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Expert system for shrimp aquaculture – an ICT aided tool for knowledge management

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ABSTRACT

Shrimp aquaculture is a knowledge intensive and high value farming enterprise in the coastal agro-ecosystem. Due to on-farm and off-farm exigencies, aquaculture production practices are constantly getting improved to deal with the emerging scenarios. The extension personnel need to be educated on Better Management Practices (BMP) for shrimp aquaculture in order to enable them to provide appropriate management advices to the aquafarmers. In the present scenario, mechanism for communication and capacity building of extension personnel is poorly organised. In the present study, an Expert System for Shrimp Aquaculture (ESSHA) has been developed to help the extension personnel with information on shrimp farming technology for knowledge management and onward dissemination to the aquafarmers. The system was designed and developed using Microsoft Visual Basic as front-end and Microsoft Access as back-end software. The findings indicated that the knowledge level of the public and private extension personnel was enhanced by 60.02 and 27.72% respectively after using the expert system. ESSHA as a knowledge management tool can be employed by the research and development agencies for capacity building of the extension personnel and other end users including aquafarmers.

Keywords**:** Aquaculture extension, Expert system, Knowledge management, Perception, Shrimp aquaculture

Introduction

Fisheries and aquaculture are sources of livelihood to over 14 million people in India and also important constituents of foreign exchange earnings, contributing about 1% of the national GDP and 4.5% of the agriculture GDP of the country (DAHDF, 2012). Globally, India ranks second in aquaculture production (FAO, 2012). Aquaculture in brackishwater has played an important role in productive utilisation of coastal waste lands and significant increase in seafood export earnings (Ayyappan and Diwan, 2007). Shrimp aquaculture being an intensive and high investment farming enterprise, requires constant communication of information between the research, extension and farmer subsystems to bring out practical solutions to deal with emerging production and farm management related issues. Effective Research-Extension-Farmer (REF) linkage ensures that farming innovations are more appropriate and productive to enhance the overall production and ensure the livelihoods of farmers. However, such an REF linkage is non-existent in Indian fisheries sector and it is unlikely that a mechanism to facilitate such a linkage will be put in place in the near future. In the absence of a vibrant REF linkage for two way communication and capacity building, it is important to look for an alternative strategy. In the era of information revolution, Information Communication Technology (ICT) aided tools could offer a solution to address this gap and expert system is one such important tool.

An expert system is a computer program that uses knowledge base to solve problems, which emulates the decision-making ability of a human expert. Expert systems are like human consultant which give advices and explain the information (Turban and Aronson, 2001). Expert systems have been extensively developed in agriculture and allied disciplines (Edrees *et al*., 2003; Mansingh *et al*., 2007; Zetian *et al*., 2005; Thammi Raju *et al*., 2006; Mohamad *et al*., 2008; Sivakami and Karthikeyan, 2009) and found to be effective tools for knowledge transfer and capacity development. In fisheries and aquaculture too, expert systems were developed for fish identification (Chen *et al*., 2005; Guisande *et al*., 2010), fisheries resource management (Bender *et al*.,1992; Mackinson, 2000; Cheung *et al*., 2005; Azadivar *et al*., 2009; Sadly *et al*., 2009), aquaculture management (Lee *et al*., 2000; Wang *et al*., 2002; Halide *et al*., 2009; Xu *et al*., 2009), disease diagnosis and management (Brock *et al*., 2002; Li *et al*., 2002; Gutierrez-Estrada *et al*., 2005; Wang *et al*., 2006; Yuan *et al*., 2008; Nan *et al*., 2009; Wang and Li., 2009; Xing *et al*., 2009), fisheries information management (Freeman and Hanfmann, 1990) and fish product marketing (Liangen and Xiaoyong, 2000; Xiaoshuan, 2004; Xiaoshuan *et al*., 2005) and were reported to be effective. Expert system has the potential to be used in aquaculture as a knowledge management tool for effective and rapid transfer of technology to field level (Bahal *et al*., 2006). In this context, the present study was undertaken to develop an expert system on shrimp farming and shrimp disease diagnosis with reference to tiger shrimp (*Penaeus monodon*) and to evaluate the effectiveness of the developed expert system as a tool for knowledge management.

Materials and methods

Development of Expert System for Shrimp Aquaculture (ESSHA)

Development of Expert System for Shrimp Aquaculture (ESSHA) involved five steps *viz.*, problem selection, knowledge acquisition, knowledge representation, system design and development as well as system validation (Zetian *et al*., 2005).

The Better Management Practices (BMPs) for shrimp farming which covers entire cycle of shrimp aquaculture production with reference to tiger shrimp (*Penaeus monodon*) was selected as the subject matter for development of the expert system.The content required for the development of ESSHA was acquired from published literature on the subject and in-depth discussions with the subject matter specialists. Experts from the Central Institute of Brackishwater Aquaculture (CIBA), the nodal research institution for shrimp aquaculture in India were also consulted for sourcing information.

A rule-based knowledge representation was adopted for development of ESSHA as recommended for production systems (Plant and Stone, 1991; Gonzalez-Andujar *et al*., 1993). Each rule had two sections - a symptom pattern section and an action section, in the form of 'IF symptom pattern A, THEN the disease B', for *e.g.*, IF shrimps often observed near the surface of the water, AND white spots or patches under the carapace THEN the shrimp suffered White Spot Disease. A hierarchical logical and reasoning procedure is inbuilt for identification of shrimp diseases (Fig. 1) wherein, the knowledge is organised in a decision tree with nodes at different levels. The most general level is shrimp behaviour, while at the lowest level, shrimp disease is represented.

The knowledge base contains information under ten modules *viz.*, site selection, pond design and

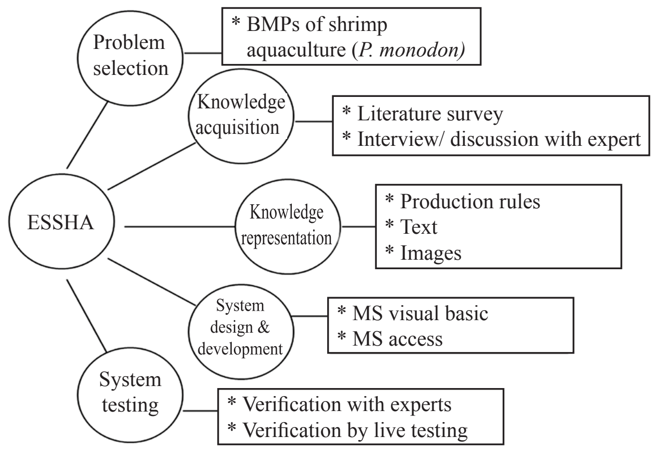

Fig. 1. Hierarchial classification tree for shrimp disease diagnosis in ESSHA

construction, pond preparation, seed selection and stocking, feed management, water quality management, health management (10 major shrimp diseases), waste water management, harvest and post-harvest management and shrimp farm biosecurity. A combination of text with pictures has been used in the present study to improve the efficiency of the expert system.

ESSHA was developed using Microsoft Visual Basic 6.0 (VB 6.0) as front end programming application and Microsoft Access (MS Access) as back end database as suggested by Lewis and Bardon (1998), Thammi Raju *et al*. (2006), Kumar *et al*. (2008) and Balasubramani and Swathi Lekshmi (2008).

Before testing ESSHA in field level, the operation of ESSHA system was initially tested by the subject matter specialists from CIBA for correctness. Further, a group of 15 aquaculture extension personnel and 15 outgoing fisheries graduates were selected for validating ESSHA. Based on the results of the system evaluation process, necessary updation of the design and implementation of ESSHA was done.

Evaluation of ESSHA as a knowledge management tool

ESSHA was evaluated for its effectiveness by means of a well constructed teacher-made knowledge test to assess the knowledge gained by the respondents on exposure to ESSHA. A teacher-made knowledge test was prepared on BMP for shrimp farming in consultation with the subject matter specialists from the CIBA. The knowledge test comprised of 25 items covering the different aspects of the developed expert system.

A sample of 120 extension personnel 60 each drawn randomly from the public funded extension personnel from the Department of Fisheries and MPEDA and private extension personnel representing input companies and independent consultants. The respondents belonged to Tamil Nadu and Andhra Pradesh. The knowledge test was administered to the respondents before exposure to ESSHA to assess their initial knowledge level on the BMPs for shrimp farming. On completion of the pre-exposure knowledge test, orientation training on ESSHA was conducted followed by allowing the respondents to individually operate ESSHA on their own. Sufficient time was allowed to view and operate ESSHA. After viewing ESSHA, the respondents were asked to undergo the post-exposure knowledge test.

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Responses before and after exposure to ESSHA were analysed. If the response given by the extension personnel matched the information provided by the ESSHA, a score of one was given, while zero was given if it mismatched. All the items in the knowledge test before and after using ESSHA were calculated. The percentage of enhancement in knowledge level was calculated using the following formula:

$$\text{Percentage of enhancement} = \frac{\text{Knowledge gain}}{\text{Pre-exposure test score}} \times 100$$

where, knowledge gain is the difference between the average score obtained before and after using ESSHA. A paired 't'statistic was applied to find out whether there existed a significant difference in knowledge level of the extension personnel before and after exposure to the expert systems.

Results and discussion

ESSHA gives advice on the management of BMPs in shrimp aquaculture. The architecture of the system is shown in Fig. 2. ESSHA was developed using Visual Basic to operate under the Microsoft Windows environment. It was developed as software package in the form of '.exe' file through 'Pack and Go Wizard' of Visual Basic. For a user to use ESSHA in his computer, it needs to be installed in the computer. The system was designed to be delivered on a PC with at least a Pentium processor, at least Windows 98 or later version Operating System, a mouse, CD-Rom drive and a hard drive with 30 MB of available memory and at least 128 MB of RAM. The ideal monitor display

Fig. 2. Architecture of ESSHA

for operation of ESSHA was 1024 x 768 pixels.

The Graphical User Interface (GUI) of ESSHA was very simple and user friendly, as the intended users of ESSHA were not supposed to be computer specialists. The user could navigate to home page from any page of the system, and could exit the system at any point of time. All the pages in ESSHA were provided with 'HELP' menu to assist the user on the operation of ESSHA as and when required. All the available features of ESSHA could be accessed from its home page interface. The home page interface of ESSHA consisted of ten buttons for each identified BMP which guided the user to the respective BMP module (Fig. 2). Once clicked, the system displays information on the particular selected module.

The site selection module gives recommendation on how to select an appropriate site for starting shrimp farming activity. The pond design layout and construction module advices on design and construction of shrimp pond.

The pond preparation module provides recommendation on disinfection and preparation of pond for stocking of shrimp seed and suggests the level of organic manure and inorganic fertilizer to be used, based on the information provided by the user on the available carbon, nitrogen and phosphorus content in soil. The seed selection and stocking module deals with seed quality, its transportation and stocking in pond. Feed management module suggests daily feeding regime as per information provided by the user. Further this module deals with feed quality, monitoring of feed intake, feeding frequency, feed size and feeding rate. Water quality management module suggests management of water quality in the shrimp pond including recommendation on quantity of lime to be applied in shrimp culture pond as per user's requirement. Health management module helps user to identify the major shrimp diseases by selecting the appropriate symptom(s) from the list of symptoms. The module also provides cause for the identified disorder, recommendation for its treatment and image of the identified disorder. The waste water management module deals with the management strategies for pond discharge and harvest. Post-harvest module deals with the management strategies for shrimp harvest and post-harvest. Bio-security module suggests the vectors carrying disease into the shrimp farm, their risk and management measures.

It was observed that the developed expert system, ESSHA was effective in improving the knowledge level of the extension personnel. Mean pre and post-exposure knowledge test scores and percentage of enhancement in knowledge level of the respondents are furnished in the Table 1. The results showed that significant difference existed in the knowledge level of extension personnel before and after exposure to ESSHA ($p \leq 0.01$). This indicated that the ESSHA was effective in improving the knowledge on shrimp aquaculture BMPs. The mean percentage enhancement in the knowledge level after exposure to ESSHA was highest among the public extension personnel (60.02%) than the private extension personnel (27.72%). Most of the respondents had a minimum knowledge on the BMPs of shrimp farming (15.13) before using ESSHA. However, after exposure to ESSHA, the respondents improved knowledge score to 24.22. The private extension personnel had pre-exposure score of 19.12 which improved to 24.42 after using the ESSHA. Studies by Rafea and Shallan (1996), Helen and Kaleel (2009) and Sivakami and Karthikeyan (2009) who have studied the application of expert systems for knowledge transfer among the extension personnel in agriculture and animal husbandry reported similar findings that exposure to expert systems enhanced the knowledge level of the extension workers. The reason for the enhancement in the knowledge level of the respondents could be attributed to the effective treatment and presentation of the information and the involvement of the respondents both physically and mentally.

The findings of the study revealed that expert system is an effective tool for knowledge dissemination and could be used as a tool for knowledge management and dissemination in shrimp aquaculture. The developed expert system was found to enhance the knowledge level of extension personnel significantly. The system has been presently developed in english language only with the objective to assist the extension personnel; however, the technology could be adapted to develop such systems in local languages so that it could be helpful to farmers too. Further, the system has been designed as stand-alone and PC based, which can be extended in future as web-based expert system that would make the system accessible to everyone with a computer and internet connection.

In the absence of an adequate research-extension linkage and shortage of manpower, orientation and budget with public funded fisheries extension departments, this expert system could be used as a tool to bridge the gaps. It is also to be noted that being a mass contact tool, it will certainly enhance the knowledge of the end-user, however, it may not substitute the subject matter specialists *per se.* The research institutions could make use of the expert system as a tool for capacity building of the extension personnel and dissemination of information to the end users. Expert systems need to be developed on other aquacultured species, which may be hosted as a part of a knowledge portal on aquaculture for wider know-how transfer and management which can altogether enhance the aquaculture production and its sustainability.

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Table 1. Effectiveness of the expert system in improving the knowledge level of respondents

Study group	Mean score			Mean % of enhancement	Significance ('t' value)
	Pre-exposure	Post-exposure	Knowledge gain		
Public extension personnel (n = 60)	15.13	24.22	9.09	60.02	20.42**
Private extension personnel (n = 60)	19.12	24.42	5.30	27.72	25.04**

** *Significant at 1% level ($p \leq 0.01$)*

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