Entrepreneurial management in aquaponics

Gestión empresarial en acuaponia

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ABSTRACT

The aim of the paper is to present a model of entrepreneurial management for aquaponics activities, to provide a financial planning and analysis tool. This model can also be of assistance to land-based farmers who want to more thoroughly utilize their water resources by developing small-scale aquaponics systems to provide supplementary income. Aquaponics is an innovative approach located within two concepts based multifunctional agriculture and aquaculture. This integrated management of production system can satisfy human food needs and enhance environmental quality by producing crops using environmentally friendly practices that minimize water and nutrient waste discharges to the environment.

Keywords: entrepreneurial, management, aquaponics.

RESUMEN

El objetivo del documento es presentar un modelo de gestión empresarial para actividades acuapónicas, para proporcionar una herramienta de análisis y planificación financiera. Este modelo también puede ser útil para los agricultores terrestres que desean utilizar sus recursos hídricos más a fondo mediante el desarrollo de sistemas acuapónicos a pequeña escala para proporcionar ingresos suplementarios. Aquaponica es un enfoque innovador ubicado en dos conceptos basados en la agricultura multifuncional y la acuicultura. Esta gestión integrada del sistema de producción puede satisfacer las necesidades de alimentos humanos y mejorar la calidad ambiental produciendo cultivos que utilizan prácticas respetuosas con el medio ambiente que minimizan las descargas de desechos de agua y nutrientes al medio ambiente.

Palabras clave: empresarial, gestión, acuaponia.

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Introduction

The objective of this article is to present an entrepreneurial management model of the business plan for aquaponics activities. Policy-makers and development agents are increasingly viewing aquaponics as an integral component of the search for global food security and economic development.

Fisheries and aquaponics can provide a key contribution to food security and poverty alleviation. However, productivity gains in fisheries do not always imply long-term increases in supply. In fact, in wild capture fisheries such gains can ultimately lead to the demise of stocks and reduced production.

Agricultural and livestock activities are considered the biggest consumers of fresh water. Estimations reveal that 85% of the global fresh water consumption is for agriculture and nearly one-third of the total water footprint of agriculture in the world is used for livestock products in Hoekstra (2007) and Mekonnen & Hoekstra (2012). Aquaponics has ancient roots. Aztec cultivated agricultural islands known as chinampas in a system considered by some to be the first form of aquaponics for agricultural use (Diver, 2006), where plants were raised on stationary islands in lake shallows and waste materials dredged from the chinampa canals and surrounding cities were used to manually irrigate the plants in Boutwelluc (2007) and Rogosa (2013). Also, South China, Thailand, and Indonesia who cultivated and farmed rice in paddy fields in combination with fish are cited as examples of early aquaponics systems. Aquaculture development as a whole in the country in combination with production technology, favorable socioeconomic condition and culture environment has already proven successful in terms of increasing productivity, improving profitability and maintaining sustainability by Toufique (2014).

This entrepreneurial management model has been specifically designed for recirculation aquaponics technology. The bio-economic model used can be classified as a non-optimizing budget simulation which uses the growth and FCR (feed conversion rate) and mortality characteristics of a particular species and cash and accrual accounting principles to arrive at performance and profitability measures. Various scenarios (including farm size, species characteristics, harvesting and sales strategies) using different bio-economic inputs (including risk) can be compared and contrasted.

Informational system provides the currently operating aquaponics and the potential of the critical information that will allow the user to model expected cash flows and associated profitability ratios and indices for a particular sized operation farming a particular species of fish.

The entrepreneurial management model has built into its program the ability to enter risk aversion details in order to more adequately depict the learning curve situation that new entrants experience at the beginning, and also build into the ten year production cycle the one in ten year production short fall that normally occurs in farm production due to unforeseen circumstances. As a result the ten year cash flow stream will more adequately depict reality by accounting for risk.

The aquaponics informational system will be able to answer the following critical questions in relation to investment decisions or ongoing financial management of an aquaponics operation:

- How much do I have to invest to attain a certain cash flow stream?
- What will be the return on that investment?
- How much will I have to borrow?
- What is the minimum sale price that can be accepted for the product?
- What is the profit margin?
- How much do I have to increase production by to maintain profit levels if sale prices fluctuate?
- Which harvesting and sales strategy maximizes cash-flow?
- How does fluctuating FCR affect profit?
- How is profit affected by a learning curve?
- What is the current equity position?

Entrepreneurial management model is a financial planning, harvesting and sales management tool, which enables you to plan your investment and determine the size of your commitment before you begin, taking the risk out of your investment. It allows developing and evaluating sustainable aquaponics systems and management practices at both an operational and strategic level.

The system can determine potential profitability of the farm as investment levels and other key performance indicators vary. You can see how critical movements in the key elements of aquaponics can affect the performance of your farm, enabling you to determine the amount of production required in relation to cost. Relevant data such as fish growth and mortality statistics are used to calculate key performance and profitability indicators. Other key data information includes:

- Sale price of fish and vegetables;
- Type of product (live or processed);
- Number of tanks or ponds;
- Stock density;
- Cost of feed;
- Cost of fingerlings;
- Loan size and costs;
- Risk aversion (production assumptions incorporating learning curves);
- Harvesting planning charts;
- Water cost and use.

The software provides easy-to-read accounts, giving you a concise summary of your farm's potential. You can see how critical movements in this key data can affect the performance and profitability of your farm, and demonstrate the feasibility of investing in this exciting new industry.

The software package is delineated into eight major modules, each capable of producing custom-built reports for business plan development and on-going farm financial management and monitoring. The modules include the following areas of Accounts:

- General Report, brings major variables together to allow scenario mapping;
- Species Variables, includes industry best practice growth rates, FCR's and mortality;
- Bio-economic Variables includes all the variables necessary to develop a aquaponics;
- Aquaponics Model Accounts, over a ten year period;
- Internal Rate of Return Analysis;
- Cash Flow Statement, describes opening and closing cash balance;
- Key Financial Ratios, produces accounts to calculate critical financial and profitability ratios;
- Volume Cost Analysis, produces fixed and variable cost accounts for volume planning;
- Harvesting and Sales Strategy produces annual harvesting by product type;
- Charts, produces a series of charts and diagrams.

The Aquaponics Model

Green leafy vegetables with low to medium nutrient requirements are well adapted to aquaponic systems, including lettuce, basil, spinach, chinese cabbage, chives, herbs, and watercress (www.backyardaquaponics.com).

The selection of plant species in aquaponics system is important. Lettuce, herbs, okra and especially leafy greens have low to medium nutritional requirements and are well suitable to aquaponics system. Plants yielding fruits like tomato, bell pepper and cucumber have higher nutritional requirement and perform better in a heavily stocked and well established aquaponics system (Adler, 2000).

A few fish species are adapted to recirculating aquaculture which includes tilapia, trout, perch, arctic char and bass. Most commercial aquaponics system in North America is based on tilapia. Furthermore, tilapia is tolerant of fluctuating water conditions such as pH, temperature, oxygen and dissolved solids by Rakocy (1999). Tilapia is the fish species which is very hardy, can tolerate wide range of environmental parameters, can live with versatile of feed and are fast grow thing fish species by Salam (2012).

The farm model is a ten year account of the farm enterprise calculated from the various bio-economic inputs and the species characteristics. The software assumes that capital is purchased in Year 0 and that the revenue streams begin in year 1, depending on the time taken for final grow-out.

The aquaponics account assumes that once costs (except those costs associated with biomass such as feed, electricity, and product insurance) have been set in year 1, they remain the same throughout the ten year cycle. The aquaponics account therefore presents what is expected from the parameters.

The farm is set up using a particular set of data relating to a particular species. This data includes:

- Cohort growth to final grow-out;
- Mortality;

- FCR;
- Recovery rates from fish.

This module shows the critical variables which affect production and financial performance of your farm. The entrepreneurial management feasibility results include the following performance measurements:

- Internal Rate of Return;
- Benefit Cost Ratio;
- Profit Margin;
- Assets Turnover;
- Return on Total Assets;
- Debt to Equity;
- Leverage Return;
- Return on Equity;
- Contribution to Overheads;
- Cost per Kilo (variable and total);
- Harvesting Strategy and Cashflow1.

Critical Bio-economic Data

Pond water quality is largely defined by temperature, transparency, turbidity, water color, carbon dioxide, pH, alkalinity, hardness, unionized ammonia, nitrite, nitrate, primary productivity, biological oxygen demand and plankton population (Bhatnagar, 2013).

The accepted level of ammonia should be under the range of 0.05 to 0.10 mg/l by Shoko (2014) and above range it is toxic to the cultured fish in Francis-Floyd (2009).

According to Mizanur et al., intensive aquaculture ponds sediments has various fertilizing components such as nitrogen, phosphorous, sulphur etc. which are very useful for growth and production of aquaponic plants by Mizanur (2004). Moreover, water spinach is an efficient plant having clustered roots that can absorb nutrients from the water very efficiently by Kibria (2012).

Aquaponics is an integrated and intensive fish-crop farming system under constant recirculation of water through interconnected devices. It is considered a promising technology, which is highly productive under correct set up and proper management by Lal (2013). First, fish feed is eaten by fish and converted into ammonia (NH_3). Some ammonia ionizes in water to ammonium (NH_4^+). Then, bacteria (Nitrosoma) convert ammonia into nitrite (NO_2^-) and consequently bacteria (Nitrobacter) oxidize nitrite into nitrate (NO_3^-) by Tyson (2011). Finally, the water delivers nutrients and oxygen to promote plant growth. Graber and Junge, found similar yields between hydroponic systems and aquaponics systems. Finally, it is important to establish systems under "smart water" use and to balance nutrient concentrations in water to ensure maximum fish and plant growth by Graber (2009).

Aquaponics is considered a method where water and nutrients are efficiently used and maintained within the system by Liang and Chien (2013). In aquaponics it is possible to reduce daily water loss to 2% of the total water volume of the system. Due to the constant recirculation of water it is also possible to maintain evenly distributed high nutrient concentrations in the water (nitrate) as the small addition of water to compensate the daily loss will not dilute the nutrients by Rakocy (2006).

The critical bio-economic data that interacts with the feasibility results includes data associated with the size of the farm and other crucial assumptions which impact on the feasibility of an aquaponics venture. These data items include:

- Fingerling Price: This price is either taken from commercial reality or calculated from on-farm nursery costs associated with raising a fingerling to a certain size.
- Number of Fingerlings: The number of fingerlings for each stocking (one to twelve times per year) will determine the size of the farm and the revenue generated from product sold.
- Initial Weight of Fish: This will determine what part of the growth table will be used to start the aquaponics operating.
- Feed Price: This is an average price of feed per kilo over the grow-out period of the fish.
- Stocking Density (initial grow): This is described in kg per cubic meter.
- Stocking Density (final grow): This is described in kg per cubic meter.
- Production Sold Live: The proportion of fish production sold live.
- Production sold HOGG: The proportion of fish product sold HOGG (head on, gutted and gilled).
- Production sold fillet: The proportion of fish product sold filleted.

- Price of fish and vegetables: The farm gate sale prices of fish product (live, HOGG and filleted).

Results and Discussions

The Aquaponics Feasibility Results are key profitability ratios and indices that have been calculated from reports and tables attached to the program. These include the following:

- Net Present Value (NPV): This is the discounted value of the ten year cash-flow stream. The NPV will depend on the discount rate (which is entered in the bio-economic variables input table); the value is usually equal to the current rate of interest.

- Internal Rate of Return: The Internal Rate of Return (IRR) is the discount rate that equates the present value of net cash flows with the initial outlay. It is the highest rate of interest an investor could afford to pay, without losing money, if all of the funds to finance the investment were borrowed, and the loan was repaid by application of the cash proceeds as they were earned. Conventional projects involve an initial outlay followed by a series of positive cash flows. In this case, if the IRR is higher than the required rate of return then the NPV is positive.

- Benefit Cost Ratio: Instead of showing the NPV as an absolute amount, the benefit cost ratio relates the present value of cash flows to the initial outlay. If the ratio (sometimes called the profitability index) is greater than one, then the project is acceptable.

- Profit Margin (PM): Profit Margin is the sales return before interest. The Profit Margin is equal to the Net Income (NI) before interest {NI + after tax interest expense (ATI)} (averaged over 10 years) divided Revenue (averaged over 10 years). This ratio indicates the percentage of sales revenue that ends up as income. It is a useful measure of performance and gives some indication of pricing strategy or competitive intensity.

- Asset Turnover (AT): The Asset Turnover is equal to Revenue divided Total Assets (applicable to the year of the ten year production cycle). This ratio relates to the farm's dollar sales volume to its size, thereby answering the question, "How much volume is associated with a dollar of assets?". This ratio tends to move in the opposite direction to the Profit Margin. Companies with high turnover tend to have low margins, and those with low turnover tend to have high margins.

- Return on Total Assets (ROTA): This is the operating return, which indicates the company's ability to make a return on its assets before interest costs. ROTA equals Profit Margin (PM) times Asset Turnover (AT).

- Debt to Equity Ratio (DER): This relates ratio reveals the extent of debt that is part of the venture's financing. The ratio equals Liabilities divided by Equity (Owners investment contribution plus the value of assets already owned that are used for the venture plus retained earnings).

- Leverage Return: Measure the relationship between borrowings and equity. Financial leverage is measured by the Debt to Equity Ratio times {Return on Total Assets (ROTA) minus the Average Interest Rate after Tax (IN)}. The Average Interest Rate After Tax (IN) is equal to the After-tax Interest Rate Expense (ATI) divided by liabilities.

- Return on Equity (ROE): This is equal to Return on Total Assets plus Leverage Return. The company's return is made up of returns from operations and from borrowed funds. If there is a positive difference between the operating return and the cost of borrowing, a company may take advantage of this difference via using leverage to enhance its returns by borrowing relative to the owner's equity base.

- Hasegawa Index: The Hasegawa index is a convenient way to obtain an indication of the profitability of an aquaponics venture (given that detailed economic data may not be available). This index compares the ratio of the selling price and the price of feed to the ratio of the conversion ratio and the ratio of feed cost to total costs.

- Contribution to Overhead (CTO): CTO is the portion of revenue from each unit of sale that remains after variable costs are covered.

- Cost per Kilo: The cost per kilo of fish is equal to current costs (minus depreciation) divided by total production (tones).

Cash Flow Statement3

The Cash Flow Statement shows the calculated Closing Cash Balance over the ten year cycle. This balance is assumed to be reported as cash in hand after each period, and can be used to reduce debt faster, buy more capital equipment or place in special savings portfolios such as a superannuation fund

Financial Ratios Module

This module details the Assets and Liabilities over each of the ten years. By inserting the Year number at the top of the screen, the accounts will change depending on the depreciation and liabilities.

The financial ratios calculated from this are:

- Profit Margin
- Asset Turnover
- Equity
- Return on Total Assets
- Debt to Equity Ratio
- Leverage Return
- Return on Equity.

Equity is calculated by subtracting total liabilities from total assets. It is calculated in the profit linkage model in a different way to show how the accounts interact.

Trading Results

The Trading Results Report summarizes the Assets/Liabilities and the resulting (Loss/Surplus) or equity and the trading results. This module is used to calculate the Cash Available for Debt Service (CAFDS) Ratio, which is used by financial institutions to determine the capacity of a proposed business to cover loan repayments. Financial institutions have certain performance measures that are used to determine the eligibility for a financial loan. For example, a bank may require that the minimum interest cover is a CAFDS which is twice the amount of an interest repayment. Equity is defined as the owner's capital investment for setup capital costs and the value of any assets contributed to the venture4.

Volume Cost Analysis

This system module shows a breakdown of Fixed and Variable Costs and calculates the following major indicators:

- Contribution to overheads
- Breakeven Volume

Profit planning module is included to assist the farmer in determining what volume (sales) is required to attain a particular gross profit.

Fixed Cost module is included to assist the farmer in determining the amount of additional sales required to cover an addition to fixed costs (e.g. a new pump).

Variable Cost module has been included to determine the impact of expected inflation and its impact on variable cost.

Profitability Linkage Model

This screen shows how Return on Equity (ROE) is calculated. The calculations take into account the following data from the various accounts:

- Net Income
- Total Assets
- Total Liabilities
- Equity
- Return on Total Assets
- Debt to Equity Ratio
- Leverage Return

Print out Reports

Entrepreneurial management model produces a general report which summaries the farm scenario outlined in the assumptions laid down. Reports and graphics include:

- Consolidated Report
- Bio-economic variables
- Profit and Loss Account
- Financial Ratios (Assets and Liabilities)
- Trading Results (Cash available for Debt Service)
- Cash Flow Account
- Internal Rate of return Analysis
- Volume Cost Analysis
- Profitability Linkage Model (Return on Equity)
- Capital Start up Payback Period Bar Chart
- Current Costs Pie Chart
- Fish Tonnage Chart

Conclusions

The aquaponics can be developed in a sustainable manner to generate food and jobs and improve the income and livelihoods of rural and urban populations, thus alleviating hunger and poverty. Developing an accurate and practical tool to predict plant and fish growth and monitor nutrient concentrations in water, will improve the adoption and implementation small or commercial scale of aquaponic systems as urban farming or as a business model for household food security.

The entrepreneurial management model of the business plan represent an engine for economically resilient and sustainable fisheries and aquaponics is the government's will and resolves to establish sound policies to support and develop the sector. The entrepreneurial management model allowed to analysis the influence of production system inputs to the farm yield and cost.

The input of aquaponics production system (fingerlings, feed, water, etc.) determines yield and cost in both a direct and indirect way. When an input is used more intensively (for example, when more fish are stocked per ha) yield may rise enough to offset the increase in cost, resulting in a more profitable farm. As production intensity increases, however, the greater use of an input, such as feed, can have an indirect and negative effect on yield via changes in pond water quality. This can result in a lower yield and higher cost per kg harvested, reducing profit to the farm.

Full employment of productive factors, including human resources, continuous improvements in the legal and regulatory framework for the development of the sector, and scientific breakthroughs in production technologies will strengthen aquaponics and ensure its sustainability.

The aquaponics represent a component of rural development policies. The aquaponics activities offers the perspective of multispectral development in rural areas.

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