the pond data in their register and during the end of the week, all the pond data captured in different registers is consolidated and fed into the computer in the form of an excel sheet. This approach is not only time consuming but also delays data analysis leading to delay in decision making. India being the second largest consumer of mobile phone [14], has a great opportunity to introduce ICT based solution for Aqua farming. Hence, TCS developed "mKRISHI® -AQUA", a mobile based solution to capture the field observations and present the trends and results in graphical format.

4. DESIGN APPROACH

4.1 Prototype Design

We carefully studied how aqua farming is practiced in India. Several visits to various farms were conducted and the activities performed by the farmers were observed and recorded (Figure 1). Based on our observation, we narrowed down the whole process of aqua farming into various activities viz. Farmer Registration, Pond Creation, Pond Management and Pond Report. Pond Management was further sub categorized into various aqua farming processes like Stocking, Feed management, Water Parameter and Harvesting. By referring to the farm register (as mentioned above in Figure 2) used by farmers in the field, we defined various fields/parameters that needed to be captured in each activity. Based on these insights, an application call flow was designed and a prototype application was developed for Android platform. Application was developed in both English and local language (Guajarati) so that farmer can use it without any external help. This prototype consists of the following modules (Figure 4):

4.1.1 Farmer Registration

It includes farmer's personal information like name, location, education, etc. and farmer's farm data like pond area, water sources, etc. Farmer registration is a onetime process. If farmer is already registered we automatically fetch his data from our database which takes him directly to the main menu screen of the application.

4.1.2 Pond Creation

Here we capture the location data of the pond, its latitude/longitude, area and unique identity number.

4.1.3 Pond Management

This module is further categorized into various pond operations as explained below:

- Stocking: captures information related to seed species/variety, average size of shrimp and total stock weight.
- Feed Management: captures quantity of feed provided to shrimp and amount of feed consumed by shrimp.
- Water Test: captures pH, salinity, temperature of water used in pond.
- Harvesting: captures count-wise quantity of shrimp harvested.

4.1.4 Pond Report

It displays all the pond operations performed by farmers till date in a tabular form (Figure 3). Graphical representation of data was provided enabling the farmers to analyze their pond data.

Figure 3. Pond Report in Tabular Format

Besides the above functionality farmers were given weather forecast information in a graphical format. Also they had the provision of recording their queries and sending to aquaculture experts.

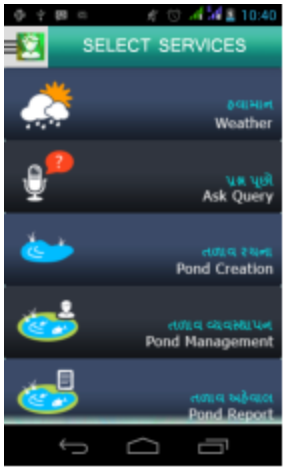

Figure 4. First Prototype Main Menu Screen

Figure 5. Farm Visit

Figure 6. Group Discussion with Domain Experts

4.2 Domain Experts Participation

Once our prototype app was ready, we conducted farm visit (Figure 5) and group discussions to analyze each flow again (Figure 6). Participants in these group discussion included domain experts from MPEDA and design/technical team from TCS Innovation labs-Mumbai. We demonstrated our prototype application to domain experts. Detail analysis of each flow was done and based on experts inputs the below modifications were made:

4.2.1 Adding Sampling Information

Previously we were capturing only stocking data in Pond Management, but experts suggested to provide provision for periodic assessment of survival of seeds stocked and growth of the shrimp. Hence new functionality to capture Sampling information was introduced. From this data farmer can estimate how much of the total feed given in a day is consumed (i.e., daily food consumed) by the shrimp and hence estimate the biomass, total population (total number of shrimp in the pond) and the survival rate.

4.2.2 Modifying Harvest Flow

Experts suggested to capture total quantity of harvest data instead of count-wise quantity data. As in general average count and total count only is estimated at the farm site. The detailed counts and quantity is available to the farmer later only.

4.2.3 Adding Growth Chart

It generates a graph to indicate the shrimp size on the particular date of sampling in comparison with the standard growth chart (Figure 7). This helped them understand, deviations if any, from the recommended growth chart and accordingly they can adjust their feed or provide additional nutrients or probiotic.

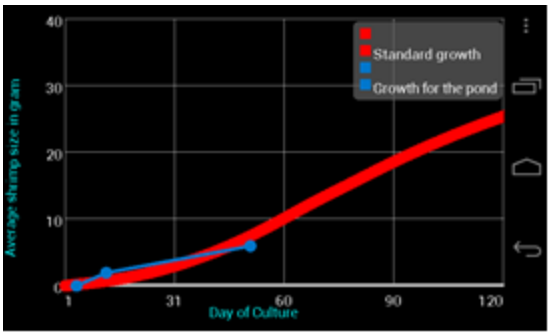

Figure 7. Growth Chart

4.2.4 Best Practices

Experts suggested to provide guidelines to farmer about do's and don'ts while practicing aqua farming. These included the management of the water effluents by the way of periodic water exchange, avoiding the banned chemicals, the right mix of the animal and plant proteins as part of the feed. Hence the best practices module was introduced wherein farmer was provided with Aqua farming guidelines in the form of images and video.

4.2.5 Market Prices

Aqua farmer requires market prices on timely basis; it helps them to decide on their harvest timing. Thus a utility was developed to show them market price in a form of marquee text as soon as they start the application.

4.2.6 Web Console

For progressive farmer who possess larger farms, it was suggested to provide web console. Hence laborers who work under these farmers can capture pond data using mobile application and the farmer can view the consolidated data in the web console using their credentials (Figure 8).

Figure 8. Web Console showing pond summary

4.3 Prototype launch and Farmer Training

Considering the above changes a revised version of the application was developed and launched. Farmer training program was arranged, where farmers from different age groups (22 years to

45years) and different educational background (10th standard to graduates) were invited. During this training few new farmers were included too, who were not aware of the benefits of such applications. But as soon as the live demonstration of app was given, they started co-relating the application flow with the farm register which they used to capture the pond data in their farm. At the end of the training we took note of the difficulties cited and their suggestions for next version.

4.4 Farmer Feedback

Periodically system data and log analysis was performed at the web server to observe the usage of application. After a period of two months a meeting was arranged to collect farmer's feedback (Figure 9, 10). Farmers were provided with a questionnaire having some of the below questions:

- Do you find the icon used in the App self -explanatory?
- Are you comfortable using the App in local language or in English?
- Are you able to understand the graph used in the application?
- Which features do you like the most in the application

Figure 9. Farmer Feedback form

4.5 Enhancements based on feedback

We also conducted an open interaction walkthrough where they shared their suggestions and experiences. The feedback received from the questionnaire /open forum is consolidated into a list of changes to be implemented to make our application more users friendly. Major observations are in described in below section.

4.5.1 Keep location data same as of previous pond in Pond Creation

Farmers explained that their pond's location remain same for 5-10 years (depending on land lease period). Every season, only pond area and pond number changes. As per their suggestion, whenever they create a new pond, application should fetch their previous pond location data and ask them if they want to continue or change location data. This will save number of actions and data entry time.

4.5.2 Provide Optional Fields in Water Test Flow

In the 'Capture Water Test Parameter' service flow, all data field were marked Mandatory. But based on feedback received from farmers, we realized that small farmers do not perform all the water test activities at the same time. Hence, we modified the flow to let them choose from the fields and fill the values. This brought the flexibility in entering the data.

4.5.3 Changes in terminology used in application

In the application the terminology previously used was pure Gujarati words which farmers were unable to understand and suggested to replace with words which they commonly use in their day to day life. Some of these changes are illustrated in Table 1.

Table 1. Terminology used in application

Words	Text Used Earlier	Text Suggested by Farmer
Harvesting	કાપણી (kaapni)	લણણી (lanani)
Next	આગામી (aagami)	પછીનું (pachhinu)
Open Well	વાવ (vaav)	ખુલ્લો કુવો (khullo kuwo)

Figure 10. Farmer Feedback Session

5. CHALLENGES AND LEARNING

While designing and developing this application we faced many challenges, a few of them are mentioned below:

5.1 Gathering Domain Knowledge

Being an IT expert it was a difficult task understanding the Aqua farming domain. But after visiting the farms, meeting with farmers, exporters and analyzing the insights provided by our partner MPEDA, we were able to create wireframe, develop a prototype and call for a shorter pilot with three farmers. This periodic feedback approach helped gaining the knowledge and implementing the associated features.

5.2 Gaining the trust of farmers

Initially farmers were hesitant in providing their farm data as they were concerned about data security and privacy. But with

multiple discussion and partner MPEDA's involvement when they got assured that their farm information would be secure and only they would have access to their data and modify it. They were also ensured that no other farmers would be able to see their farm data. Within no time we gained their trust and they started using the application without any concern.

6. BENEFITS

On farm data capture and digitization leads to a paperless office. The process of data capture, aggregation and visualization helps in an immediate feedback to the end user and enables a quicker decision making. This helps in optimizing the feed quantity and maintaining required water salinity in line with weather forecast. The cumulative data reports in text, table or graph farms can be seen anytime, anywhere. Growers and exporter agents can take the print and submit for the export compliance procedure.

Mobile application is in local language. Hence, with little training, farm laborers or the farmers themselves can enter the data.

Going forward, *Growth models* can be integrated. This can lead to the milestone based predictions or alerts such including as disease forecast or the production estimate.

7. RESULT

The services have been rolled out to 2 districts of Southern Gujarat in India. 14 farmers and 4 aqua experts are using the applications in Gujarati and English. 93 ponds are created. Around 841 water test data, 65 sampling data, 444 feed operation and 15 harvest data has been entered into the system using this application.

Farmers are using the weather forecast and have taken action related to water salinity management, when they saw the forecast of the heavy rain in last week of June and July.

8. RECOMMENDATIONS AND FUTURE WORK

The entire iterative process was based on participatory design where the end users participated in sharing their need statement, pain areas and provided periodic feedback. Hence, in such applications targeted for masses, participatory design is a necessity.

We also observed that the participant end user group should represent the correct sample of the mass users. It must include the diversity of the majority of the users such as different age groups, different farm holding, education level, types of mobile phones, etc.

The above recommendations were considered and enhanced version was launched as a part of e-governance initiatives for the marine sector under 'Digital India' program by Ministry of Commerce of Govt. of India [15].

Our next attempt is to scale this solution across India starting with rest of coastal districts of Gujarat, Andhra and Tamilandu. It is a challenging task and also provides good opportunity to bring further design changes to cater to growers across India. During our farmer feedback session many progressive farmers requested to provide iPhone version of the application. Hence we are also planning to design and develop an iPhone app in the coming year.

The service will be rolled out in multiple phases and feedback will be conducted at the end of every phase.

9. CONCLUSION

It's important to continuously monitor the farm culture data – such as dissolved oxygen, feed consumption trend, chemical use, habitat and effluent management and diseases— to assess farm growth, potent risks, expected production and also its environmental impact and sustainability. Responsible producers and other stakeholders need to collect, analyze and share this data.

"mKRISHI® -AQUA" provides an easy tool to do this. It was developed in close interaction with its end users through continuous dialogue. Identification of precise needs, ease of use and field pilots, resulted in a simpler application for data entry, analyze and immediate communication of the results and patterns. The feedback cycles led to identify perceived knowledge gaps and impediments. This improved the service further by addition of sampling and growth features for better planning and management.

10. ACKNOWLEGEMENT

We would like to thank MPEDA chairman Mrs. Leena Nair for her guidance and effort to make this initiative a part of Digital India program. We would also like to thank Mr. Manoj, Mr. Shreejith from MPEDA for sharing their suggestion to make application user friendly. We thank TCS Team Dr. Arun Pande, Dr. Srinivasu Pappula, Mr. Sanjay Kimbahune, Mr. Sujit Shinde, Mr. Rahul Sharma, Mrs. Della Sajan, Mr. Aditya Tiwari and Mr. Siddhesh Nar for their contribution and guidance. Finally we thank all the farmers for using our application and providing their valuable suggestions and feedback.

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