Developing a Risk Management DSS for Supporting Sustainable Vietnamese Catfish Farming

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Abstract
The development of a prototype DSS, named Fish@Risk, for risk management in Vietnamese catfish farming is detailed in this paper. The prototype enables aquaculture farmers to manage risks in catfish farming systematically and efficiently. It facilitates risk analysis, risk evaluation and prioritization, and selection of the most efficient risk management strategies for mitigating risks. Fish@Risk has three main components, a database component, a model component, and a graphical user interface. The database component allows users to manage data on risk and risk management strategies. The model component accommodates formulas and predetermined probability distribution functions (PDF) of risk consequences and likelihoods that facilitates risk analysis. For ease of use and accessibility reasons, the DSS was developed using Visual Basic for Application on the Microsoft Excel platform. We demonstrate the usefulness of Fish@Risk by illustrating its use in a commonly encountered scenario in catfish farming. Fish@Risk provides four main outputs: (1) a table of Levels of Risk (LOR), (2) a matrix matching risks and risk management strategies (RMS) by RMS efficacy, (3) a matrix matching risks and risk management strategies by RMS net benefit, and (4) a two dimensional graph mapping risks with risk likelihood on the vertical axis and with risk consequence on the horizontal axis.

1. Introduction
Vietnamese catfish farming is a highly profitable but risky business. The fast growing catfish industry is troubled by many problems, challenges and uncertainties such as: environmental and edaphic regulations, export-import restrictions, increasing production costs, sustainability, oversupply and other global and regional socio-economical problems. All these uncertainties are potentially detrimental risks to the catfish industry and they need to be managed in a systematic way for the sustainable development of the industry. Vietnamese catfish farmers are dealing with risks on a trial-and-error or ad hoc basis. A sound and solid risk management framework and a DSS tool that facilitates the implementation of the framework is a much needed tool for risk management in Vietnamese catfish farming.

We describe the development of Fish@Risk, a DSS for risk management in catfish farming in the Mekong Delta, Vietnam. Fish@Risk is designed to facilitate risk management activities including risk data handling, risk analyzing, and risk management selection.

The remainder of the paper is organized as follows. Section 2 provides a brief introduction to the Vietnamese catfish industry and related work in risk management framework and aquacultural DSS areas. Section 3 describes the development of Fish@Risk. An illustration of the use of the DSS in a typical scenario is presented in section 4. Section 5 discusses the implication issues related to the development of the DSS and its use in practice. Finally, Section 6 concludes the paper and suggests future research interests.
2. Background and Related Work

2.1. Vietnamese catfish farming

Raising catfish in the Mekong Delta has a history of hundreds of years. Catfish has mostly been raised in ponds at the household level and mainly for household consumption. Only a small amount of catfish was exported to outside markets such as Hong Kong, Singapore, and Taiwan before 1975. Since the mid-1980s, catfish began to be exported again, initially in the form of fillets to Australia. Export markets later expanded to Hong Kong and Singapore in the early 1990s and to North America and the European Union (EU) in the mid 1990s. The expansion of markets and demand led to a phenomenal development in catfish farming [20]. Before 2002, just before the “catfish war” with the USA, most of the catfish were produced in cages, ponds, and enclosures and at a relatively small scale, with an average productivity of 32 tons/cage and 12.96 tons/ha of pond [20]. Before 2003, the main market for the Vietnamese catfish export was the USA. The market share of the Vietnamese catfish import in the US market grew from 0.14% in 1996 to 17.34% in 2002. This strongly shocked the US catfish industry and led to the anti-dumping trial of the Vietnamese catfish in the US market in 2003 [20, 17].

After 2003, the catfish industry went through a period of difficulty, as export to the US market dropped by almost 50% due to higher anti-dumping tax. This seriously affected the fragile local economy and livelihood of catfish farmers and other stakeholders. There was an increase in rural unemployment as many fish producers could not sell their products. They ran into financial losses, which in turn led to bankruptcy, as catfish farming was their main occupation [20]. However, the industry recovered quickly by the end of 2004, due to expansion of international markets to other regions in the world, especially, the European Union and other ASEAN countries. By the end of 2005, the EU became the largest export market for the Vietnamese catfish industry, accounting for 37.6% of total Vietnamese catfish export and equivalent to 28,219 tons. The second important market was the ASEAN market with 15.6% of total export value and equivalent to 22,435 tons, followed by the USA market with 11.7% of total export and equivalent to 21,229 tons. The quick adaptation to the challenges in the world market led to a continuing increase in catfish production after 2003 [20]. The areas for catfish farming grew up to 5,600 hectares, a ten-fold increase from 2000. Catfish output has increased from 264,436 tons in 2004 to 825,000 tons in 2006, and reached 1.5 million tons with an export value of 1.2 billion of dollars for the year 2007 [15, 21]. Due to the decreasing prices in the last three years, recent estimation of the catfish production and export decreased by about 30-40% of those in the year 2007. For the year 2011, the total output of live catfish production is estimated at 800 thousand tons and the export value can only reach up to USD 700 million [18, 9].

2.2. Related work

Although decision support systems have been extensively developed for and applied to many fields of the economy, DSSs for aquaculture, especially for risk management in aquaculture, have been used to a far lesser extent. For example, DSSs for risk management can be developed and applied to construction project management [6], flood risk management [5], and even in e-commerce development [14], mentioned just to a few.

Like most DSSs, an aquacultural DSS has three main components, a database component, a model component, and a user interface. The database component is used to manage all the input and output data of the DSS. The data can be internal, external, or a hybrid system [7]. The model sub-system is designed to perform the calculation or computational tasks of the DSS. The graphical user interface is the means of interaction between the user and the system. Depending on the objectives of the DSS, the database system, the model system, and the user interface can be simple or very complex.

In marine fisheries, a DSS was developed for fisheries management in the North-eastern Sea of the US [2]. The DSS was developed using operations research and a systems science approach. The DSS combined fishery models and operation research methods to provide information for the design of fishery management policies. Fishery models were used to consider multiple stocks and fisheries simultaneously while balancing the catch among targeted and protected fish. The core component of the DSS applies operation research techniques of simulation and optimization to determine the optimal inter-annual and intra-annual fishery plans in terms of fishing efforts in each of sub-area and time period. The DSS was linked to a GIS for graphical representation and spatial analysis in terms of stock status in a given period.

Regarding pond and cage management, DSSs can be used for making decisions for aquaculture investments (including site classification, site
selection, calculating holding capacity, and economic appraisal [10]. Bourke et al. [4] developed a DSS for Aquaculture Research and Management to facilitate the collection, manipulation, and analysis of physiochemical and biological data generated in aquaculture research. The system allows researchers to measure the impact of environmental variables on (1) production failure, (2) increase in biomass, and (3) survival rate of seeds. The system also allows researchers to simulate the system using different environmental variables inputs prior to carrying actual experiments.

POND [3] is a sophisticated DSS developed for aquacultural management in the US. Its architecture includes a series of mini-databases, a number of knowledge-based components (derived from experts), models of pond eco-system, and various support features. POND includes the following main services: (1) basic time flow synchronization of system components, (2) data storage, collection, display, and output, (3) linear programming tools for optimization, and (4) parameter estimation methods to determine the best fit model parameters. The software was developed using an object-oriented approach.

Our review of the literature conducted on aquacultural DSSs did not reveal any substantial previous work on any form of DSS for supporting risk management in aquaculture. Although aquacultural DSSs are developed for specific purposes and hence have different inputs, outputs and modeling functions, the general structure of a DSS consists of three main components, namely: a database component, a model component and a dialog component. Our proposed DSS follows that general structure.

2.3. Risk management framework

The implementation of Fish@Risk is based on a risk management framework developed in a previous study [11]. In order to provide an understanding of the foundation for developing Fish@Risk and its operation, this section briefly describes a risk management framework previously developed for Vietnamese catfish farming.

The approach used for developing the risk management framework is to combine the catfish business process model together with the risk management process. We next describe the Vietnamese catfish farming business process and the general risk management process suggested by the Australia Standard and New Zealand Standard for Risk Management (AS/NZS 4360:2004) [1] before presenting our risk management framework.

2.3.1 Catfish farming process, associated risks and risk management strategies

The general catfish farming process for the growing-out stage can be divided into 5 main steps or sequential activities, namely: (1) pond location selection and pond preparation, (2) fingerling (small fish) selection and stocking, (3) growing out, (4) harvesting, and (5) marketing [8].

The catfish farming business process starts with the sub-process of pond location selection and pond preparation. The second step is to select the fingerlings for the crop and stock them in ponds for rearing. The third step is the growing-out step and is the most important sub-process in catfish farming. It takes a period of 6-7 months to complete. There are many activities that catfish farmers have to take care of simultaneously in this step of the production. When the fish reach maturity size, the next sub-process in the general process is harvesting. After that, the final sub-process is marketing.

In a previous study [13], it was found that throughout the catfish business process, there are around 40 sources of risks involved in the catfish production cycle. The growing-out sub-process has most of the risks, accounting for 22 of the 40 sources of risk. The fingerling selection and stocking sub-process has the second largest number of risks with 7 risks. The marketing and cost management sub-process takes third place in terms of the number of risks. There are 5 sources of risk involved in this sub-process. The number of risks in pond location selection and preparation is 4 and the harvesting sub-process had the least number of sources of risks with 2.

In the same previous study, 50 risk management strategies (RMSs) were found to be available for mitigating risks in catfish farming and they can be classified into 6 categories: (1) farming techniques (8 RMSs), (2) economic and financial measures (13 RMSs), (3) education and extension (4 RMSs), (4) input control (6 RMSs), (5) diversification (4 RMSs), and (6) pond site and investment (7 RMSs) [13].

2.3.2. Risk management process

A risk management process consists of a series of steps that, when undertaken in sequence, enables continuous improvement in decision making [19]. According to the AS/NZS 4360:2004, the risk management process consists of 7 steps, which are closely related to each other, namely: (1) communicate and consult, (2) establish the context, (3) identify the risk, (4) analyse the risk, (5) evaluate the risk, (6) treat the risk and (7) monitor and review.
2.3.3. Proposed risk management framework

After having developed the business process for Vietnamese catfish farming, we applied the general risk management process suggested by AS/NZS 4360:2004 to each of the catfish farming production sub-processes to obtain the risk management framework for catfish farming. At each production sub-process, associated risks are assessed (including identifying, evaluating, and analyzing risks) and the corresponding risk mitigating strategies are developed.

Based on the developed risk management framework, we implemented a prototype DSS as a tool for facilitating risk management in Vietnamese catfish farming. The development of the DSS is discussed in the next section.

3. Developing the DSS

The DSS, Fish@Risk, is designed in such a way so as to proactively facilitate the identification of potentially highly probable risks in Vietnamese catfish farming and suggest appropriate risk mitigating strategies. The tool is not designed to be used reactively. The intention is not to react to a problem situation by finding probable causes and remedies but rather to take a proactive approach to prevent or minimize the impact of risks on the outcomes of catfish production.

This section describes the development of the DSS and its conceptual architecture. First the approach and the steps used in developing the DSS are explained. Next, the conceptual architecture of the DSS is described. Finally, data collection and analysis activities are explained followed by a flow chart showing how to operate the system.

3.1. Approach Used

The DSS Fish@Risk was developed according to the following 6 steps: (1) DSS conceptualization, (2) data collection and analysis, (3) DSS design, (4) implementation, and (5) testing and evaluation. In addition, stakeholders were consulted as such consultation is an important and necessary activity during all the steps of the development process. This ensured that the DSS is suitable for end-users in terms of functionalities provided and easy-of-use of the system. The process used for developing the DSS is presented in Figure 1.

3.2. Conceptual Design of Fish@Risk

Like most DSSs, Fish@Risk has three main components: a model sub-system, a data sub-system, and a user interface. The main components of Fish@Risk are described in Figure 2, in terms of the general architecture and the relationships between the sub-systems.

3.2.1. Data sub-system

The data sub-system allows the user to manage both input data to and result outputs from the system. The data sub-system is made up of an input database which contains 4 tables for storing the following information: (1) risks in catfish farming, (2) risk management strategies used to mitigate risks in catfish farming, (3) predetermined probability functions of consequences and likelihoods of risks, and (4) costs and benefits of risk management strategies. When using the system, the task of the user is facilitated as all the user needs to do is to choose from data already stored in the system.

The data sub-system also contains an output database which stores the following results: (1) a table of levels of risk, (2) a scatter diagram of sources of risk as a two dimensional graph, (3) a matrix of risks and risk management strategies sorted by RMS efficacy, and (4) a matrix of risks and risk management strategies sorted by RMS net benefit.
3.2.2. Model sub-system

Fish@Risk implements a framework for risk assessment and risk management decision-making. Input data on risk consequences and likelihoods (using a Likert scale) are first converted into continuous values using cumulative probability functions (CDF) of the respective variables. Then the levels of risk are calculated using the formula of risk exposure from AS/NZS 4360:2004 defined as: \[ \text{Level of Risk (LOR)} = \text{Risk Consequence (RC)} \times \text{Risk Likelihood (RL)} \]. The system then ranks and prioritizes the risks according to the level of risk in descending order. Risks with low LOR are considered acceptable risks (ALAAR) and are not considered for further treatment.

Figure 2. DSS Conceptual Architecture

The model system also allows costs and benefits analysis for selected risk management strategies appropriate for the selected sources of risk. The results of costs and benefits analysis are displayed on the screen or can be printed out for future reference. Fish@Risk was implemented using Visual Basic for Application (VBA) on the Excel platform to take advantage of Excel’s tabling and graphing facilities and the numerous built-in statistical functions. In addition, Excel is commonly available software and requires the most basic computer skills to use.

3.2.3. User interface

When using the Fish@Risk system, the user interacts with the DSS via a user-friendly graphical user interface (GUI) written in Excel VBA. Due to the low computer literacy of catfish farmers, the graphical user interface is designed with ease of use in mind. All calculations and analysis procedures are suppressed from the screen and only necessary inputs and outputs are displayed for entering data or evaluating the results respectively. The complete data set and the GUI details of Fish@Risk can be found in Le [11]. For illustration purposes, we present screenshots of the data entry screen, the risk analysis screen and the risk management screen for selecting risk management strategies by net benefit in sections 3.2.4 and 4.

3.2.4. Using Fish@Risk

Figure 3 presents the process of using Fish@Risk through a complete risk management session. The process consists of a series of actions or activities: managing input data, conducting risk analysis, and selecting optimal risk management strategies. This section explains how Fish@Risk works.

When Fish@Risk is started, it is ready to accept input data from the user such as: data on risks, risk management strategies, and costs and benefits of various risk management strategies (box 1). Input data are saved in relevant databases (implemented as Excel spreadsheets). Lists of identified risks and risk management strategies are then displayed to the user. The user can add, modify, or remove risks and risk management items during this step of the process.

Figure 4 presents one of the data entry screen of the DSS, “Risk data”. By selecting the appropriate tab, the system will allow the user to enter or modify input data on risk, risk management strategy efficiency, and costs and benefits of risk management strategies.

In the risk input data screen (refer to Figure 4), the user enters his/her perceptions on risk consequence and likelihood for every source of risk included in the list using combo box. The combo box provides the list of five choices (from 1 to 5). User simply clicks on the desired level to reflect his/her perception of risk consequence and likelihood.

Once input data on risks and risk management strategies are provided to the system, users are ready to conduct a risk analysis session (box 2). At this step, the system will automatically calculate the levels of risk of all sources of risks entered into the system using predetermined probability distribution functions (PDF) and predetermined formulas. The result of this step is a table containing all the sources of risks and their calculated levels of risk. Fish@Risk ranks the risks according to their importance with higher level risks assigned higher ranks i.e. smaller rank number (box 3). In this step, the system allows the user to prioritize the risks that need to be treated by their corresponding ranks.
After having calculated the table of levels of risks, the user can decide which risks require treatment and which risks do not need further attention based on comparisons between the levels of risk and threshold values of ALAAR (box 4). Once, the user decides on which risks require treatment, the system will take him/her to the risk management step (box 5).

At this stage, the system will perform risk management strategy prioritization according to different criteria. The user can select risk management strategies by efficacy (box 6a) or by net benefit (benefit minus cost) of applying a risk management strategy (box 6b). After reviewing the output results, the user can then make his/her decision on choosing specific risk management strategies for his/her catfish farming business (box 7).

### 3.4. Data Collection and Analysis

Two types of data are used for the operation of the DSS. The first type is data on the perceptions of risk and risk management, which is directly entered into the system.
by the user. This type of data includes data on risk consequence, risk likelihood, risk management strategy efficacy, and costs and benefits of the risk management strategy considered. Users enter the data into the system by selecting the appropriate values in the provided combo and pop-up boxes on the data entry screen (refer to Figure 4). For example, to enter risk input data into the system, the user simply selects the desired value among the five values provided by the combo box for risk consequence and the likelihood for each source of risk. The entering of input data on risk management strategy efficacy and cost and benefit can be done similarly. There is no default parameter in the system except predetermined probability functions that are locked to prevent accidental change by the user.

The second type of data is the predetermined probability distribution functions estimated using primary data collected from a fresh survey on risk perceptions in Vietnamese catfish farming [12, 13]. The @Risk V5.0 simulation software developed by Palisade is used to estimate probability functions for risk consequences and risk likelihoods. Predetermined probability functions are then incorporated into the DSS for risk analysis functionalities.

Input data on risk and risk management are processed by the DSS to calculate the levels of risk. Based on the calculated levels, the DSS ranks, prioritizes, and evaluates the risks. Combined with the risk management input data; the system suggests optimal risk management strategies available for treating the risk according to the efficacy or net benefit of the relevant risk management strategies.

4. Using Fish@Risk

This section presents an example of using Fish@Risk for managing risks in Vietnamese catfish farming. As an example, we assume a typical catfish farmer who is conducting a risk management process for his/her farm.

Using the data collected from a survey of 261 catfish farmers on the perceptions of risks and risk management in catfish farming, we identified the characteristics for a typical catfish farmer in the Mekong Delta, Vietnam. A typical Vietnamese catfish farmer is aged around 40, with high school education, having less than five years of catfish farming experience, and growing catfish on an area of between 5,000 and 10,000 m². There are 40 sources of risk and 50 risk management strategies that have been identified in Vietnamese catfish farming [12, 13]. Although it has been shown that there are multi-dimensional relationships among risk factors and risk management strategies [13], we found that it is too difficult or complicated to measure the impacts of a risk factor or a risk management strategy on other risks or risk management strategies. Therefore, in our study, we assume these risks and risk management strategies are independent and can be treated and applied separately. Given that assumption, without the risk management framework and/or the DSS, it is difficult for a catfish farmer (especially inexperienced ones) to decide which risks are the most important and hence must be treated. In such situations, risk management would be approached in a trial-and-error or naive way based on subjective judgment without considering efficiencies and net benefits of various potential risk management strategies.

With the support of Fish@Risk and the input data on perceptions of risk and risk management strategies, catfish farmers can conduct a risk management process more systematically and efficiently. Based on the data on the perceptions of risks and risk management strategies from a typical catfish farmer, the top ten (out of 40) most important sources of risk and their ranks by the levels of risk are presented in Figure 5.

Using the table of the levels of risks provided by Fish@Risk, a catfish farmer can easily identify which risks are the most important ones that need to be treated in their catfish farming activities. After deciding which risks need to be treated, the user can continue to use Fish@Risk for evaluating which risk management strategies can be used for mitigating the risks according to efficacy or on cost-benefit grounds.

To illustrate how a typical catfish farmer can use Fish@Risk to select the most appropriate risk management strategy, we developed a scenario named “High Fingerling Mortality Rates” which is described next.

Scenario: High Fingerling Mortality Rates

High fingerling mortality rates are among the top-rated sources of risk in catfish farming. The level of mortality rises up to 30% during the early stages of the production cycle and is less than 10% in the later months [16]. Various reasons can account for high fingerling mortality rates, some of which are: high stocking rate of fingerlings, disease infection, and low fingerling quality. High fingerling mortality rates decrease the catfish yield at the harvest time, so it is important to control and reduce the mortality rates.

Without Fish@Risk, catfish farmers usually deal with this situation by continuing to stock new
fingerlings into the pond to make up for the dead fingerlings. In so doing, farmers incur costs and may cause disease transfer to the new fingerlings in the pond. This in turn will increase disease infection to the fish in the entire pond and cause the fish to continue to die. The cycle will repeat itself if the farmer continues to re-stock fingerlings again to make up for the loss. With the average stocking density of 48 fingerlings/m² and the aforementioned fingerling mortality rates, the cost incurred to replace lost fingerlings can be very high; up to VND 19.2 million per 1000 m² of pond surface (48*0.4*1000 VND/fingerling*1000 m²).

With the availability of Fish@Risk, catfish farmers can compare and choose the best strategies for dealing with the risk and avoid such repetitive mistakes to mitigate the risk of high mortality. The benefits of using the DSS in such a situation are explained next.

Fish@Risk suggests four risk management strategies to mitigate the risk of high fingerling mortality rates, namely: "Prevent disease infection by regular checking and observation of pond (RMS#21)", "Well manage water environment in pond (RMS#20)", "Strictly follow government regulations and technical guides (RMS#12)", and "Reduce density of fingerling stocking (RMS#13)". Applying any of these risk management strategies will incur costs as well as benefits. Figure 6 depicts the costs and benefits of these risk management strategies. Based on the net benefit ranking, Fish@Risk lists the risk management strategies available for the specific source of risk in descending order of net benefit. Given the ranked risk management strategies, the catfish farmer can now select the most economically efficient strategy (or the one that he/she is most comfortable with).

In our example, among the four potential risk management strategy candidates for mitigating the risk of high fingerling mortality rate, "Reduce density of fingerling stocking" is the most efficient economically. According to the data collected from the survey [11] on costs and benefits of applying risk management in Vietnamese catfish farming, the optimal stocking density ranges from 20 to 25 fingerlings/m², a reduction of 50% of the current stocking density. By doing so, catfish farmers can reduce the loss of fingerlings due to disease infection and reduce the cost of fingerlings by 50% (saving VND 24 million/1000 m²).

The other three risk management strategies shown in Figure 6 relate to pond management. Assume that the farm owner can hire a technical laborer to take care of the farm. The cost of hiring a technical laborer for the whole production cycle is VND 18 million (VND 3 million/month * 6 months). The average cost for applying one of those three risk management strategies is VND 6 million. Thus, the benefits of these strategies far more exceed the costs. According to opinions gathered from a survey on the...
costs and benefits of risk management strategies in Vietnamese catfish farming [11], hiring a technical laborer to take care of the farm can reduce the cost of farm management by 30%; this is equivalent to VND 18 million. The net benefit of applying one of these risk management strategies is about VND 12 million. In comparison to the traditional approach, applying risk management strategies suggested by Fish@Risk are obviously more economically efficient.

5. Discussion

Through the scenario, the benefit of using Fish@Risk is obvious. Firstly, catfish farmers can learn more about a range of available risk management strategies rather just the one(s) he/she would normally use in the absence of Fish@Risk. Secondly, when using Fish@Risk, catfish farmers can choose a preferred strategy from a range of suggested risk management strategies according to efficacy or net benefit of applying the risk mitigating measures. In our example, the risk management strategy “reducing the fingerling stocking density” showed to be the most promising strategy.

In addition, comparing the results of risk management for the cases of using Fish@Risk against not using it, the net benefits of all strategies suggested by the DSS are higher than the benefits of not using the DSS. Specifically, the net benefit of applying the strategies “Reduce density of fingerling stocking”, “Strictly follow government regulations and technical guides”, “Well manage water environment in pond”, and “Prevent disease infection by regular checking and observation of pond” are VND 24, 12, 12, and 12 millions, respectively while in the case of not using the DSS, the cost incurred is VND 19.2 millions per 1000 m$^2$ of pond area. Using Fish@Risk, leads to significant improvements in the profits of the farm.

It is worth noting that the DSS does not always suggest the same strategies for each user. The strategies vary according to the user’s perception of risks and risk management strategies, the cost and benefit that a specific user may incur and gain when applying the risk management measures, etc. The most efficient strategy may also vary by location, season, and farming system. In other words, although the DSS works the same way for every user, the suggested strategies might be different for different users depending on individual perceptions on risks and risk management as well as other business environmental variables.

Although Fish@Risk was intentionally developed for risk management in Vietnamese catfish farming, the tool can be generalized and adapted to other aquacultural sectors such as: shrimp, snakehead fish, tilapia, etc. due to similarities in farming practices and environmental conditions.

In general, catfish farmers have low levels of computer literacy. Thus, training on the use of Fish@Risk will greatly improve the chances of the acceptance and hence increase its usefulness.

Owing to the difficulties in collecting data on costs and benefits for all risk management strategies identified in this study, more research efforts should be done in order to improve the quality of the DSS by providing a more complete and accurate analysis on the net benefits of the risk management strategies. This will make the DSS become more useful in practice.

As the DSS is still under development, the system will be introduced to more potential users (catfish farmers) for further testing and evaluation. In addition,
information on costs and benefits of risk management strategies needs to be updated continuously to account for changes in operating conditions.

6. Conclusion and Future Work

We presented a prototype DSS for risk management and demonstrated its use in a typical situation in Vietnamese catfish farming. As with other DSSs, our prototype, named Fish@Risk, consists of three main components: a database subsystem, a model subsystem, and a user interface. It was developed using Visual Basic for Application on the Microsoft Excel platform.

In terms of using the DSS, a scenario named “High Fingerling Mortality Rates” is used to illustrate the usefulness of Fish@Risk in making decisions on risk management. The scenario analysis results show that catfish farmers can choose the most efficient strategy for risk management in the presence of the DSS; in the absence of the DSS, the decision could be different, i.e., less efficient. Thus, the DSS is a useful tool to catfish farmers for managing risks systematically and efficiently. Besides the direct benefits of the DSS in managing risks in catfish farming, Fish@Risk also provides educational opportunities on risk management. Through its usage, catfish farmers can increase their perceptions of risks and risk management strategies in their catfish farming business, especially for inexperienced catfish farmers.

7. References


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